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WRAP 2A ADVANCED CONCEPTUAL DESIGN REPORT

The Final Advanced Conceptual Design Report is submitted to the Westinghouse Hanford Company in accordance with the Statement of Work for Off-Site Architect-Engineer Services, Revision 4D.

K. J. Iverson by DEC — 3-1-94

Kenneth J. Iverson, PE — **Date**
Project Manager
United Engineers & Constructors

R Basu — 3-1-94

Rathin Basu, PE — **Date**
Project Engineering Manager
United Engineers & Constructors

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ABBREVIATIONS & ACRONYMS

ACD	ADVANCED CONCEPTUAL DESIGN
ACDR	ADVANCED CONCEPTUAL DESIGN REPORT
AGV	AUTOMATED GUIDED VEHICLE
ALARA	AS LOW AS REASONABLY ACHIEVABLE
AMU	AQUEOUS MAKE UP
ANS	AMERICAN NUCLEAR SOCIETY
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
ARM	AREA RADIATION MONITORING
ASCE	AMERICAN SOCIETY OF CIVIL ENGINEERS
ASHRAE	AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR CONDITIONING ENGINEERS
AS/RS	AUTOMATIC STORAGE/RETRIEVAL SYSTEM
ASTM	AMERICAN SOCIETY OF TESTING MATERIALS
BDAT	BEST DEMONSTRATED AVAILABLE TECHNOLOGY
BFD	BLOCK FLOW DIAGRAM
BFS	BLAST FURNACE SLAG
BNFL	BRITISH NUCLEAR FUELS LIMITED, INC.
CAM	CONTINUOUS AIR MONITOR
CCTV	CLOSED CIRCUIT TELEVISION
CDR	CONCEPTUAL DESIGN REPORT
CF/CFT	CUBIC FEET
CFM	CUBIC FEET PER MINUTE
CFR	CODE OF FEDERAL REGULATIONS
CH	CONTACT HANDLED
CHLLMW	CONTACT HANDLED LOW LEVEL RADIOACTIVE MIXED WASTE
CMAA	CRANE MANUFACTURERS ASSOCIATION OF AMERICA
DB	DRY BULB
DBA	DESIGN BASIS ACCIDENT
DBE	DESIGN BASIS EARTHQUAKE
DCS	DISTRIBUTED CONTROL SYSTEM
DMS	DATA MANAGEMENT SYSTEM
DOE	U.S. DEPARTMENT OF ENERGY
DOE-RL	U.S. DEPARTMENT OF ENERGY FIELD OFFICES, RICHLAND
DOT	DEPARTMENT OF TRANSPORTATION
EPA	ENVIRONMENTAL PROTECTION AGENCY
ERDA	ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
ES&H	ENVIRONMENT, SAFETY & HEALTH
FACP	FIRE ALARM CONTROL PANEL
FDC	FUNCTIONAL DESIGN CRITERIA
FLT	FORK LIFT TRUCK
FM	FACTORY MUTUAL
FY	FINAL YEAR
GEA	GAMMA ENERGY ASSAY
GPD	GALLONS PER DAY
HAZOP	HAZARDS AND OPERABILITY
HCWC	HANFORD CENTRAL WASTE COMPLEX
HDW-EIS	HANFORD DEFENSE WASTE ENVIRONMENTAL IMPACT
HEL	HIGHER EXPLOSIVE LIMIT

ABBREVIATIONS & ACRONYMS

HEPA	HIGH EFFICIENCY PARTICULATE AIR
HFD	HANFORD FIRE DEPARTMENT
HLAN	HANFORD LOCAL AREA NETWORK
HP	HORSEPOWER
HVAC	HEATING, VENTILATION AND AIR CONDITIONING
IMT	INTEGRATED MANAGEMENT TEAM
KEH	KAISER ENGINEERS HANFORD
LAN	LOCAL AREA NETWORK
LCC	LIFE CYCLE COST
LDR	LAND DISPOSAL RESTRICTIONS
LEL	LOWER EXPLOSIVE LIMIT
LETF	LIQUID EFFLUENT TREATMENT FACILITY
LLW	LOW-LEVEL WASTE
MCC	MOTOR CONTROL CENTERS
MCFL	MAXIMUM CREDIBLE FIRE LOSS
MFD	MATERIAL FLOW DIAGRAM
MLLW	LOW LEVEL RADIOACTIVE MIXED WASTE
MPFL	MAXIMUM POSSIBLE FIRE LOSS
MRP	MANAGEMENT REQUIREMENTS & PROCEDURES
MR/YR	MILLIREM PER YEAR
MS	MILITARY SPECIFICATION
NCI/G	NANOCURIES/GRAM
NDA	NON-DESTRUCTIVE ASSAY
NEC	NATIONAL ELECTRICAL CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NESHAP	NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
OIU	OPERATOR INTERFACE UNITS
OPC	ORDINARY PORTLAND CEMENT
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
PA	PERFORMANCE ASSESSMENT OR PUBLIC ADDRESS
PCB	POLYCHLORINATED BIPHENYL
PCS	PLANT CONTROL SYSTEM
PFA	PULVERIZED FLY ASH
PFD	PROCESS FLOW DIAGRAM
pH	POTENTIAL OF HYDROGEN
PLC	PROGRAMMABLE LOGIC CONTROLLER
PMS	PLANT MANAGEMENT SYSTEM
PSAR	PRELIMINARY SAFETY ANALYSIS REPORT
PSE	PRELIMINARY SAFETY EVALUATION
PSF	POUNDS PER SQUARE FOOT
PSIA	POUNDS PER SQUARE INCH - ABSOLUTE
PSIG	POUNDS PER SQUARE INCH - GAUGE
RAM	RANDOM ACCESS MEMORY
RCRA	RESOURCE CONSERVATION AND RECOVERY ACT
RFAR'S	RADIO FIRE ALARM REPORTERS
RH	REMOTE-HANDLED
RMW	RADIOACTIVE MIXED WASTE
RWP	RESTRICTED WORK PERMIT

ABBREVIATIONS & ACRONYMS

R_W	FORCE REDUCTION FACTOR
SCFM	STANDARD CUBIC FOOT PER MINUTE
SDRD	SUPPLEMENTAL DESIGN REQUIREMENTS DOCUMENT
SMA	SAMPLE MANAGEMENT AREA
SSW	SOUTH SOUTH WEST
SWITS	SOLID WASTE INFORMATION TRACKING SYSTEM
SWOC	SOLID WASTE OPERATIONS COMPLEX
SWP	SPECIAL WORK PERMIT
T-BACT	BEST AVAILABLE CONTROL TECHNOLOGY FOR TOXICS
TAPS	TOXIC AIR POLLUTANTS
TBD	TO BE DETERMINED
TCAPCA	TRI-COUNTY AIR POLLUTION CONTROL AUTHORITY
TCLP	TOXICITY CHARACTERISTIC LEACHING PROCEDURE
TEC	TOTAL ESTIMATED COST
TEDF	TREATED EFFLUENT DISPOSAL FACILITY
TLVS	THRESHOLD LIMIT VALUES
TPC	TOTAL PROJECT COST
TRU	TRANSURANIC
TSDF	TREATMENT, STORAGE AND DISPOSAL FACILITY
TTF	THERMAL TREATMENT FACILITY
UBC	UNIFORM BUILDING CODE
UCRL	UNIVERSITY OF CALIFORNIA RESEARCH LABORATORY
UE&C	UNITED ENGINEERS & CONSTRUCTORS
UK	UNITED KINGDOM
UL	UNDERWRITERS LABORATORIES
UPC	UNIFORM PLUMBING CODE
UPS	UNINTERRUPTIBLE POWER SUPPLY
VCR	VIDEO CASSETTE RECORDERS
VE	VALUE ENGINEERING
VES	VINYL ESTER STYRENE
VGA	VIDEO GRAPHICS ARRAY
VOC	VOLATILE ORGANIC COMPOUNDS
WAC	WASHINGTON ADMINISTRATIVE CODE OR WASTE ACCEPTANCE CRITERIA
WB	WET BULB
WC	WATER COLUMN
WDOE	STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
WFQ	WATER FORM QUALIFICATION
WG	WATER GAUGE
WHC	WESTINGHOUSE HANFORD COMPANY
WID	WASTE IMMOBILIZATION DEMONSTRATION
WIPP	WASTE ISOLATION PILOT PLANT
WIPP-WAC	WIPP WASTE ACCEPTANCE CRITERIA
WSW	WEST SOUTH WEST
WNW	WEST NORTH WEST
WRAP	WASTE RECEIVING AND PROCESSING

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WASTE RECEIVING AND PROCESSING, MODULE 2A, FEED SPECIFICATION

1.0 INTRODUCTION

The objective of this document is to provide descriptions of all Waste Receiving and Processing (WRAP) Module 2A feed streams, including physical and chemical attributes, and describe the pathway that was used to select data for volume estimates. The feed specification document is an essential part of the WRAP Module 2A technical basis documentation plan described in WHC-SD-W100-SD-001, *WRAP 2A Process Confirmation Plan* (Benar 1993). The feed specification directly supports WHC-SD-W100-ES-006, *Waste Receiving and Processing Facility, Module 2A, Process Selection Summary* (Sexton 1993), and product specifications and treatment and disposal compliance strategies (roadmaps) that will be prepared. Other project activities that have a strong dependence on the feed specification are development of process flow diagrams, process demonstration testing using surrogate waste, and formulation of the regulatory strategy to be used for waste form certification.

The WRAP Module 2A is being designed for nonthermal treatment of contact-handled (CH) mixed low-level waste (MLLW) Category 1 and Category 3 as defined in WHC-EP-0063-3, *Hanford Site Solid Waste Acceptance Criteria* (Willis 1991), herein referred to as Class 1 and Class 3, using U.S. Environmental Protection Agency (EPA)-accepted technologies. The amount of waste to be processed encompasses waste currently in storage, waste to be generated by Westinghouse Hanford Company (WHC) and Pacific Northwest Laboratory operations at the Hanford Site, and waste shipped to the Hanford Site from about 12 U.S. Department of Energy (DOE) sites. In addition, volumes to be processed include buried waste that is being reclaimed for sorting in the WRAP Module 1 (currently awaiting approval to proceed with construction) and is determined to be MLLW, and CH MLLW ash from a thermal treatment facility (TTF). This TTF is a proposed 1997 line item project to complete the necessary treatment of MLLW requiring thermal treatment to remove organic contaminants. All the waste will be received and stored in the 200 West Area Phase V storage complex before transport to WRAP Module 2A for treatment and disposal in a Hanford Site trench that meets *Resource Conservation and Recovery Act of 1976* (RCRA) requirements.

The WRAP Module 2A design will be based on immobilization and encapsulation treatment technologies using grout or polymer. Capabilities also will be available to treat mercury, lead, and contained liquids using developed and demonstrated EPA methods or other appropriate technologies for hazardous material disposal.

The overall plan for cost-effective disposal of waste at the Hanford Site is to take maximum advantage of the treatment methods available in WRAP Module 2A and minimize the amount of waste to be sent to the TTF, which will use a more costly incineration process. For planning purposes, when the waste container contents are uncertain and there is no indication the waste requires thermal treatment, the assumption is made that the waste can be routed to WRAP Module 2A. In accordance with this assumption, the WRAP Module 2A processing

lines are being designed with sufficient flexibility to handle the maximum volume of waste and range of chemical components.

Descriptions for each of the WRAP Module 2A feed streams are a compilation of information for numerous sources. This information is needed in order to proceed with design, process demonstration, and regulatory activities. It is anticipated that this document will be updated periodically and the data will be modified as new information becomes available regarding waste contents and volume projections.

2.0 DATA SOURCES AND RATIONALE

The WRAP Module 2A feed streams encompass a wide range of materials and are derived from several sources based on existing and forecast information. The primary information sources are the solid waste information and tracking system (SWITS) database that includes information for existing CH MLLW, and the verified database used to prepare WHC-EP-0567-1, *1993 Solid Waste Reference Forecast Summary* (Valero 1993). The latter database is a compilation of data from waste generators obtained in the summer and fall of 1992. Other sources of data include the 183-H Basin closure reports (DOE-RL 1988, DOE-RL 1991, Powers et al. 1990), Richland-Solid Waste Information Management System (R-SWIMS), and feed specification data based on flowsheets received directly from representatives for each of the Liquid Effluent Treatment Facilities (LETF). These data sources are discussed in the sections below.

Throughout this document, the volumes designated for a specific feed stream include the entire volume within the container and not the overpack. The containers, and in some cases the polyethylene liners, will be reduced in size and are expected to be disposed of as low-level waste or debris. No effort has been made to include the waste generated by operation of WRAP Module 2A because this waste is separate from the incoming feed streams and is included in the overall process design.

2.1 SWITS DATABASE

The SWITS database provides a relatively detailed description of the MLLW that is in storage at the Hanford Site. Efforts have been made to interrogate this database to obtain an understanding of the different types of CH MLLW that will be processed in WRAP Module 2A.

In some cases, the SWITS data need to be supplemented by additional information available in the Storage Disposal Approval Record (SDAR) for a specific drum or group of drums. This information provides details of the waste drum, including how the waste was prepared, and may add clarification regarding specific constituents and attributes of the waste. The SDAR information could be important when decisions associated with grouping of drums into a lot are made or information is needed to answer specific questions on a waste type. Currently, the SDAR data are separate from SWITS and inquiries require the completion of additional paperwork to obtain a copy. In the future, the SDAR information will be included in the SWITS.

Presently there is no distinction in the SWITS database, other than waste codes, as to the specific waste that must be thermally treated. Therefore, the database must be evaluated, drum by drum, for waste codes and characteristics that indicate the waste will be suitable for processing in WRAP Module 2A or requires thermal treatment. Composition and physical/chemical attributes (in addition to waste codes) that would lead to designation of a specific drum as requiring thermal treatment are relatively high concentrations of organics in a liquid form, such as solvents, oils, and insecticides, or the presence of organic chemicals that would not be amenable to immobilization using grout or polymer. Waste that is primarily debris

which has been contaminated with small quantities of organics, in general, would be included in the feed for WRAP Module 2A.

2.2 FORECAST DATA

Each year, the forecast database is updated using input from the Hanford Site and other DOE site generators. This database can be interrogated extensively and is suitable for grouping data by waste type and class to prepare many different types of tables. The data of most interest for CH MLLW waste volume projections are tables that group the volume by physical content descriptor (PCD) and chemical contaminants. Figure 2-1 presents various types of waste that were screened out of the forecast and are intended for thermal treatment or processing in other facilities. The darkened boxes in Figure 2-1 show specific chemical contaminants and PCDs that were excluded to determine the yearly forecast volume of waste to be processed in WRAP Module 2A using immobilization, encapsulation, or other appropriate treatment technologies including EPA treatment methods.

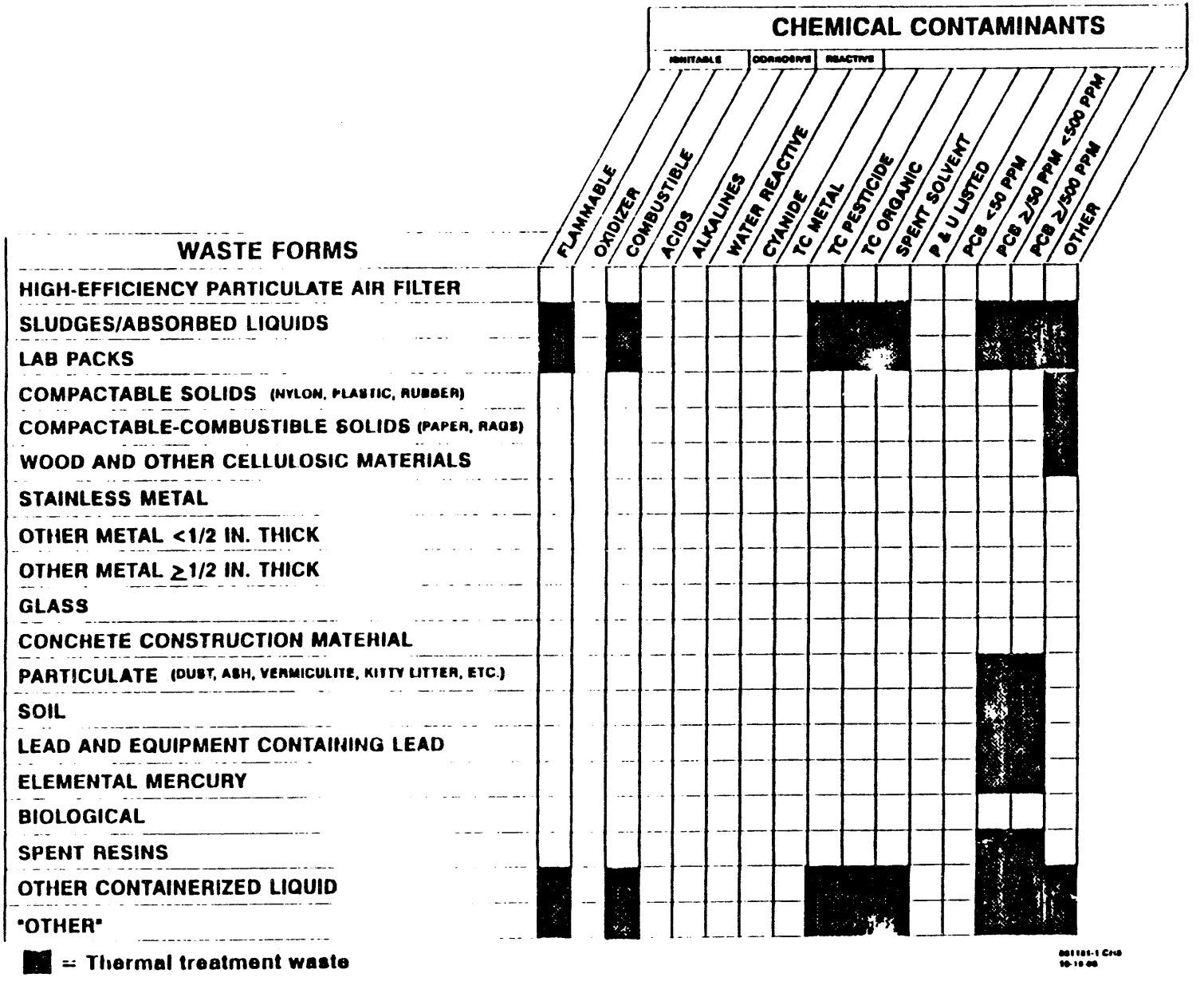
The forecast data are sufficient to provide a breakdown of the various characteristics that require special treatments, e.g., mercury, lead, and contained liquids or lab packs that will be treated in WRAP Module 2A. As shown in Figure 2-1, the PCD information on waste provides further insight that is useful for determining processing requirements, such as the volumes for particulates, including soils and resins, as well as metals, filters, etc.

Although the current plan is to maximize the amount of waste for immobilization treatment, some PCD classifications for the forecast waste are uncertain and overlap with thermal treatment may exist. The "other" chemical contaminant fields in Figure 2-1 are not defined; consequently, there is no basis for making a clear separation of thermal and nonthermal treatable waste. A major portion of this waste is thought to be debris, and the particulate-type waste may not contain organics. Therefore, for planning purposes, this waste has been included in the volume projections for WRAP Module 2A presented later in this document.

Current planning calls for the WRAP Module 2A facility to treat CH MLLW ash from the TTF. Evaluation of the SWITS and forecast data has been quite helpful in providing a basis for the volume and composition of this feed stream to WRAP Module 2A. Certain waste constituents, including metals, concrete, and soils, would not be expected to change volume appreciably during incineration. This premise was used to arrive at a reduction factor through detailed analysis of the constituents obtained from the SWITS database. The volumes for thermal treatment waste from the forecast data (see the Figure 2-1 darkened fields) and SWITS were multiplied by the reduction factor to estimate the volume of ash for WRAP Module 2A.

Information is needed for WRAP Module 2A design to ensure the box breakdown area will have sufficient capacity and the mechanisms for drum entry and handling are adequate. Forecast data can be used to relate the container type to the PCD shown in Figure 2-1. However, there is currently no way to relate the container type to the chemical contaminants in a manner that would separate the thermal treatment waste from waste to be processed in WRAP Module 2A. This situation does not present any major difficulties now and

Figure 2-1. Matrix of Waste Forms and Chemical Contaminants used to Screen Out Thermal Treatment Contact-Handled Mixed Low-Level Waste from Forecast Database.



should be resolved in the next update of the forecast data. A major interest for WRAP Module 2A is the number of boxes requiring processing because previous information has been very limited. The data appear to be suitable for projecting the number of boxes to be processed with some degree of uncertainty.

2.3 OTHER INFORMATION SOURCES

A small portion of the feed to WRAP Module 2A is projected to come from WRAP Modules 1 and 2B when they are operational. The WRAP Module 1 facility will separate the MLLW from the transuranic waste obtained from the burial trench and package the MLLW for treatment in WRAP Module 2A. Descriptions of the buried waste in the R-SWIMS and SWITS databases are being used to determine the portion of the WRAP Module 1 waste that eventually will be sent to WRAP Module 2A. An assumption has been made that the WRAP Module 1 waste to be treated in WRAP Module 2A will be proportioned into approximately the same waste types as the waste in storage (SWITS). For this proportioning calculation, certain cleanup waste streams were eliminated and adjustments were made to account for a high portion of lead in storage from cleanup operations onsite and offsite.

The WRAP Module 2B mission will include repackaging of MLLW that is in containers too large or too heavy for WRAP Module 2A to handle. The container size limit for WRAP Module 2A is 5 ft high by 5 ft wide by 9 ft long and the weight limit is 12,000 lb. The WRAP Module 2B feed stream to WRAP Module 2A is included in the SWITS database and the forecast data; therefore, no special adjustments are necessary.

The two LETFs at the Hanford Site are the Effluent Treatment Facility (ETF), Project C-018, which is being constructed in the 200 Area, and the Treated Effluent Disposal Facility (TEDF), Project L-045, under construction in the 300 Area. Engineers responsible for these facilities have been consulted for detailed descriptions of the LETF waste based on the latest flowsheet calculations and this information has been incorporated into the feed specification data.

3.0 FEED STREAM DEFINITION

The rationale for selection of the various feed streams for WRAP Module 2A is determined by many different factors. Some of the ramifications and logic are discussed further in the following sections.

3.1 PREVIOUS FEED STREAM DESIGNATIONS

Various feed streams were defined during the conceptual design phase for WRAP Module 2A in order to proceed with plant layout and determine process equipment requirements. These feed streams are shown at the top of Figure 3-1. Eight major feeds were defined with subvariations for the 183-H Basin waste, LETF secondary solids, and metals. Most of the feed streams were determined by the major sources of the waste at the Hanford Site and the treatment technologies specified by the EPA for special wastes such as lead, mercury, and lab packs.

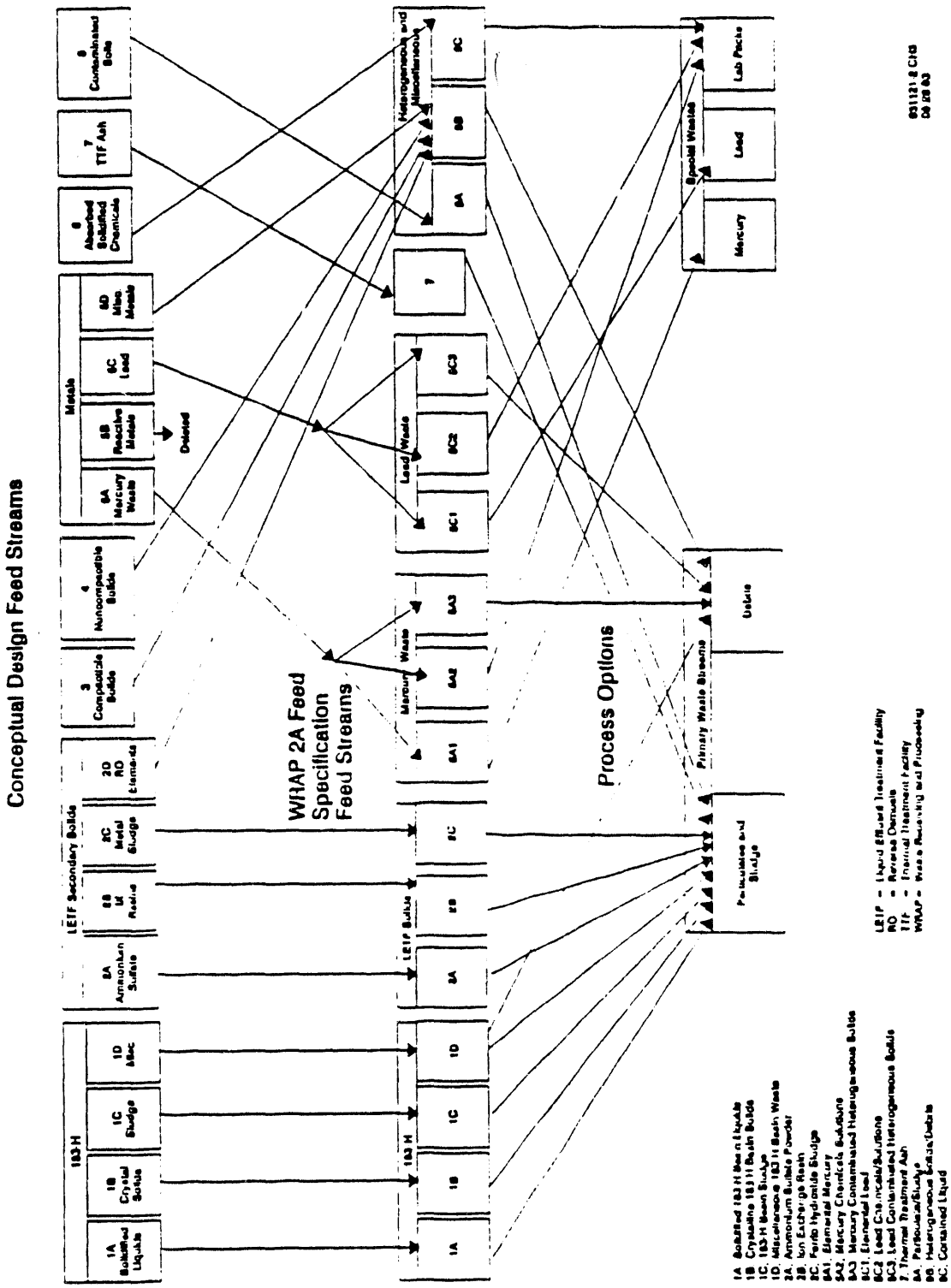
A reactive metals stream also was identified for the WRAP 2A conceptual design. Subsequent consideration of the ramifications of processing reactive metals and examination of the records showed that this feed stream should be eliminated from processing in WRAP Module 2A. No reactive metals of uranium and zirconium turnings were found in the SWITS database. This situation is consistent with the practices in place at all DOE sites for many years of treating this waste type by burning and/or grout stabilization. Elemental sodium or sodium and potassium alloy at the Hanford Site will require special treatments that are not part of the WRAP Module 2A mission. Elemental uranium or zirconium in bulk form would not be classified as reactive metals, and would be processed along with other metals as debris.

Further investigation of the feed for WRAP Module 2A indicates that much of the waste is heterogeneous. The compactable and noncompactable solids are mixed and contain metals, concrete, glass, and other materials. The mercury and lead wastes contain elemental mercury and lead intermixed with absorbent and miscellaneous materials including metals. Quantities of elemental mercury contained within the drums are limited to a small portion of the drum contents. In addition, new feeds of lead and mercury chemicals need to be defined.

3.2 NEW FEED STREAM DESIGNATIONS

Based on the above information, the decision was made to redefine the feed streams in a manner that would better convey the heterogeneous nature of some of the waste to be processed in WRAP Module 2A. Another factor in determining the specific feed streams for WRAP Module 2A is the issuing of 57 FR 37194, "Land Disposal Restrictions for Newly Listed Wastes and Hazardous Debris," by the EPA in the fall of 1992. This "debris rule" recognized the difficulties in processing and certification sampling of certain types of heterogeneous solid waste and introduced alternate treatment technologies for consideration. Sampling of debris waste was eliminated as a requirement but specified treatments must be certified. Some of the feed streams for

Figure 3-1. Schematic Diagram Showing Relationship Between Conceptual Design and New Waste Receiving and Processing Module 2A Feed Stream with Associated Processing Alternatives.



WRAP Module 2A were appropriately affected by the debris rule. For example, the LETF reverse osmosis filter elements, compactable solids and noncompactable solids, and miscellaneous metals were combined into a single debris feed stream (see Figure 3-1). This feed definition also closely follows the breakdown of the forecast waste shown in Figure 2-1. The forecast waste forms of high-efficiency particulate air (HEPA) filters, compactable solids, compactable-combustible solids, wood and other cellulosic materials, stainless steel, other metal <1/2 in. thick, other metal >1/2 in. thick, glass, concrete construction material, biological, and "others" appear to meet debris requirements and were combined into a single feed stream of heterogeneous solids/debris.

This combination of PCDs into one feed stream assumes many of the containers will have PCDs in various combinations to one another and the WRAP Module 2A process line must be suitable for handling a wide range of feed materials. If the PCD types are received as a segregate feed type, an effort will be made to combine these containers into a subgroup for processing.

The particulate 183-H Basin wastes and LETF secondary solids were kept as separate feed streams to retain all the detailed information on the different feed types for process testing and waste acceptance verification. Each of these particulate feed streams is expected to be processed as separate lots or sublots in WRAP Module 2A versatile processing equipment.

Mercury and lead wastes were divided into several separate feed streams to emphasize the different technologies that will be required for treatment. At this time, the forecast data (see Figure 2-1) do not provide a breakdown of the lead and mercury into these various streams. Ratios based on the waste in storage are used to estimate the feed volumes in the different categories.

The absorbed solidified chemicals feed stream in the CDR was identified for treatment of lab packs. This stream has been combined into a broader category of contained liquids which includes lab packs and some liquids known to be in containers packed within drums surrounded by absorbent materials. Lab packs are defined as a separate category in the forecast data, and this waste is included in the total volume for the contained liquids feed stream.

The TTF ash was not changed from the CDR designation. As indicated previously, the technical basis for this feed stream has improved significantly but there are still many uncertainties that will need to be considered as processing options are evaluated. The forecast data have been used to estimate the waste volume of this feed stream.

The CDR feed stream designated "contaminated soils" was combined into a new stream of particulates/sludges that includes a wide range of particulate materials with undefined characteristics. It is anticipated that this feed stream will be processed in the same equipment that will be used to treat 183-H Basin and LETF particulate wastes; however, a wider chemical and physical characteristics variability can be anticipated in process lots.

In general, all the waste can be allocated to three major processing alternatives: particulate including sludge, soil, spent resins, process condensate, coprecipitates, absorbent, etc.; heterogeneous solid waste or debris; and special treatment-type wastes such as lead- and mercury-

contaminated materials and lab packs including contained liquids. Grouping of the various feed streams to the different processing options is shown in Figure 3-1.

4.0 WASTE DESCRIPTIONS

4.1 EXISTING WASTE

Waste in storage is made up of the 183-H Basin waste and other heterogeneous waste that is defined by waste codes. These codes are used to separate the various drums into specific categories or waste streams that can be further analyzed for constituents. The SWITS contains data for all the stored waste in considerable detail including the percentage of the various constituents. A brief description of the 183-H Basin waste and other feed streams is provided in the following sections.

4.1.1 183-H Basin Waste

The 183-H Basin waste was generated from closure of four basins used from 1973-85 for solar evaporation of neutralized acid etch solutions from the N Reactor fuel fabrication. The closure activities resulted in generation of four feed streams for processing in WRAP Module 2A. Detailed descriptions of the various feed streams are based on the considerable amount of chemical and physical data that were obtained to determine constituents in the waste and meet regulatory requirements for closure. The four feed streams resulted from efforts to segregate the waste and provide treatment of the liquid waste prior to loading the waste into drums according to approved procedures.

Supernatant liquid from all four basins, consisting primarily of sodium nitrate, was transferred between basins and consolidated during closure efforts. This liquid was mixed with Sorbond* LPC II solidification agents using a batch process and loaded into drums in 1988-89. The solidified drums constitute Feed Stream 1A, Solidified 183-H Basin Liquids, which is expected to be processed as a lot in WRAP Module 2A. These drums may require special techniques for removing waste from the drum and breaking up the solidified material to facilitate intimate mixing with grout or polymer into a waste form that meets certification requirements.

A distinct strata of relatively dry sodium nitrate crystalline solids occurred on the interior edges of basins 1, 3, and 4 when the supernatant liquid was drained for solidification. This material was combined with sludge from basin 1 and packaged into drums using layers of absorbent where needed. This waste is a separate feed stream for WRAP Module 2A designated 1B, Crystalline 183-H Basin Solids, which is expected to be processed as a single lot.

Sodium nitrate sludge and crystalline solids from basins 3 and 4 also were removed from the basins and packaged together indiscriminately as a separate feed stream. Absorbent was used to retain any liquid present with this waste type. Here again, this waste is expected to be processed as a lot with the designation 1C, 183-H Basin Sludge.

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*Sorbond is a trademark of American Colloid Company.

The remaining feed stream consists of sandblast grit and many different types of debris including liner material, gloves, boots, shovels, concrete, crushed tumbleweed, etc., that have been packaged into drums and boxes. This feed stream, designated 1D, Miscellaneous 183-H Basin Waste, is expected to require some sorting to remove the particular fraction from the larger solids. It is not clear at this time if more than one lot will be necessary for processing in WRAP Module 2A.

All the 183-H Basin waste carries a waste code of U123 for a small quantity of formic acid that was routed to the basins and would normally require incineration for treatment. However, formic acid is known to oxidize readily in the presence of nitric acid and would no longer be detectable. Efforts are in progress to sample the waste drums and obtain data that will be used for a variance petition to the EPA and the Washington State Department of Ecology. The waste sampling effort also is expected to provide additional chemical and physical data that will be helpful in evaluating processing alternatives for all 183-H Basin waste.

4.1.2 Other Heterogeneous Waste

Most of the other waste in storage is within a broad category of heterogeneous waste and must be separated by waste code and characteristics into mercury, lead, contained liquid, particulate, and heterogeneous solids/debris waste. Each of the drums, and in some cases the SDAR, must be examined to determine the proper designation. This process was used to identify the waste types and volume estimates as provided in Appendix A. Assumptions used in selecting waste drums, methods used for calculating the waste volumes of the different waste streams, and other information on the amount of each waste type in the group of drums, including drum density, also are described in Appendix A.

To determine the volume of elemental mercury or lead within a drum or box, the weight of the drum contents for these elements was divided by the density. This information provided an estimate of the amount of elemental material available for processing. Ratios also were established for the amount of existing waste to be applied to the waste volumes coming from WRAP Module 1 and forecast waste projections. Estimated volumes for each of the lead and mercury waste streams are shown in Appendix A. Waste volumes, gross weight, weight of constituent, average density, and assumptions for contained liquids, particulate, and heterogeneous solids/debris wastes also are provided in Appendix A.

4.2 NEWLY GENERATED WASTE

4.2.1 LETFs

The ETF will treat Evaporator 242-A acidified process condensate to produce a powdered solid waste (Feed Stream 2A) consisting of up to 83% ammonium sulfate with a small percentage of sodium sulfate that could be as low as 8%. The dry powdered material is produced from the operation of a thin-film dryer. This equipment is used to remove water from a major stream

of liquid waste brine generated during processing reverse osmosis refects and minor streams of filter back flush and ion-exchange regeneration. The ETF will generate relatively small volumes of spent ion-exchange resins that are used for deionization. Small quantities of debris-type waste also will be generated and are included in the waste volume projections for this waste type.

Process water from the 300 Area will be treated in the TEDF. The major feed stream from TEDF for WRAP Module 2A, designated 2C, will be ferric hydroxide sludge. Periodic refurbishment of the ion-exchange columns will produce small quantities of spent ion-exchange resin. For simplification, this ion-exchange resin stream has been combined with the resin from the ETF because the treatment used for both resins is expected to be similar.

4.2.2 Thermal Treatment Ash

Most of the ash produced in the TTF (Feed Stream 7) is expected to require treatment in WRAP Module 2A to immobilize hazardous constituents consisting primarily of toxic metals. Silica will be a major component of the incineration ash. Iron also could be present in a substantial quantity if the drums are shredded and processed with the waste. Wide variations in the chemical content of the ash are anticipated and will depend on the waste being treated at various times. Because ash has been shown to be a stabilizing additive for grouts, immobilization in grout or polymer would be acceptable.

4.2.3 Other Forecast Wastes

No specific information is readily available for the remaining forecast waste. The various waste forms and hazardous constituents used for collecting the data from generators, shown in Figure 3-1, can be used to format the forecast volumes into different types of reports but specific information on the waste components is limited. Further assessment of the data in fiscal year (FY) 1994 may be attempted using waste codes from different generators and waste form information to provide insight into the waste contents. Data showing amounts of specific constituents for each drum or box will not be available until the waste is actually generated; this type of information is essential for determining processing alternatives and lot designations.

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5.0 WASTE VOLUME PROJECTIONS

5.1 FORECAST DATABASE

To arrive at the estimated volume for each waste stream, the data from all generator sources must be added together. A special query of the forecast database was run to generate waste volume tables by waste form for CH MLLW Classes 1 and 3 and these tables are shown in Appendix B. Note that this Appendix B forecast database does not include single-shell tank retrieval operations and decontamination and decommissioning of surplus facilities. These wastes are excluded because they are the responsibility of the environmental restoration organization. The Appendix B tables show the estimated waste generated by year from 1993-2022 according to PCD and are divided into separate sections for Class 1 and Class 3 waste. A separate table in Appendix A shows the total volumes for each PCD and how these PCDs were combined into feed streams for WRAP Module 2A.

Data for particulate waste and spent resins in the Appendix B tables were adjusted in Appendix A to eliminate the LETF volumes because ETF, TEDF, and resins are separate streams (see Figure 3-1). This adjustment was made by obtaining the volume projections by generator and subtracting the volumes entered for ETF and TEDF submitted for the 1992 forecast database. In Appendix A, new forecast information for debris-type waste recently obtained from LETF representatives was added to the heterogeneous solids/debris feed stream. In addition, new forecast volume data for the ETF and TEDF were obtained and these projections were used for these feed streams in the following sections of this document.

The total volumes of nonthermally treatable Class 1 and Class 3 CH MLLW estimated by each waste generator are also shown in Appendix B. As can be seen, the total amounts of Class 1 and Class 3 waste forecasted are 746,365 ft^3 and 246,817 ft^3, respectively. About 94% of the Class 1 waste will be generated by the following seven generators: Argonne National Laboratory-East; Pacific Northwest Laboratory; Portsmouth; WHC 222-S Analytical Laboratory; WHC Tank Farms; WHC TEDF; and WHC ETF. A total of 227,386 ft^3, or approximately 30% of the Class 1 waste, are expected to be received from offsite generators. In comparison, almost 100% of the Class 3 waste will be generated at the Hanford Site.

Based on the Appendix B volume breakdown by waste generator and including the volume projection for TTF ash, the Hanford Site is expected to generate almost 80% of the total forecast waste volume. Clearly, most of the forecast waste will be under WHC control and this situation will provide the opportunity to obtain detailed information on waste attributes with minimum investment of time as WRAP Module 2A design progresses.

Note that the forecast volumes are expected to change with each yearly update. In general, the amount of CH MLLW to be processed in WRAP Module 2A has shown a steady increase during the past several years. This trend is expected to continue as the Hanford Site mission turns toward environmental cleanup and other DOE sites are faced with the same emphasis.

5.2 WRAP MODULES 1 AND 2B

The volume of MLLW that is expected to come from the WRAP Module 1 facility has been estimated using a solid waste projection model computer program. Based on evaluation of the data for currently buried drums that are to be sent to WRAP Module 1, 33% of the low-level waste is expected to be classified as MLLW and contain small but significant quantities of plutonium (<100 ηCi/g). About 50% of this MLLW is thought to require thermal treatment and the rest would go to WRAP Module 2A. Use of these percentages, in conjunction with the records for buried waste volumes, provides the volume (approximately 27,400 ft^3) of MLLW coming from WRAP Module 1.

For WRAP Module 2B, the situation is more uncertain because no treatment technologies have been established for this project and little is known about the waste contents. It is anticipated that WRAP Module 2B may treat a fraction of the MLLW that is routed to this facility for repackaging. As indicated previously, some of the forecast waste will be in containers too large to be received by WRAP Module 2A and will be required to go to WRAP Module 2B for breakdown of the waste into drums. This fraction of the waste from WRAP Module 2B is already taken into consideration by use of the total volumes in the forecast tables (see Appendix B). The WRAP Module 2A is currently thought to be the best place for treating much of the lead shielding that will be used to reduce the radiation levels of remote-handled waste to be sent to WRAP 2B. There is considerable uncertainty regarding this waste stream and no attempt has been made to estimate the amount of this waste for the WRAP 2A feed specifications. Therefore, the projected elemental lead feed stream volumes for WRAP 2A could increase significantly at a later date when more information is available.

5.3 TOTAL VOLUME ESTIMATES

The total volume estimates for all years shown in the Appendix B tables were combined with the volumes calculated in Appendix A to obtain the total estimated volumes for each feed stream as shown in the feed stream breakdown in Appendix C and the summary provided in Table 5-1. The breakdown in Appendix C shows how the feed stream volumes were developed from the different contributing sources. Table 5-1 shows that the 183-H Basin, ETF, TEDF, particulate, and heterogeneous solids/debris wastes are the major contributors to the total waste to be processed in WRAP Module 2A. Heterogeneous solids/debris wastes could constitute as much as one-third of the total waste. Elemental mercury and lead chemicals/solutions are expected to be very minor streams with a total volume of approximately 443 ft^3. Volumes of lead-contaminated heterogeneous solids, mercury chemicals/solutions, and mercury-contaminated heterogeneous solids are expected to be approximately 6,735 ft^3. The bulk of the special waste to be treated in WRAP Module 2A is expected to be elemental lead and contained liquids.

Low projections are shown in Table 5-1 for some of the feed streams to provide a range estimate that accounts for various uncertainties associated with operation of the TEDF and the Hanford Grout Facility. The total volume of 1,192,468 ft^3 is based on the scenario of all facilities operating as planned. A lower volume estimate of 836,708 ft^3 assumes some of the

Table 5-1. Summary of Waste Receiving and Processing Module 2A, Feed Stream Volumes.

Number	Feed stream	Volume	
		m^3	ft^3
1A	Solidified 183-H Basin Liquids	575.5	20,322
1B	Crystalline 183-H Basin Solids	922.7	32,580
1C	183-H Basin Sludge	971.4	34,299
1D	Miscellaneous 183-H Basin Waste	148.5	5,243
2A	Ammonium Sulfate Powder	6,485.4	229,000
2B	Ion-Exchange Resin	405.0	14,300
2C	Ferric Hydroxide Sludge	3,964.9[1] 317.3[2]	140,000[1] 11,200[2]
5A1	Elemental Mercury	11.2	395
5A2	Mercury Chemicals/Solutions	28.4	1,003
5A3	Mercury-Contaminated Heterogeneous solids	47.5	1,677
5C1	Elemental Lead	729.0	25,741
5C2	Lead Chemicals/Solutions	1.4	48
5C3	Lead-Contaminated Heterogeneous Solids	114.9	4,055
7	Thermal Treatment Ash	2,044.7	72,200
9A	Particulate/Sludge	4,136.1 2,569.5[3]	146,047 90,729[3]
9B	Heterogeneous Solids/Debris	12,759.6 7,898.6[3]	450,540 278,898[3]
9C	Contained Liquid	425.3	15,018
Total		33,771.4 23,696.2[4]	1,192,468 836,708[4]

[1]Waste volume projection based on routine operating conditions and does not take into account maximum possible flows.

[2]Option for standby operation of TEDF (L-045) with treatment by City of Richland.

[3]Without grout waste volume.

[4]Volume projection if TEDF and Grout Projects do not operate as planned.

facilities will be modified or replaced by other technologies and their associated waste volumes will be significantly reduced or eliminated.

5.4 UNCERTAINTIES

There are several uncertainties regarding a few of the previously described waste streams that could have a significant impact on the volumes of waste to be processed in WRAP Module 2A. The DOE, Richland Operations Office, has asked that the use of the City of Richland water treatment plant be considered as an option for treatment of the TEDF waste. If implemented, the TEDF would be used only for pretreatment, stand-by, or abnormal operation and the volume of waste would be reduced appreciably. This situation would not have a severe impact on WRAP Module 2A because feed uncertainty is factored into the volume projections and operations baseline.

Because less than a year has passed since the debris rule was implemented and the volumes of many of the forecast waste forms must be combined to determine the total debris volume, there is a relatively high degree of uncertainty regarding the estimated total volume of this waste. All waste generators are being asked to segregate the MLLW debris for the 1993 forecast and this could lead to changes in the forecast volumes for the heterogeneous solids/debris feed stream in 1994.

Considerable amounts of the heterogeneous solids/debris and particulate wastes are expected to be generated by the Hanford Grout Project. This project is dependent on the outcome of the Tank Waste Remediation System (TWRS) reviews with the DOE and the Washington State Department of Ecology. Volume projections shown for grout waste may not be consistent with the eventual TWRS decision. Nevertheless, treatment of the waste tank supernate eventually will be implemented and operation of a new facility would be expected to generate some MLLW that would need to be treated in WRAP Module 2A. Any modifications to the Hanford Grout Project would only be expected to impact the forecast volumes and would not change WRAP Module 2A process selection.

Another consideration is that minor hazardous components of the ETF waste have not been thoroughly evaluated at this time. Immobilization testing is being conducted with a range of components to provide sufficient data for treatment assessment. Additional effort may need to be focused on this stream as the facility initiates operation and more characterization information becomes available.

6.0 FEED SPECIFICATION DATA

6.1 FORMAT AND FEED DESCRIPTIONS

The attribute format selected for all the feed streams is based primarily on the information needed for design and process flow diagrams and resulted from several discussions with UE&C-Catalytic Inc., the Architect-Engineer for WRAP Module 2A. Other considerations were data needed for the waste acceptance and testing activities that are being conducted by WHC for process verification, and the radionuclide information needed for RCRA trench performance assessment for MLLW disposal.

The feed specification attributes for each of the WRAP Module 2A feed streams are provided in Appendix D. Attributes are grouped under the main headings of feed stream, generation, physical characteristics, radiological characteristics, chemical characteristics, and packaging description. Each of these main headings has several subheadings that include brief narrative descriptions of the waste, volumes, physical state and other properties, waste class, radionuclide content, dose rate, chemical constituents, waste codes, hazardous characteristics and components, container type, internal packaging, gross weight, and closure mechanisms. Efforts have been made to provide as much information as deemed necessary for design activities and waste acceptance.

The following information is provided to help clarify the Appendix D tables and provide information concerning waste codes and characteristics for various feed streams.

- Some of the feed stream specifications were compiled from computer searches of receipt records for MLLW stored at the Hanford Site. Because of the nature of these summaries, conclusions should be made very carefully to avoid misinterpreting the data. For example, the waste code sections in the Appendix D tables summarize all the waste codes assigned to any of the containers included in a particular feed stream group; therefore, for Feed Streams 5 and above a specific waste container would not be expected to be designated for all these waste codes but this situation is not precluded.

- The feed specification represents current projections of wastes intended for treatment in WRAP Module 2A. Wastes identified in the future for treatment in WRAP Module 2A may have other codes.

- No individual wastes have yet been identified that bear all three codes (D001, D002, and D003), and if any future wastes are identified for which incineration is the appropriate treatment, such wastes will not be treated in WRAP Module 2A.

- Each container in a feed stream group may contain more than one individual waste package and the waste codes on the drum and recorded constituent quantities for each drum summarize information on all the individual packages in that drum. It should not be presumed that each of the codes on a drum apply to all the individual waste packages in that drum or that the constituents in

that drum are evenly distributed among the various individual packages within that drum.

- The computer searches of receipt records for mixed waste stored at the Hanford Site are limited by the quality of the data originally received with these containers. If a constituent is incorrectly identified or if the records are incomplete, it may not be possible to correct or complete the information after the fact without sampling.

- The best management practices by which MLLW is packaged at the Hanford Site and at other sites for storage at the Hanford Site attempt to err on the side of conservatism. This practice may occasionally provide information that can be misinterpreted. For example, some procedures require that waste identified as corrosive be pH-adjusted to neutral, and that the waste code of D002 be retained on the waste even though it no longer meets the RCRA definition of corrosive waste.

- The D001 code has six subcategories:

  - Ignitable liquids with high organic content
  - Ignitable liquids with low organic content
  - Ignitable liquid wastewater
  - Ignitable compressed gases
  - Ignitable reactives
  - Oxidizers.

  Almost all the D001 wastes treated in WRAP Module 2A will be in the subcategory of oxidizers.

  None of the D001 wastes intended for treatment at WRAP Module 2A will be in the three D001 subcategories for ignitable liquids (i.e., none of the wastes intended for treatment in WRAP 2A will have a flashpoint <140 °F). In addition, none of the D001 wastes intended for treatment at WRAP Module 2A will be in the D001 subcategory of ignitable compressed gases.

- The chemical characteristics narrative description in the Appendix D tables identifies the presence of "water-reactive substances" in Feed Stream 9C. The only water-reactive substances intended for treatment in WRAP Module 2A will be strong acids and bases packaged in lab pack-type quantities (because these wastes can react violently with water, they may be coded D003).

- No alkali metals will be treated in WRAP Module 2A.

- Although WRAP Module 2A is not intended to treat wastes such as oils, solvents, and alkali metals, it is expected that small quantities of these types of materials may occasionally be "discovered" during waste sorting. Upon discovery, such wastes will be repackaged and returned from WRAP Module 2A to storage. It is not intended that this consideration have significant impacts on the complexity or cost of WRAP Module 2A.

It should be recognized that with the exception of volume projections and the information that has been accumulated from other sources for the 183-H Basin and LETF wastes, a major portion of the data provided in the feed specification is based on waste in storage. From all indications, the variability of the existing waste in conjunction with the information on the other major feed streams and the issuing of the debris rule provide a reasonable basis for design and permitting of WRAP Module 2A.

6.2 RADIONUCLIDE DATA

Although some radionuclide information is presented along with the feed specification data, there may be need for a wider range of radionuclide values. The data available for Feed Streams 1 and 2 have been incorporated into the feed specification tables. Tables of existing waste radionuclide data that cover a wide range of radionuclides for Feed Streams 5 through 9 are provided in Appendix E. These tables show the range, total, and average radionuclide inventory and may be helpful for specific evaluations requiring these data.

6.3 BOX WASTE

Currently, there is no way to analyze the existing container forecast data to sort out the waste that will require thermal treatment. However, a query of the forecast CH MLLW database was conducted to determine the volume of waste that is expected to be contained in boxes and to obtain some indication of the total amount of boxes that will need to be processed in WRAP Module 2A. These data suggest that the number of boxes has increased substantially over past estimates and as many as 35 to 40 boxes per year may require processing. Examination of existing data indicates that most of the box waste would be expected to be in the form of HEPA filters, sludge, concrete, soil, metal, and lead. Evaluation of the new 1993 forecast data is expected to be undertaken early in FY 1994 to determine the yearly number of boxes to be processed and which feed streams will be impacted.

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7.0 PLANNED SWITS DATA UPGRADES

Efforts are in progress to develop software for computer interrogation of the SWITS data for MLLW. This software is expected to be helpful for grouping drums by waste code and evaluating the composition and radionuclide ranges of constituents. The software capability is expected to be available in FY 1994 for updating the feed specification data.

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9.0 GLOSSARY

ABBREVIATIONS AND ACRONYMS

CDR	conceptual design report
CH	contact handled
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
HEPA	high-efficiency particulate air
LETF	Liquid Effluent Treatment Facility
MLLW	mixed low-level waste
PCD	physical content descriptor
RCRA	Resource Conservation and Recovery Act
RO	reverse osmosis
SDAR	Storage Disposal Approval Record
SWITS	solid waste information and tracking system
TEDF	Treated Effluent Disposal Facility
TTF	thermal treatment facility
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company
WRAP	Waste Receiving and Processing

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APPENDIX A

METHODOLOGY FOR OBTAINING VOLUMES OF FEED STREAMS 5A1-A3, 5C1-C3, 9A, 9B, AND 9C

CONTENTS

MERCURY WASTE TO BE PROCESSED AT WRAP 2A A-3

LEAD WASTE TO BE PROCESSED AT WRAP 2A A-5

HETEROGENEOUS SOLID WASTE TO BE PROCESSED AT WRAP 2A A-7

Mercury Waste to be Processed at WRAP 2A

Existing Data

<u>Elemental Mercury</u>

SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Mercury*	*Hazardous Constituent Wt. %*	*Drum Density (lb/ft3)*
1.7	61	8	829	58	7%	30

Mercury M3	*% by Volume*
0.00428	0.20

Assumptions

1) Polyethylene, glass or metal containers that sole hazardous constituent is mercury in a form of liquid surrounded by absorbent or as one of several possible absorbents saturated or nearly saturated with liquid.
2) Seven % by weight of this lot is elemental mercury. The remaining 93% is containers and absorbents.

<u>Mercury Chemicals/Solutions</u>

SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Mercury*	*Hazardous Constituent Wt. %*	*Drum Density (lb/ft3)*
4.4	156	21	4689	5	<1%	66

Assumptions

1) Polyethylene, glass or metal containers containing hazardous constituent of mercury in various chemicals, in a form of dry solids, liquid surrounded by absorbent or as one of several possible absorbents saturated or nearly saturated with liquid.
2) The mercury makes up <1% by weight of the lot. The remaining 99% is containers, absorbents, and chemicals.

<u>Mercury Contaminated Waste</u>

SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Mercury*	*Hazardous Constituent Wt. %*	*Drum Density (lb/ft3)*
7.4	261	36	4275	34	<1%	36

Mercury Contaminated Waste Cont.

Assumptions

1) Hazardous constituents include mercury in the form of any combination of cloth, diatomaceous earth, metal, paper, polyethylene, wood, absorbent glass, rubber, conwed[1] pads, stainless steele, floor tile, rock or batteries.
2) The mercury makes up <1% by weight of the lot. The other 99% is contaminated debris as defined above.

1 Conwed is a trademark of Leucadia, Inc.

Calculations

Existing Data

Percent of Mercury coded waste to total volume of non-183H existing waste.
13.55 /205*100 6.61%

Percent by volume of elemental mercury to total mercury volume.
1.74/13.55*100 = 12.84%

Percent by volume of chemical/sol'n mercury to total mercury volume.
4.42/13.55*100 = 32.62%

Percent by volume of mercury contaminated waste to total mercury volume.
7.39/13.55*100 = 54.54%

Forecast data

CH_LLMW_I (page 5b of forecast printout)	21.8
CH_LLMW_III (page 10b of forecast printout)	0.4
Total Forecast mercury (m3)	22.2

	Total ft3	Total m3	Mercury Total m3 [2]
WRAP 1	27400 [3]	776.0	51.3

2 Based on calculation of volume of Hg to volume of non-183H existing waste. (6.61%)

3 Volume based on solid waste projection modeling results.

Summary-Existing plus Forecast plus WRAP 1 Volumes

Mercury	Existing	Forecast	WRAP 1 [4]	Total m3	Total ft3	Total DE
Elemental	1.7	2.9	6.6	11.2	395	54
Chem/Sol	4.4	7.2	16.7	28.4	1003	137
Hg Cont.	7.4	12.1	28.0	47.5	1677	228
Totals	13.6	22.2	51.3	87.1	3074	419

4 Mercury breakdown using the above percentages (12.84,32.52,54.54) of each category.

Lead Waste to be Processed at WRAP 2A

Existing Data

Elemental Lead SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Lead*	*Hazardous Constituent Wt. %*	*Drum Density (lb/ft3)*
109.9	3880	528	148616	124813	84%	97

Lead M3	*% bt Volume*	*Box Density (lb/ft3)*
13.1	12%	74

Assumptions

1)Hazardous constituents include lead in the form of elemental lead or metal representitive of the lead.
2)Eighty-three % by weight of this lot is elemental lead. The remaining 17% is in the form of any combination of absorbent, polyethylene, paper, metal, asbestos, rubber or cloth.

Lead Chemicals/Solutions SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Lead*	*Hazardous Constituent Wt. %*	*Drum Density (lb/ft3)*
0.2	7	1	61	0	<1%	13

Assumptions

1)Polyethylene, glass, or metal containers that hazardous constituent is lead i.e. PbO_2 in solution with various others, in a form of liquid surrounded by absorbent or as one of several possible absorbents saturated or nearly saturated with liquid.
2)The lead makes up <1% by weight of the lot. The remaining 99% is containers, absorbents, and chemicals.

Lead Contaminated Waste SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Lead*	*Hazardous Constituent Wt. %*	*Drum Density (lb/ft3)*
17.3	511	83	16620	9842	59%	35

Lead Contaminated Waste Cont.

Assumptions

1)Hazardous contituents include lead in the form of any combination of cloth, diatomaceous earth, metal, filters, wire, stainless steel, paper, polyethylene, wood, absorbent, glass, rubber, or conwed pads.
2)The lead makes up 59% by weight of this lot. The remaining 41% is to be considered debris as defined above.

Calculations

Existing Data

Percent by volume of Lead coded waste to total volume of non-183H existing waste.
127.4 /205*100 62.15% This high percentage due to site clean-up.

Percent by volume of elemental lead to total lead volume.
109.89/127.4*100 = 86.25%

Percent by volume of chemical/sol'n lead to total lead volume.
.21/127.4*100 = 0.16%

Percent by volume of lead contaminated waste to total lead volume.
17.3/127.4*100 = 13.59%

Forecast data

CH_LLMW_I (page 5b of forecast printout)	329.4
CH_LLMW_III (page 10b of forecaste printout)	155.4
Total Forecast lead(m3)	484.8

	Total ft3	Total m3	Lead Total m3 [1]
WRAP 1	27400 [2]	776.0	232.3

1 Based on evaluation of the contents of WRAP 1 waste a decision was made to reduce the amount of lead expected from WRAP 1 to 30%.

2 Volume based on solid waste projection modeling results.

Summary- Existing plus Forecast plus WRAP 1 Volumes

Lead	Existing	Forecast	WRAP I [3]	Total M3	Total ft3	Total DE	Total BE
Elemental	109.9	418.1	201.0	729.0	25741	3159	18
Chem/Sol	0.2	0.8	0.4	1.4	48	6	0
Pb Cont.	17.3	65.9	31.7	114.9	4055	552	0
Totals	127.4	484.8	233.0	845.2	29844	3718	18

3 Lead breakdown using the above percentages (86.25,0.16,13.59)of each category.

Heterogeneous Solid Waste to be Processed at WRAP 2A

Existing Data

Contained Liquid SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Constituent*	*Hazardous Constituent wt. %*	*Drum Density (lb/ft3)*
9.3	328	45	5465	496	9%	37

Min. Gross Wt. Kg.	*Max. Gross Wt. Kg.*
7	441

Assumptions

1) Polyethylene, glass or metal containers that have various hazardous constituents, excluding lead and mercury, in a form of liquid surrounded by absorbent or as one of several possible absorbents saturated or nearly saturated with liquid.
2) Nine % by weight of this lot is hazardous constituents. The remaining 91% is containers and absorbents.
3) Thirty of the containers have "Y" in the lab pack flag designator (meaning they are definitely lab packs) whereas the others were selected for this category based on waste characteristics information.

Particulates SWITS Database

Volume M3	*Volume Ft3*	*Drum Equiv.*	*Kg Gross Weight*	*Kg of Constituent*	*Hazardous Constituent wt. %*	*Drum Density (lb/ft3)*
27.7	979	133	30093	13970	46%	68

Min. Gross Wt. Kg.	*Max. Gross Wt. Kg.*
12	345

Assumptions

1) Containers that have various hazardous constituents, excluding lead and mercury, in the form of liquid with absorbent (no mention of polyethylene), absorbent only, sludges (with or without absorbent),resins,chemicals,soils,clay or asbestos material.
2) Forty-Six % by weight of this lot is hazardous constituents. The remaining 54% is absorbents, clay and polyethylene, metal or glass containers.
3) None of the containers have "Y" in the lab pack flag designator.

Solid/Debris Waste

SWITS Database

Volume M3	Volume Ft3	Drum Equiv.	Kg Gross Weight	Kg of Constituent	Hazardous Constituent wt. %	Density (lb/ft3)
26.5	935	127	12974	884	7%	31

Min. Gross Wt. Kg.	Max. Gross Wt. Kg.
5	372

Assumptions

1) Containers that have various hazardous constituents, excluding lead and mercury, in the form of any combination of cloth, diatomaceous earth, metal, paper, polyethylene, wood, absorbent, glass, rubber, conwed pads, stainless steel, or filters including HEPA filters.
2) Seven % by weight of this lot is hazardous constituents. The remaining 93% is debris type waste as defined above.
3) Containers that have the "F" codes have <0.5% of that constituent on them and therefore are considered to be incidental contact containers.
4) Three of the containers have "Y" in the lab pack flag designator and appear to have contaminated equipment in them.

Calculations

Existing Data

Percent by volume of Heterogeneous waste to total volume of non-183H existing waste.
63.53 /205*100 = 30.99%

Percent by volume of Contained Liquid to total Heterogeneous volume.
9.30/63.53*100 = 14.64%

Percent by volume of Particulate to total Heterogeneous volume.
27.74/63.53*100 = 43.66%

Percent by volume of Solid/Debris to total Heterogeneous volume.
26.49/63.53*100 = 41.70%

Forecast Data

Volumes of LETF waste in from forecast data (see Appendix B)

L045 (LLMW_I)	Designated Stream	Volume m3
sludge/ab liquid	Particulates	4058.0
spent resins	Particulates	238.0
Sub-Total		*4296.0*
compactable solid	Debris	1029.0
comp/comb solid	Debris	1106.1
Sub-Total		*2135.1*

C018H (LLMW_I)	Designated Stream	Volume
compactable solid	Debris	669.7
comp/comb solid	Debris	937.6
HEPA filters	Debris	200.9
Sub-Total		*1808.2*
particulate	Particulates	14767.6
spent resin	Particulates	167.4
Sub-Total		*14935.0*

C018H Debris

New 1993 forecast information.

HEPA	Debris	0.3
RO Filters	Debris	87.0
Particulate Filters	Debris	28.0
Charcoal Filters	Debris	2.8
Rags	Debris	112.0
Sub-Total		*230.1*

Grout Project

(see Appendix B)	LLMW_I	LLMW_III	Volume m3	Designated Stream
particulate	0.0	1327.5	1327.5	Particulate
Sludge/AB Liquid	0.0	239.1	239.1	Particulate
Sub-Total	*0.0*	*1566.6*	*1566.6*	
HEPA filters	0.0	58.6	58.6	Debris
Compactble Solid	0.0	2648.5	2648.5	Debris
Comp/comb solid	0.0	650.7	650.7	Debris
Stainless metal	0.0	286.3	286.3	Debris
other metal <.5	0.0	286.3	286.3	Debris
other metal >.5	0.0	865.5	865.5	Debris
other	0.0	65.1	65.1	Debris
Sub-Total	*0.0*	*4861.0*	*4861.0*	

Summary of Forecast data for other feedstreams (see Appendix B)

	LLMW I	LLMW III	Volume m3	Designated Stream
HEPA filters	1581.8	132.1	1713.9	Debris
Compactable solid	3107.9	2662.1	5770.0	Debris
comp/comb solid	3541.1	820.7	4361.8	Debris
wood	21.6	0.8	22.4	Debris
stainless metal	107.4	286.7	394.1	Debris
other metal <.5	280.0	413.1	693.1	Debris
other metal >.5	109.6	865.8	975.4	Debris
Glass	1378.8	7.6	1386.4	Debris
Concrete	738.1	4.3	742.4	Debris
Biological	33.8	0.0	33.8	Debris
Other	82.7	65.1	147.8	Debris
Sub-Total	*10982.8*	*5258.3*	*16241.1*	
Sludge/AB Liquid	4398.6	241.4	4640.0	Particulate
Particulate	15041.3	1329.0	16370.3	Particulate
Soil	1686.0	2.9	1688.9	Particulate
Spent Resin	425.0	0.4	425.4	Particulate
Sub-Total	*21550.9*	*1573.7*	*23124.6*	
Cont Liquid	60.0	0.0	60.0	Contained Liquid
Labpacks	281.8	2.2	284.0	Contained Liquid
Sub-Total	*341.8*	*2.2*	*344.0*	

Both L045 and C018H are accounted for in other streams in the Feed Specification Document. In order to obtain an accurate Forecast amount,the volumes for L045 and C018H where subtracted from the total volumes for debris and particulate feed streams. The new C018H Debris volume of 230.1 m3 was added back in for a new Adjusted volume. Also, the adjusted volume may be considered with/without the Grout Project volume.

	Total	L045	C018H	C018H Debri	Adjusted [1]	Grout	Adj-Grout [2]
Debris	16241.1	-2135.1	-1808.2	230.1	12527.9	4861.0	7666.9
Particulate	23124.6	-4296.0	-14935.0	0.0	3893.6	1566.6	2327.0
Cont.Liquid	344.0	0.0	0.0	0.0	344.0	0.0	344.0
Total					16765.5		10337.9

1 less L045 and C018H forecast(C018H Debris added back in).

2Assumes Grout facility does not operate as currently planned.

	Total ft3 [4]	Total m3	Heter. Total m3 [3]
WRAP 1	27400	776.0	492.0

3 Based on % of Lead (30%) plus % of Hg (6.6%) leaving 63.4%.

4 Volume based on silid waste projection modeling results.

Summary-Existing plus Forecast plus WRAP 1 Volumes

Heterogeneous	Existing	Forecast [5]	WRAP 1 [6]	Total M3	Total ft3	Total DE
C. Liquid	9.3	344.0	72.0	425.3	15019	2045
Particulate	27.7	3893.6	214.8	4136.1	146047	19885
Solid/Debri	26.5	12527.9	205.2	12759.6	450541	61344
Total	63.5	16765.5	492.0	17321.1	611608	83274

5 Forecast amount with Grout.

6 Heterogeneous breakdown for WRAP 1 uses the existing stream percentages (14.64,43.66,41.70).

A.2 GLOSSARY

ABBREVIATIONS AND ACRONYMS

CH	contact handled
DE	drum equivalent
HEPA	high-efficiency particulate air
MLLW	mixed low-level waste
RO	reverse osmosis
SWITS	solid waste information and tracking system
WRAP	Waste Receiving and Processing

APPENDIX B

FISCAL YEAR 1992 FORECAST VOLUME SUMMARY

CONTENTS

Fiscal Year 1992 Forecast Volume Summary - Yearly and Total Forecast Volumes of Nonthermally Treatable Contact-Handled Mixed Low-Level Waste, Class 1 and Class 3, by Physical Content Descriptor B-3

Fiscal Year 1992 Mixed Low-Level Waste Forecast Volume Summary - Nonthermally Treatable Volumes by Waste Class and Waste Generator B-23

7/30/93

FY 1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HEPA FILTERS	TC METAL		.0	.3	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	SPENT SOLVENT		0	.0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER	57.4	185.1	46.9	38.9	44.5	44.2	38.1	38.4	38.2	38.3	50.9	38.2	38.5	38.9	43.1	55.5
Total HEPA FILTERS		57.4	185.1	47.2	42.5	48.1	47.8	41.7	42.0	41.8	41.9	54.4	41.8	42.1	42.5	46.7	59.1
SLUDGE/AB LIQ	OXIDIZER		1	1	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ACIDS		9	.9	.9	.9	.9	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
	ALKALINES		1.3	1.3	1.3	1.3	1.3	1.1	1.1	.9	.9	.9	.9	.9	.9	.9	.9
	TC METAL	2.8	26.5	8.5	74.7	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.7
	P & U LISTED		0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER	2.4	8.7	14.8	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.2	78.2
Total SLUDGE/AB LIQ		5.2	37.5	25.5	155.0	155.0	155.0	154.7	154.7	154.5	154.5	154.5	154.5	154.5	154.5	154.5	154.5
LABPACKS	OXIDIZER	.6	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
	ACIDS	.6	3.2	2.5	2.1	2.6	2.6	2.6	2.4	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.8
	ALKALINES	.6	2.0	1.3	1.0	1.3	1.3	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	WATER REACTIVE	.6	2	2	.3	.3	.3	3	.3	.3	.3	.3	.3	.3	.3	.3	.3
	CYANIDE	.6	2	.2	3	.4	4	.4	.3	.3	.3	.3	.4	.4	.4	.4	.4
	TC METAL	6	5	5	.4	.4	4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
	P & U LISTED	.6	2	1.0	1.9	4.2	4.2	4.2	3.4	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7
	PCB < 50 PPM		2	.2	2	.2	2	.2	.2	.2	.2	.2	.3	.3	3	.3	.3
	OTHER	.6	5	1.0	1.3	2.7	2.6	2.6	2.2	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Total LABPACKS		5.1	7.3	7.3	7.8	12.3	12.3	12.3	10.7	8.8	8.8	8.8	8.9	8.9	8.9	8.9	8.9
COMPACTBLE SOL	FLAMMABLE		.1	1	1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	OXIDIZER		.0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	COMBUSTIBLE		.0	0	0	.0	.0	.0	.0	.0	.0	.6	.0	.0	.0	.0	.6
	ACIDS		4	4	4	.4	4	.0	.0	.0	.0	.0	.0	.0	0	0	.0
	ALKALINES		.6	6	6	.6	.6	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1

NOTE Excludes WHC_SSTRET, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group.

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FY-1992 FORECAST VOLUME SUMMARY
NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
HEPA FILTERS	TC METAL	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	100.8	6.4
	SPENT SOLVENT	.0	0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.0
	OTHER	39.2	38.9	39.1	39.5	51.5	39.3	40.0	39.9	44.5	57.2	40.4	40.6	41.2	41.1	53.6	1480.8	93.6
Total HEPA FILTERS		42.8	42.5	42.7	43.1	55.1	42.9	43.6	43.4	48.1	60.8	44.0	44.2	44.8	44.7	57.2	1581.8	100.0
SLUDGE/AB LIQ	OXIDIZER	0	0	.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0
	ACIDS	.7	.7	.7	.7	.7	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	23.1	.5
	ALKALINES	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	29.9	.7
	TC METAL	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.8	74.8	74.8	74.8	74.8	2128.8	48.4
	P & U LISTED	.0	0	.0	.0	.0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.8	.0
	OTHER	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.3	78.3	78.3	78.3	78.3	2214.9	50.4
Total SLUDGE/AB LIQ		154.6	154.6	154.6	154.6	154.6	154.6	154.6	154.7	154.7	154.7	154.7	154.7	154.8	154.8	154.8	4398.6	100.0
LABPACKS	OXIDIZER	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4	9.8	3.5
	ACIDS	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	60.3	21.4
	ALKALINES	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	34.2	12.1
	WATER REACTIVE	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4	9.7	3.4
	CYANIDE	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	11.5	4.1
	TC METAL	.4	.4	.4	.4	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	13.3	4.7
	P & U LISTED	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	81.9	29.1
	PCB < 50 PPM	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7.8	2.8
	OTHER	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	53.3	18.9
Total LABPACKS		8.9	8.9	8.9	8.9	8.9	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.2	281.8	100.0
COMPACTIBLE SOL	FLAMMABLE	1	1	1	1	1	1	1	.1	.1	.1	.1	1	1	.1	.1	2.4	.1
	OXIDIZER	.0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.0
	COMBUSTIBLE	.0	0	0	0	6	0	0	.0	.0	.6	.0	.0	0	.0	.6	3.2	.1
	ACIDS	0	0	0	0	0	0	0	0	.0	0	.0	.0	0	0	.0	2.2	.1
	ALKALINES	1	1	1	1	1	1	1	.1	.1	.1	.1	.1	1	1	.1	4.8	2

NOTE. Excludes WHC_SSTREI, WHC_1171FSP and all members of D&D/Surplus fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total WOOD		0.0	1.1	1.1	1.1	1.0	1.0	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
STAINLSS METAL	OXIDIZER		0	0	0	.0	.0										
	ACIDS		.3	.3	.3	.3	.3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	ALKALINES		.2	.2	.2	.2	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	WATER REACTIVE		6.4														
	TC METAL		.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER		4.4	4.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Total STAINLSS METAL		0.0	11.3	5.0	3.6	3.6	3.6	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
OTH METAL <.5	OXIDIZER		.1	1	1	.1	.1										
	ACIDS		.4	.4	.4	.4	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES		.4	.4	.4	.4	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	TC METAL	1.1	.5	1	1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	TC ORGANIC		.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.9	.0	.0	.0
	OTHER		12.9	13.0	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.8	8.8	8.8	8.8	8.8	8.8
Total OTH METAL <.5		1.1	14.4	14.0	9.8	9.7	9.7	8.8	8.8	8.8	8.8	8.8	8.9	8.9	8.9	8.9	8.9
OTH METAL >= 5	TC METAL		0	0	0	0	.0	0	0	.0	.0	.0	.0	.0	.0	.0	.0
	TC ORGANIC		0	0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	PCB >= 500 PPM	6.2	2.8	6	7	1	1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	OTHER		4.4	4.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Total OTH METAL >=.5		6.2	7.3	5.0	3.8	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
GLASS	TC METAL		28.4	22.7	24.9	34.0	37.4	24.9	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
	SPENT SOLVENT		28.3	22.7	24.9	34.0	37.4	24.9	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
	OTHER		3.7	4.2	4.9	4.9	4.9	4.9	4.9	4.9	4.9	5.4	5.4	5.4	5.4	5.4	

NOTE: Excludes WHC_SSTRET, WHC_1171FSP and all members of D&D/Surplus fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
Total WOOD		6	6	6	6	6	7	.7	.7	.7	.7	.7	.7	.7	.7	.7	21.6	100.0
STAINLSS METAL	OXIDIZER																.2	.2
	ACIDS	.1	1	1	1	.1	1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2.6	2.4
	ALKALINES	.1	1	1	1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2 4	2.2
	WATER REACTIVE																6.4	5.9
	TC METAL	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.1
	OTHER	3 1	3 1	3 1	3 1	3 1	3 1	3 1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	95.7	89.1
Total STAINLSS METAL		3 2	3 2	3 2	3 2	3 2	3 2	3 2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	107 4	100 0
OTH METAL < 5	OXIDIZER																.4	.2
	ACIDS	0	0	0	.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	2 9	1.0
	ALKALINES	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.4	.9
	TC METAL	0	0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.6	.9
	TC ORGANIC	.0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.1
	OTHER	8 8	8 8	8 8	8.8	8 8	8 8	8.8	8 8	8.8	8.8	8.8	8 8	8.8	8.8	8.8	271 4	96.9
Total OTH METAL < 5		8 9	8 9	8 9	8 9	8 9	8 9	8 9	8 9	8.9	8.9	8.9	8.9	8 9	8.9	8.9	280.0	100.0
OTH METAL >= 5	TC METAL	.0	0	0	0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.3	.2
	TC ORGANIC	0	0	0	0	.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.1	.1
	PCB >= 500 PPM	1	1	1	1	.1	1	1	1	.1	.1	.1	.1	.1	.1	.1	13 6	12.4
	OTHER	3 1	3 1	3 1	3 1	3 1	3 1	3 1	3 1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	95.7	87.3
Total OTH METAL >=.5		3 2	3 2	3 2	3 2	3 2	3 3	3 3	3 3	3.3	3.3	3.3	3 3	3.3	3.3	3.3	109 6	100.0
GLASS	TC METAL	27 2	13 6	13 6	13 6	13 6	13 6	13 6	11 3	11 3	11.3	11 3	11 3	9.1	9.1	9.1	609 9	44 2
	SPENT SOLVENT	27 2	13 6	13 6	13 6	13 6	13 6	13 6	11 3	11.3	11.3	11.3	11 3	9.1	9 1	9.1	609.6	44.2
	OTHER	5 4	5 4	5 4	5 4	5 4	5 9	5 9	5 9	5.9	5.9	5 9	5 9	5.9	5 9	5.9	159 3	11.6

NOTE. Excludes WHC_SSTRET, WHC_1171ESP and all members of D&D/Surplus fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
COMPACTBLE SOL	TC METAL		18.4	17.5	46.5	51.9	53.9	46.5	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8
	TC ORGANIC		11.4	9.1	10.0	13.7	15.0	10.0	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
	SPENT SOLVENT		11.4	9.2	10.1	13.7	15.1	10.1	11.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	PCB >=50,< 500									2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	OTHER		15.6	18.8	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.7	44.2	44.2	44.2	44.2	44.2
Total COMPACTBLE SOL		0.0	58.0	55.6	111.2	123.8	128.6	110.3	113.5	116.9	116.9	117.5	117.4	117.4	117.4	117.4	118.1
COMP/COMB SOL	FLAMMABLE		1	1	1	.1	1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	OXIDIZER		0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	COMBUSTIBLE		5.1	5.1	3.4	3.4	3.4	3.4	3.4	3.4	3.4	4.1	3.4	3.4	3.4	3.4	4.1
	ACIDS		4	4	.4	.4	4	.0	.0	.0	.0	.0	.0	.0	.0	0	.0
	ALKALINES		6	.6	.6	.6	.6	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	TC METAL	.3	18.5	18.0	52.7	58.0	60.1	52.6	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
	TC ORGANIC		11.4	9.1	10.0	13.7	15.0	10.0	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
	SPENT SOLVENT	.2	11.5	9.2	10.1	13.7	15.1	10.1	11.0	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
	PCB >=50,< 500									4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	PCB >= 500 PPM	.3	.2	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER		9.6	13.3	45.8	45.8	45.8	45.8	45.8	45.8	45.8	45.8	46.3	46.3	46.3	46.3	46.3
Total COMP/COMB SOL		.8	57.5	55.9	123.0	135.6	140.4	122.0	125.2	133.1	133.1	133.8	133.7	133.7	133.7	133.7	134.4
WOOD	FLAMMABLE		.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OXIDIZER		.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	COMBUSTIBLE		.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ACIDS		.2	2	.2	.2	2	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES		.2	2	.2	.2	2										
	TC METAL		.1	1	1	.1	1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	TC ORGANIC		0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	SPENT SOLVENT		.1	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER		4	4	5	.5	5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5

NOTE. Excludes WHC_SSTRLT, WHC_1171FSP and all members of D&D/Surplus fac waste generator group.

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FY 1992 FORECAST VOLUME SUMMARY
NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	NCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
COMPACTIBLE SOL	TC METAL	47.8	39.6	39.6	39.6	39.6	39.6	39.6	38.3	38.3	38.3	38.3	38.3	36.9	36.9	36.9	1252.8	40.3
	TC ORGANIC	10.9	5.5	5.5	5.5	5.5	5.5	5.5	4.6	4.6	4.6	4.6	4.6	3.7	3.7	3.7	245.1	7.9
	SPENT SOLVENT	12.0	6.5	6.5	6.5	6.5	6.5	6.5	5.6	5.6	5.6	5.6	5.6	4.7	4.7	4.7	269.4	8.7
	PCB >=50,< 500	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	54.6	1.8
	OTHER	44.2	44.2	44.2	44.2	44.2	44.8	44.8	44.8	44.8	44.9	44.8	44.8	44.8	44.8	44.9	1273.1	41.0
Total COMPACTIBLE SOL		117.4	98.3	98.3	98.3	99.0	99.0	99.0	95.8	95.8	96.5	95.8	95.8	92.6	92.6	93.3	3107.9	100.0
COMP/COMB SOL	FLAMMABLE	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2.4	.1
	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.0
	COMBUSTIBLE	3.4	3.4	3.4	3.4	4.1	3.4	3.4	3.4	3.4	4.1	3.4	3.4	3.4	3.4	4.1	109.0	3.1
	ACIDS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.2	.1
	ALKALINES	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	4.8	.1
	TC METAL	54.0	45.8	45.8	45.8	45.8	45.8	45.8	44.4	44.4	44.4	44.4	44.4	43.1	43.1	43.1	1425.9	40.3
	TC ORGANIC	10.9	5.5	5.5	5.5	5.5	5.5	5.5	4.6	4.6	4.6	4.6	4.6	3.7	3.7	3.7	245.1	6.9
	SPENT SOLVENT	14.1	8.7	8.7	8.7	8.7	8.7	8.7	7.8	7.8	7.8	7.8	7.8	6.8	6.8	6.8	319.3	9.0
	PCB >=50,< 500	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	109.2	3.1
	PCB >= 500 PPM	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.7	.0
	OTHER	46.3	46.3	46.3	46.3	46.3	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	1322.3	37.3
Total COMP/COMB SOL		133.7	114.6	114.6	114.6	115.3	115.2	115.2	112.1	112.1	112.7	112.1	112.1	108.9	108.9	109.6	3541.1	100.0
WOOD	FLAMMABLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.4
	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.4
	COMBUSTIBLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.4
	ACIDS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.3	6.1
	ALKALINES																1.1	4.9
	TC METAL	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	1.8	8.4
	TC ORGANIC	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.8
	SPENT SOLVENT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.1	5.0
	OTHER	.5	.5	.5	.5	.5	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	15.9	73.6

NOTE: Excludes WHC SSTRET, WHC 1171FSP and all members of DOD/Surplus fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total GLASS		0.0	60.4	49.6	54.7	72.9	79.7	54.7	59.3	59.3	59.3	59.3	59.8	59.8	59.8	59.8	59.8
CONCRETE	FLAMMABLE		0	0	0	.0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0
	OXIDIZER		0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	COMBUSTIBLE		0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ACIDS		4	4	.4	.4	4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES		4	4	4	4	4										
	TC METAL		11.4	9.2	10.1	13.7	15.1	10.0	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
	TC ORGANIC		0	0	0	0	0	.0	.0	.0	.0	0	.0	.0	0	.0	.0
	SPENT SOLVENT		22.7	18.2	20.0	27.2	30.0	20.0	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
	OTHER			7	.1												
Total CONCRETE		0.0	34.9	28.8	31.0	41.7	45.8	30.0	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7
PARTICULATE	FLAMMABLE		2	3	4	.5	.5	.5	.5	.4	.4	.4	.4	.4	.4	4	.4
	COMBUSTIBLE		2	3	4	.5	.5	.5	.5	.4	.4	.4	.4	.4	.4	.4	.4
	ACIDS		4	4	4	4	.4										
	ALKALINES		4	4	4	4	4										
	TC METAL		1	22.0	263.0	263.0	263.0	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9
	SPENT SOLVENT			1	2	6	6	6	.5	.3	.3	.3	.3	.3	.3	3	.3
	OTHER		7.6	31.4	270.4	270.1	270.1	270.1	270.1	270.1	270.1	270.1	270.6	270.6	270.6	270.6	270.6
Total PARTICULATE		0.0	8.8	54.8	535.1	535.5	535.5	534.7	534.5	534.2	534.2	534.2	534.7	534.7	534.7	534.7	534.7
SOIL	FLAMMABLE		0	0	0	.0	.0	0	.0	.0	.0	0	.0	0	0	.0	.0
	OXIDIZER		0	0	0	0	0	0	.0	.0	.0	0	.0	0	.0	.0	.0
	COMBUSTIBLE		0	0	0	0	0	0	.0	.0	.0	0	.0	0	.0	.0	0
	ACIDS		4	4	4	.4	4	.0	.0	.0	.0	0	.0	.0	.0	.0	.0
	ALKALINES		4	4	4	4	4										
	TC METAL		113.4	1.2	9	9	9	8	.8	.8	.8	8	8	8	8	8	.8
	TC ORGANIC		2	2	3	.2	2	2	.2	.2	.2	.2	.3	.3	.3	.3	.3

NOTE: Excludes WHC_SSTRET, WHC_1171FSP and all members of D&D/Surplus fac waste generator group.

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FY 1992 FORECAST VOLUME SUMMARY

NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_1

(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
Total GLASS		59.8	32.5	32.5	32.5	32.5	33.1	33.1	28.6	28.6	28.6	28.6	28.6	24.0	24.0	24.0	1378.8	100.0
CONCRETE	FLAMMABLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	COMBUSTIBLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ACIDS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.9	.3
	ALKALINES																1.9	.3
	TC METAL	10.9	5.4	5.4	5.4	5.4	5.4	5.4	4.5	4.5	4.5	4.5	4.5	3.6	3.6	3.6	244.6	33.1
	TC ORGANIC	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	SPENT SOLVENT	21.8	10.9	10.9	10.9	10.9	10.9	10.9	9.1	9.1	9.1	9.1	9.1	7.3	7.3	7.3	488.8	66.2
	OTHER																.8	.1
Total CONCRETE		32.7	16.3	16.3	16.3	16.3	16.3	16.3	13.6	13.6	13.6	13.6	13.6	10.9	10.9	10.9	738.1	100.0
PARTICULATE	FLAMMABLE	.4	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	13.1	.1
	COMBUSTIBLE	.4	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	13.1	.1
	ACIDS																1.9	.0
	ALKALINES																1.9	.0
	TC METAL	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	262.9	7384.2	49.1
	SPENT SOLVENT	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	10.3	.1
	OTHER	270.6	270.6	270.6	270.6	270.6	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1	7616.7	50.6
Total PARTICULATE		534.7	534.7	534.7	534.7	534.7	535.3	535.3	535.3	535.3	535.3	535.3	535.3	535.3	535.3	535.3	15041.3	100.0
SOIL	FLAMMABLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
	COMBUSTIBLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
	ACIDS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.2	.1
	ALKALINES																1.9	.1
	TC METAL	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	136.8	8.1
	TC ORGANIC	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	8.1	.5

NOTE: Excludes WHC SSIRET, WHC_1171FSP and all members of DOD/Surplus Fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SOIL	SPENT SOLVENT	.1	70.7	56.6	62.2	84.8	93.3	62.2	67.9	67.9	67.9	67.9	67.9	67.9	67.9	67.9	67.9
	OTHER		.8	.8	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Total SOIL		.1	186.0	59.6	63.7	87.2	95.7	63.8	69.4	69.4	69.4	69.4	69.5	69.5	69.4	69.4	69.4
LEAD	TC METAL	30.7	20.5	13.7	10.9	9.6	9.9	8.8	8.8	8.7	8.8	8.8	8.9	9.5	9.0	9.0	9.0
Total LEAD		30.7	20.5	13.7	10.9	9.6	9.9	8.8	8.8	8.7	8.8	8.8	8.9	9.5	9.0	9.0	9.0
MERCURY	TC METAL	1.0	1.7	.7	.6	.7	.7	.7	.6	.6	.6	.6	.6	.6	.6	.6	.6
Total MERCURY		1.0	1.7	.7	.6	.7	.7	.7	.6	.6	.6	.6	.6	.6	.6	.6	.6
BIOLOGICAL	P & U LISTED		1.7	1.7	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	OTHER		.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Total BIOLOGICAL		0.0	1.8	1.8	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
SPENT RESINS	FLAMMABLE		.2	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	COMBUSTIBLE		.5	.3	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	TC METAL		.1	.7	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
	SPENT SOLVENT		.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	OTHER		.4	1.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Total SPENT RESINS		0.0	1.1	2.2	15.2	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.1	15.1	15.1	15.1	15.1
CONT LIQ	ACIDS		10.2	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
	TC METAL		10.2	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
Total CONT LIQ		0.0	20.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
OTHER	ALKALINES		3.2														

NOTE: Excludes WHC SSTRET, WHC 1171FSP and all members of D&D/Surplus fac waste generator group.

FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
SOIL	SPENT SOLVENT	67.9	33.9	33.9	33.9	33.9	33.9	31.9	28.3	28.3	28.3	28.3	28.3	22.6	22.6	22.6	1521.3	90.2
	OTHER	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.4	.4	15.4	.9
Total SOIL		69.4	35.5	35.5	35.5	35.5	35.5	35.5	29.8	29.8	29.8	29.8	29.8	24.2	24.2	24.2	1686.0	100.0
LEAD	TC METAL	9.1	9.1	9.2	9.9	9.3	9.4	9.5	9.5	9.6	9.7	10.4	9.9	9.9	10.0	10.4	329.4	100.0
Total LEAD		9.1	9.1	9.2	9.9	9.3	9.4	9.5	9.5	9.6	9.7	10.4	9.9	9.9	10.0	10.4	329.4	100.0
MERCURY	TC METAL	.6	.6	.6	.6	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	21.8	100.0
Total MERCURY		.6	.6	.6	.6	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	21.8	100.0
BIOLOGICAL	P & U LISTED	1.0	1.0	1.0	1.0	1.0	1.0	.9	.9	.9	.9	.9	.9	.9	.9	.9	30.8	91.1
	OTHER	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3.0	8.9
Total BIOLOGICAL		1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	33.8	100.0
SPENT RESINS	FLAMMABLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.4	.3
	COMBUSTIBLE	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	4.1	1.0
	TC METAL	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	205.3	48.3
	SPENT SOLVENT	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2.6	.6
	OTHER	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	211.6	49.8
Total SPENT RESINS		15.0	15.0	15.0	15.0	15.0	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	425.0	100.0
CONT LIQ	ACIDS	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	30.0	50.0
	TC METAL	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	30.0	50.0
Total CONT LIQ		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	60.0	100.0
OTHER	ALKALINES																3.2	3.8

NOTE: Excludes WHC_SSTRET, WHC_1171FSP and all numbers of D&D/Surplus Fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_I
(volumes in cubic meters)

PLD Abbrev	MCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
OTHER	WATER REACTIVE		3.2	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER		.0	6	1.1	3.2	5.9	2.9	2.2	1.6	1.6	1.6	1.6	7.3	1.8	2.0	2.0
Total OTHER		0.0	6.4	6	1.1	3.2	5.9	2.9	2.2	1.7	1.7	1.7	1.7	7.3	1.8	2.1	2.1
Total CH LLMW_I		107.5	721.4	4.9.7	1173.7	1260.7	1292.3	1169.9	1186.9	1195.0	1195.1	1209.1	1197.6	1204.3	1198.6	1203.1	1216.8

NOTE: Excludes WHC_SSTRET, WHC 1171FSP and all members of D&D/Surplus fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY

NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CM_LLMW_I

(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
OTHER	WATER REACTIVE	.0	.0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.1	4.9
	OTHER	1.6	1.6	1.6	7.3	1.8	1.6	1.6	1.6	2.0	2.0	7.3	1.8	1.6	1.6	4.4	75.4	91.2
Total OTHER		1.7	1.7	1.7	7.3	1.8	1.7	1.7	1.7	2.1	2.1	7.3	1.8	1.7	1.7	4.5	82.7	100.0
Total CM_LLMW_I		1198.8	1082.8	1083.1	1089.9	1097.2	1086.3	1087.0	1067.7	1072.9	1087.0	1074.9	1069.0	1050.4	1050.4	1067.4	33226.5	

NOTE. Excludes WHC_SSTRET, WHC_1171FSP and all members of D&D/Surplus fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_III
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HEPA FILTERS	ALKALINES		.1	.2	.4	.7	.6	.7	.7	.6	.6	.7	.7	.6	.7	.6	.6
	TC METAL		.1	.2	.4	.7	.6	.7	.7	.6	.6	.7	.7	.6	.7	.6	.6
	SPENT SOLVENT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER	.1	20.6	20.1	2.2	3.1	1.9	2.0	2.0	1.9	1.9	2.0	2.0	1.9	2.0	1.9	1.9
Total HEPA FILTERS		.1	20.7	20.5	3.0	4.4	3.0	3.3	3.3	3.0	3.0	3.3	3.3	3.0	3.3	3.0	3.0
SLUDGE/AB LIQ	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ACIDS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES	.0	.4	.7	1.4	2.4	2.1	2.4	2.4	2.1	2.1	2.4	2.4	2.1	2.4	2.1	2.1
	TC METAL	.0	.9	.9	1.7	3.0	2.6	3.0	3.0	2.6	2.6	3.0	3.0	2.6	3.0	2.6	2.6
	P & U LISTED	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER		.5	1.0	2.1	3.5	3.1	3.5	3.5	3.1	3.1	3.5	3.5	3.1	3.5	3.1	3.1
Total SLUDGE/AB LIQ		.0	1.8	2.7	5.3	8.9	7.9	8.9	8.9	7.9	7.9	8.9	8.9	7.9	8.9	7.9	7.9
LABPACKS	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	WATER REACTIVE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	CYANIDE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	TC METAL	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	P & U LISTED	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	PCB < 50 PPM	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total LABPACKS		.2	.0	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
COMPACIBLE SOL	FLAMMABLE		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES		4.2	8.7	17.3	29.4	26.0	29.4	29.4	26.0	26.0	29.4	29.4	26.0	29.4	26.0	26.0
	TC METAL		4.2	8.6	17.3	29.4	25.9	29.4	29.4	25.9	25.9	29.4	29.4	25.9	29.4	25.9	25.9
	OTHER	1.2	5.8	11.8	23.4	39.5	34.9	39.5	39.5	34.9	34.9	39.5	39.6	35.0	39.6	35.0	35.0
Total COMPACIBLE SOL		1.2	14.1	29.2	58.0	98.4	86.9	98.4	98.4	86.9	86.9	98.4	98.4	86.9	98.4	86.9	86.9

NOTE Excludes WHC_SSTREI, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group.

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FY-1992 FORECAST VOLUME SUMMARY

NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CM_LLMW_III

(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
HEPA FILTERS	ALKALINES	.7	.6	.6	.7	.6	.7	.7	.6	.3	.3	.6	.7	.8	.8	.9	17.6	13.3
	TC METAL	.7	.6	.6	.7	.6	.7	.7	.6	.3	.3	.6	.7	.8	.8	.9	17.6	13.3
	SPENT SOLVENT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER	2.1	1.9	1.9	2.0	1.9	2.1	2.1	1.9	1.5	1.5	1.9	2.0	2.1	2.2	2.3	97.0	73.4
Total HEPA FILTERS		3.5	3.0	3.0	3.3	3.0	3.5	3.5	3.0	2.1	2.1	3.2	3.4	3.7	3.9	4.2	132.1	100.0
SLUDGE/AB LIQ	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ACIDS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
	ALKALINES	2.7	2.1	2.1	2.4	2.1	2.7	2.7	2.1	1.2	1.2	2.3	2.6	2.8	3.1	3.4	65.3	27.1
	TC METAL	3.3	2.6	2.6	3.0	2.6	3.3	3.3	2.6	1.4	1.4	2.8	3.1	3.5	3.8	4.2	80.3	33.2
	P & U LISTED	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER	4.0	3.1	3.1	3.5	3.1	4.0	4.0	3.1	1.7	1.7	3.3	3.7	4.2	4.6	5.0	95.7	39.6
Total SLUDGE/AB LIQ		9.9	7.9	7.9	8.9	7.9	9.9	9.9	7.9	4.2	4.2	8.4	9.4	10.5	11.5	12.6	241.4	100.0
LABPACKS	OXIDIZER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	16.7
	WATER REACTIVE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	16.7
	CYANIDE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	16.7
	TC METAL	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	16.7
	P & U LISTED	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	16.7
	PCB < 50 PPM	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	16.7
Total LABPACKS		.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2.2	100.0
COMPACTIBLE SOL	FLAMMABLE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES	32.9	26.0	26.0	29.4	26.0	32.9	32.9	26.0	13.9	13.9	27.7	31.2	34.6	38.1	41.5	795.3	29.9
	TC METAL	32.9	25.9	25.9	29.4	25.9	32.9	32.9	25.9	13.8	13.8	27.7	31.1	34.6	38.0	41.5	794.5	29.8
	OTHER	44.2	35.0	35.0	39.6	35.0	44.2	44.2	35.0	18.8	18.8	37.3	41.9	46.5	51.1	55.7	1071.5	40.2
Total COMPACTIBLE SOL		109.9	86.9	86.9	98.4	86.9	110.0	110.0	86.9	46.6	46.6	92.7	104.2	115.8	127.3	138.8	2662.1	100.0

NOTE: Excludes WHC_SSIRET, WHC_1171HSP and all members of DOD/Surplus Fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_III
(volumes in cubic meters)

PCD Abbrev	MCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
COMP/COMB SOL	FLAMMABLE		.4	.7	1.4	2.4	2.2	2.4	2.4	2.2	2.2	2.4	2.4	2.2	2.4	2.2	2.2
	ACIDS									1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	ALKALINES		.9	1.8	3.6	6.0	5.3	6.0	6.0	7.0	7.0	7.7	7.7	7.0	7.7	7.0	7.0
	TC METAL		.9	1.8	3.5	6.0	5.3	6.0	6.0	5.3	5.3	6.0	6.0	5.3	6.0	5.3	5.3
	SPENT SOLVENT		.3	.7	1.4	2.4	2.1	2.4	2.4	4.2	4.2	4.4	4.4	4.2	4.4	4.2	4.2
	PCB >=50,< 500									1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	OTHER	1.2	1.3	2.4	4.6	7.6	6.7	7.6	7.6	6.7	6.7	7.6	7.6	6.7	7.6	6.7	6.7
Total COMP/COMB SOL		1.2	3.7	7.4	14.5	24.5	21.6	24.5	24.5	28.4	28.4	31.3	31.3	28.5	31.3	28.5	28.5
WOOD	OTHER	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total WOOD		.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
STAINLSS METAL	ALKALINES		.4	.9	1.9	3.2	2.8	3.2	3.2	2.8	2.8	3.2	3.2	2.8	3.2	2.8	2.8
	TC METAL	.0	.4	.9	1.9	3.2	2.8	3.2	3.2	2.8	2.8	3.2	3.2	2.8	3.2	2.8	2.8
	OTHER	.0	.6	1.3	2.5	4.2	3.8	4.2	4.2	3.8	3.8	4.2	4.2	3.8	4.2	3.8	3.8
Total STAINLSS METAL		.0	1.5	3.1	6.2	10.6	9.4	10.6	10.6	9.4	9.4	10.6	10.6	9.4	10.6	9.4	9.4
OTH METAL <.5	ACIDS									1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
	ALKALINES		.4	.9	1.9	3.2	2.8	3.2	3.2	2.8	2.8	3.2	3.2	2.8	3.2	2.8	2.8
	TC METAL	.0	.4	.9	1.9	3.2	2.8	3.2	3.2	4.8	4.8	5.2	5.2	4.8	5.2	4.8	4.8
	TC ORGANIC									1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
	OTHER	.0	5.1	5.8	2.5	4.2	3.8	4.2	4.2	3.8	3.8	4.2	4.2	3.8	4.2	3.8	3.8
Total OTH METAL <.5		.0	6.0	7.7	6.2	10.6	9.4	10.6	10.6	14.5	14.5	15.7	15.7	14.5	15.7	14.5	14.5
OTH METAL >=.5	ALKALINES		1.4	2.8	5.6	9.6	8.5	9.6	9.6	8.5	8.5	9.6	9.6	8.5	9.6	8.5	8.5
	TC METAL	.0	1.4	2.8	5.7	9.6	8.5	9.6	9.6	8.5	8.5	9.6	9.6	8.5	9.6	8.5	8.5
	OTHER	.0	1.8	3.8	7.5	12.8	11.3	12.8	12.8	11.3	11.3	12.8	12.8	11.3	12.8	11.3	11.3

NOTE: Excludes WHC_SSTRET, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group.

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_III
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
COMP/COMB SOL	FLAMMABLE	2.7	2.2	2.2	2.4	2.2	2.7	2.7	2.2	1.2	1.2	2.3	2.6	2.9	3.1	3.4	65.8	8.0
	ACIDS	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	39.1	4.8
	ALKALINES	8.5	7.0	7.0	7.7	7.0	8.5	8.5	7.0	4.6	4.6	7.4	8.1	8.8	9.5	10.2	202.5	24.7
	TC METAL	6.7	5.3	5.3	6.0	5.3	6.7	6.7	5.3	2.8	2.8	5.7	6.4	7.1	7.8	8.5	162.7	19.8
	SPENT SOLVENT	4.7	4.2	4.2	4.4	4.2	4.7	4.7	4.2	3.2	3.2	4.3	4.6	4.9	5.2	5.4	112.0	13.6
	PCB >=50,< 500	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	31.3	3.8
	OTHER	8.4	6.7	6.7	7.6	6.7	8.5	8.5	6.8	3.8	3.8	7.2	8.1	8.9	9.7	10.6	207.3	25.3
Total COMP/COMB SOL		34.1	28.5	28.5	31.3	28.5	34.2	34.2	28.5	18.6	18.6	29.9	32.8	35.6	38.4	41.2	820.7	100.0
WOOD	OTHER	.0	.0	0	.0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0
Total WOOD		.0	0	0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0
STAINLSS METAL	ALKALINES	3.6	2.8	2.8	3.2	2.8	3.6	3.6	2.8	1.5	1.5	3.0	3.4	3.7	4.1	4.5	85.9	30.0
	TC METAL	3.6	2.8	2.8	3.2	2.8	3.6	3.6	2.8	1.5	1.5	3.0	3.4	3.7	4.1	4.5	85.9	30.0
	OTHER	4.7	3.8	3.8	4.2	3.8	4.7	4.7	3.8	2.0	2.0	4.0	4.5	5.0	5.5	6.0	114.9	40.1
Total STAINLSS METAL		11.9	9.4	9.4	10.6	9.4	11.9	11.9	9.4	5.0	5.0	10.0	11.2	12.5	13.7	15.0	286.7	100.0
OTH METAL <.5	ACIDS	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	29.3	7.1
	ALKALINES	3.6	2.8	2.8	3.2	2.8	3.6	3.6	2.8	1.5	1.5	3.0	3.4	3.7	4.1	4.5	85.9	20.8
	TC METAL	5.6	4.8	4.8	5.2	4.8	5.6	5.6	4.8	3.5	3.5	5.0	5.4	5.8	6.2	6.5	132.8	32.2
	TC ORGANIC	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	41.1	9.9
	OTHER	4.7	3.8	3.8	4.2	3.8	4.7	4.7	3.8	2.0	2.0	4.0	4.5	5.0	5.5	6.0	124.0	30.0
Total OTH METAL <.5		17.0	14.5	14.5	15.7	14.5	17.0	17.0	14.5	10.1	10.1	15.1	16.3	17.6	18.8	20.1	413.1	100.0
OTH METAL >=.5	ALKALINES	10.7	8.5	8.5	9.6	8.5	10.7	10.7	8.5	4.5	4.5	9.0	10.2	11.3	12.4	13.6	259.6	30.0
	TC METAL	10.7	8.5	8.5	9.6	8.5	10.7	10.7	8.5	4.5	4.5	9.0	10.2	11.3	12.4	13.6	259.6	30.0
	OTHER	14.3	11.3	11.3	12.8	11.3	14.3	14.3	11.3	6.0	6.0	12.1	13.6	15.1	16.6	18.1	346.6	40.0

NOTE: Excludes WHC_SSTREI, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CM_LLMW_III
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total OTH METAL >=.5		.0	4.5	9.4	18.8	32.0	28.3	32.0	32.0	28.3	28.3	32.0	32.0	28.3	32.0	28.3	28.3
GLASS	OTHER	.7	.2	.2	.2	.2	2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Total GLASS		.7	.2	2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
CONCRETE	COMBUSTIBLE		.1														
	SPENT SOLVENT		.8	.8	.8	.8	.8										
	PCB < 50 PPM		0														
Total CONCRETE		0.0	1 0	.8	.8	.8	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PARTICULATE	FLAMMABLE	.0	7	1 4	2.9	4.9	4 3	4.9	4.9	4.3	4.3	4.9	4.9	4.3	4.9	4.3	4.3
	COMBUSTIBLE	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	ALKALINES		1.7	3 6	7 2	12.3	10 8	12.3	12.3	10.8	10.8	12.3	12.3	10.8	12.3	10.8	10.8
	TC METAL		1.7	3 6	7.2	12.3	10 8	12.3	12.3	10.8	10.8	12.3	12.3	10.8	12.3	10.8	10.8
	SPENT SOLVENT		.7	1 4	2.9	4.9	4 3	4.9	4.9	4.3	4.3	4.9	4.9	4.3	4.9	4.3	4.3
	OTHER	.1	2 1	4 4	8 7	14 8	13 0	14 8	14.8	13.0	13.0	14.8	14.8	13.0	14.8	13.0	13.0
Total PARTICULATE		.1	7 0	14 5	28 9	49.2	43 4	49.2	49.2	43.4	43.4	49.2	49.2	43.4	49.2	43.4	43.4
SOIL	ACIDS		1	1	.1	.1	.1										
	ALKALINES		.1	1	1	.1	1										
	TC METAL	.0	.2	2	2	.2	2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	TC ORGANIC	.0	0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total SOIL		.1	4	4	4	.4	4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
LEAD	ACIDS									3.6	3.6	3.6	3.6	3.6	3 6	3.6	3.6
	TC METAL	.1	2 2	2 0	2 0	2.0	2.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	TC ORGANIC									.8	.8	.8	.8	.8	.8	.8	.8

NOTE: Excludes WHC_SSTRET, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group.

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FY-1992 FORECAST VOLUME SUMMARY
NON THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_III
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
Total OTH METAL >=.5		35.8	28.3	28.3	32.0	28.3	35.8	35.8	28.3	15.1	15.1	30.2	33.9	37.7	41.5	45.2	865.8	100.0
GLASS	OTHER	.2	.2	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7.6	100.0
Total GLASS		.2	.2	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7.6	100.0
CONCRETE	COMBUSTIBLE																.1	2.7
	SPENT SOLVENT																4.2	97.0
	PCB < 50 PPM																.0	.3
Total CONCRETE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	100.0
PARTICULATE	FLAMMABLE	5.5	4.3	4.3	4.9	4.3	5.5	5.5	4.3	2.3	2.3	4.6	5.2	5.8	6.4	6.9	132.8	10.0
	COMBUSTIBLE	.0	.0	0	.0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
	ALKALINES	13.7	10.8	10.8	12.3	10.8	13.7	13.7	10.8	5.8	5.8	11.6	13.0	14.4	15.9	17.3	331.9	25.0
	TC METAL	13.7	10.8	10.8	12.3	10.8	13.7	13.7	10.8	5.8	5.8	11.6	13.0	14.4	15.9	17.3	331.9	25.0
	SPENT SOLVENT	5.5	4.3	4.3	4.9	4.3	5.5	5.5	4.3	2.3	2.3	4.6	5.2	5.8	6.4	6.9	132.7	10.0
	OTHER	16.5	13.0	13.0	14.8	13.0	16.5	16.5	13.0	7.0	7.0	13.9	15.7	17.4	19.1	20.8	399.6	30.1
Total PARTICULATE		54.9	43.4	43.4	49.2	43.4	54.9	54.9	43.4	23.2	23.2	46.3	52.1	57.8	63.6	69.4	1329.0	100.0
SOIL	ACIDS																.6	22.1
	ALKALINES																.6	22.1
	TC METAL	.0	.0	0	.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	1.2	42.6
	TC ORGANIC	.0	.0	0	.0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.4	13.2
Total SOIL		0	0	0	.0	0	0	.0	.0	.0	.0	.0	.0	0	.0	.0	2.9	100.0
LEAD	ACIDS	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	82.1	52.8
	TC METAL	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	38.2	24.5
	TC ORGANIC	.8	8	8	8	8	.8	8	.8	.8	.8	.8	8	.8	.8	.8	17.6	11.3

NOTE. Excludes WHC_SSTREET, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group

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FY-1992 FORECAST VOLUME SUMMARY
NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_III
(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	HELD	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
LEAD	SPENT SOLVENT									.8	.8	.8	.8	.8	.8	.8	.8
Total LEAD		.1	2.2	2.0	2.0	2.0	2.0	1.1	1.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
MERCURY	TC METAL	.0	.0	0	.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total MERCURY		.0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
SPENT RESINS	TC METAL	.0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	TC ORGANIC	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	OTHER	.0	0	0	0	.0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total SPENT RESINS		.0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
CONT LIQ	PCB < 50 PPM		0														
Total CONT LIQ		0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER	ALKALINES		1	2	4	.7	6	.7	.7	.6	.6	.7	.7	.6	.7	.6	.6
	TC METAL		1	2	4	.7	6	.7	.7	.6	.6	.7	.7	.6	.7	.6	.6
	OTHER		1	3	6	1.0	9	1.0	1.0	.9	.9	1.0	1.0	.9	1.0	.9	.9
Total OTHER		0.0	3	7	1.4	2.4	2.1	2.4	2.4	2.1	2.1	2.4	2.4	2.1	2.4	2.1	2.1
Total CH_LLMW_III		3.9	63.7	98.7	146.0	244.5	215.5	241.3	241.3	230.4	230.4	258.3	258.4	230.5	258.4	230.5	230.5
Grand Total		111.4	785.0	528.4	1319.8	1505.2	1507.7	1411.3	1428.2	1425.4	1425.5	1467.4	1456.1	1434.7	1457.0	1433.6	1447.3

NOTE. Excludes WHC SSTRET, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group.

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FY-1992 FORECAST VOLUME SUMMARY

NON-THERMALLY TREATABLE VOLUMES FOR WASTE CLASS: CH_LLMW_III

(volumes in cubic meters)

PCD Abbrev	HCD Abbrev	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Pct
LEAD	SPENT SOLVENT	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	17.6	11.3
Total LEAD		6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	155.4	100.0
MERCURY	TC METAL	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	100.0
Total MERCURY		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	100.0
SPENT RESINS	TC METAL	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	33.0
	TC ORGANIC	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	33.0
	OTHER	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	34.0
Total SPENT RESINS		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	100.0
CONT LIQ	PCB < 50 PPM																.0	100.0
Total CONT LIQ		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	100.0
OTHER	ALKALINES	.8	.6	.6	.7	.6	.8	.8	.6	.3	.3	.7	.8	.8	.9	1.0	19.5	30.0
	TC METAL	.8	.6	.6	.7	.6	.8	.8	.6	.3	.3	.7	.8	.8	.9	1.0	19.5	30.0
	OTHER	1.1	.9	.9	1.0	.9	1.1	1.1	.9	.5	.5	.9	1.0	1.1	1.2	1.4	26.0	40.0
Total OTHER		2.7	2.1	2.1	2.4	2.1	2.7	2.7	2.1	1.1	1.1	2.3	2.6	2.8	3.1	3.4	65.1	100.0
Total CH_LLMW_III		286.4	230.5	230.5	258.4	230.5	286.5	286.5	230.6	132.6	132.6	244.5	272.6	300.5	328.5	356.4	6990.0	
Grand Total		1485.2	1313.3	1313.6	1348.3	1327.7	1372.8	1373.5	1298.3	1205.5	1219.6	1319.4	1341.6	1350.9	1378.8	1423.9	40216.5	

NOTE: Excludes WHC_SSIRET, WHC_1171FSP and all members of D&D/Surplus Fac waste generator group

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Fiscal Year 1992 Mixed Low-Level Waste Forecast Volume Summary - Nonthermally Treatable Volumes by Waste Class and Waste Generator.

Waste class	Waste generator	Total volumes (m^3)
CH_MLLW_I	Argonne National Laboratory-East	553.6
	Bettis	45.9
	Battelle Columbus Laboratories	0.2
	Brookhaven	256.1
	University of California, Davis	1.5
	FERMI	25.8
	Lawrence Berkeley Laboratory	216.4
	Pacific Northwest Laboratory	477.5
	Portsmouth	5,184.4
	Princeton	39.5
	Rockwell Canoga Park	113.3
	University of Utah	3.0
	WHC_100 Area, Defense Reactor Division	5.9
	WHC_105DR, Large Sodium Fire Facility	2.5
	WHC_202A, Chem Processing PUREX	26.0
	WHC_221T, T Plant Bldg. 2706	39.0
	WHC-222S Laboratory	856.8
	WHC_225B, B Plant and WESF	39.5
	WHC_234SZ, Plutonium Finishing Plant	123.6
	WHC_2ETF, Tank Farms	1,674.1
	WHC_308, Fuel Fabrication Bldg.	7.4
	WHC_340, Liquid Waste Handling Facility	13.5
	WHC_4843, Alkali Metal Storage Facility	12.7
	WHC_ERA_BG9	0.1
	WHC_FMEF, Fuels and Materials Examination Facility	68.0
	WHC_HWVP, Hanford Waste Vitrification Plant	259.9
	WHC_L045H, Treated Effluent Disposal Facility	4,132.0
	WHC_LLBG, Solid Waste Operations	3.0
	WHC_MASF, Maintenance and Storage Facility	3.0
	WHC_PX_C018H, Effluent Treatment Facility	6,953.4
Total CH_MLLW_I		21,137.5
CH_MLLW_III	FUSRAP, Formerly Utilized Sites Remediation Action Program	1.0
	Pacific Northwest Laboratory	66.0
	WHC_222S Laboratory	40.6
	WHC_225B, B Plant and WESF	10.5
	WHC_2ETF, Tank Farms	45.4
	WHC-340, Liquid Waste Handling Facility	4.5
	WHC_GROUT, Grout Facility	6,427.6
	WHC_HWVP, Hanford Waste Vitrification Plant	391.0
	WHC_TRUSAF, Solid Waste Operations	3.4
Total CH_MLLW_III		6,990.0
Total CH_MLLW_I and III		28,127.5*

*Does not include 2,044.7 m^3 of thermal treatment ash.

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APPENDIX C

BREAKDOWN OF VOLUMES FOR EACH WASTE RECEIVING AND PROCESSING MODULE 2A FEED STREAM INCLUDING CONTRIBUTIONS FROM ALL SOURCES

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Table C-1. Breakdown of Volumes for Each Waste Receiving and Processing 2A Feed Stream Including Contributions from All Sources. (sheet 1 of 2)

		Existing Waste				Forecast		
Number	Stream Title	M3	Ft3	DE	BE	M3	Ft3	DE
1A	Solidified 183-H Basin Liquids	575.5	20322	2767	0	--	--	--
1B	Crystalline 183-H Basin Solids	922.7	32580	4436	0	--	--	--
1C	183-H Basin Sludge Waste	971.4	34299	4670	0	--	--	--
1D	Misc. 183-H Basin Waste	148.5	5243	409	14	--	--	--
2A	Ammonium Sulfate Powder	--	--	--	--	6485.4	229000	31180
2B	Ion Exchange Resin	--	--	--	--	405.0	14300	1947
2C	Ferric Hydroxide Sludge	--	--	--	--	3964.9	140000	19062
5A1	Elemental Mercury	1.7	61	8	0	2.9	101	14
5A2	Mercury Chemicals/Solutions	4.4	156	21	0	7.2	256	35
5A3	Mercury Contam.Het. Solids	7.4	261	36	0	12.1	428	58
5C1	Elemental Lead	109.9	3880	182	18	418.1	14765	2010
5C2	Lead Chemicals/Solutions	0.2	7	1	0	0.8	27	4
5C3	Lead Contam.Het. Solids	17.3	611	83	0	65.9	2326	317
7	Thermal Treatment Ash	--	--	--	--	2044.7	72200	9831
9A	Particulate/Sludge	27.7	979	133	0	3893.6	137483	18719
9B	Heterogeneous Solids/Debris	26.5	935	127	0	12527.9	442360	60230
9C	Contained Liquid	9.3	328	45	0	344.0	12147	1654
	TOTAL	2822.6	99664	12919	32	30172.5	1065392	145060

Table C-1. Breakdown of Volumes for Each Waste Receiving and Processing 2A Feed Stream Including Contributions from All Sources. (sheet 2 of 2)

		WRAP 1			Totals			
Number	Stream Title	M3	Ft3	DE	M3	Ft3	DE	BE
1A	Solidified 183-H Basin Liquids	--	--	--	575.5	20322	2767	0
1B	Crystalline 183-H Basin Solids	--	--	--	922.7	32580	4436	0
1C	183-H Basin Sludge Waste	--	--	--	971.4	34299	4670	0
1D	Misc. 183-H Basin Waste	--	--	--	148.5	5243	409	14
2A	Ammonium Sulfate Powder	--	--	--	6485.4	229000	31180	0
2B	Ion Exchange Resin	--	--	--	405.0	14300	1947	0
2C	Ferric Hydroxide Sludge	--	--	--	3964.9	140000	19062	0
5A1	Elemental Mercury	6.6	233	32	11.2	395	54	0
5A2	Mercury Chemicals/Solutions	16.7	591	80	28.4	1003	137	0
5A3	Mercury Contam.Het. Solids	28.0	988	135	47.5	1677	228	0
5C1	Elemental Lead	201.0	7096	966	729.0	25741	3159	18
5C2	Lead Chemicals/Solutions	0.4	13	2	1.4	48	6	0
5C3	Lead Contam.Het. Solids	31.7	1118	152	114.9	4055	552	0
7	Thermal Treatment Ash	--	--	--	2044.7	72200	9831	0
9A	Particulate/Sludge	214.8	7585	1033	4136.1	146047	19885	0
9B	Heterogeneous Solids/Debris	205.2	7244	986	12759.6	450540	61344	0
9C	Contained Liquid	72.0	2543	346	425.3	15018	2045	0
	TOTAL	776.3	27412	3732	33771.4	1192468	161711	32

APPENDIX D

SPECIFICATIONS FOR FEED STREAMS 1 THROUGH 9

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Table D-1. Specification for Feed Stream 1A, Solidified 183-H Basin Liquids, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	1A
Common Name	Solidified 183-H Basin Liquids
Subset(s)	1 - Solidified liquids consolidated from original basin supernates. 2 - Solidified miscellaneous other liquids (well purge water, washdown water, seepage from crystals).

GENERATION

Narrative Description	The four 183-H basins were used from 1973-85 for solar evaporation of neutralized acid etch solutions from N Reactor fuel fabrication activities. During closure of these basins, supernatant liquid was consolidated from all four basins. In 1988-89, the liquid was mixed with solidification agents in a batch reactor and packaged into drums. A ribbon-type blend was chosen so that proper waste-to-binder consistency and mixing homogeneity could be monitored and maintained. In 1990, additional solidified liquid drums (approximately 1,208 of the 2,767 drums) resulted from the solidification of well purge water, washdown water, and liquids that seeped from remaining crystal solids.
Generator(s)	Westinghouse Hanford Company; Decontamination and Decommissioning Program
Existing Volume	1 - Solidified evaporated liquids: 1,559 drums 2 - Solidified seepage, purge well, and wash water: 1,208 drums Total 2,767 drums The total volume is 20,322 ft^3.
Forecast	No further generation of this waste is forecast.

PHYSICAL CHARACTERISTICS

Narrative Description	The solidified waste was generated in eight drum batches with a target ratio of approximately 290 lb of solidification agent and 40 gal of liquid per drum. Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).

Physical State	Hard monolith (e.g., broke titanium shaft core samplers) with consistency of a hard lime plaster to soft solid (e.g., "cheese-like center") similar to lime plaster putty.
Density	100 to 130 lb/ft^3.
Moisture Content	Before solidification: 57% by weight average. Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991). NOTE: No free moisture is expected after solidification, but substantial amounts of water of hydration should be anticipated.
Particle Size	Before solidification, the Sorbond LPC II* particle size was reported as follows: 2% maximum retained on #100 sieve 5% maximum retained on #200 sieve 10% maximum retained on #325 sieve NOTE: It was reported that lumps up to 12 in. in diameter were encountered during the solidification operations. References: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).
Hardness	The performance specifications for the solidification agent include a cone penetrometer test for 50 to 65 mm. No data are available on solidified waste hardness. Reference: WHC-SD-WM-ES-193, *Safety Evaluation of 183-H Grouted Drums* (Cain 1993).

RADIOLOGICAL CHARACTERISTICS

Waste Class	Class I waste.
Radionuclide Content	Nominal curie values per drum for drums containing the radionuclide: ^{99}Tc 1.9 E-04 ^{237}Np 1.3 E-10 U 6.3 E-06

*Sorbond LPC II is a trademark of American Colloid Company.

Enriched uranium (1% ^{235}U) content is approximately 18 g/drum average and maximum.

Total curie inventory:

^{99}Tc	5.3 E-01
^{237}Np	3.5 E-07
U	1.8 E-02

No data are available for ^{129}I or ^{79}Se.

References: WHC-SD-WM-ES-193, *Safety Evaluation of 183-H Grouted Drums* (Cain 1993); DOE-RL 88-04, *183-H Solar Evaporation Basins Closure, Post-Closure Plan* (DOE-RL 1991); solid waste information and tracking system (SWITS) database.

Dose Rate

<1 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description

Original waste consisted of inorganic acid etching solutions that were overneutralized with caustic. The consolidated liquids were the combined supernatant liquids from all the basins. The miscellaneous liquids include seepage, well purge water, and washdown water. The solidification agent (Sorbond LPC II) was a light grey powder consisting of the following primary components:

SiO_2	14.4 - 15.6
Al_2O_3	3.1 - 3.5
Fe_2O_3	1.6 - 1.9
CaO	63.2 - 73.2
MgO	5.1 - 6.0
SO_3	1.4 - 1.8
K_2O	0.4 - 0.7
Na_2O	0.8 - 1.2
$CaCO_3$	0.3 - 0.5
Moisture	>10%

Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).

Primary Components

Before solidification:

Constituent	Average concentration (mg/L)
Nitrate	380,000
Sodium	140,000
Sulfate	8,000
Fluorine	1,500
Nitrite ion	390

Zirconium	780
Potassium	720

Trace constituents	Concentration
Aluminum	36 mg/L
Boron	63 mg/L
Calcium	9 mg/L
Chlorine ion	290 mg/L
Chromium	20 mg/L
Cobalt	0.6 mg/L
Copper	410 mg/L
Iron	7 mg/L
Manganese	7 mg/L
Molybdenum	1 mg/L
Nickel	9 mg/L
Silver	1.8 mg/L
Strontium	0.6 mg/L
Tin	15 mg/L
Zinc	2.8 mg/L
Methylene chloride	6 ppb
Acetone	48 ppb
2-butanone	24 ppb
1,1,1-trichloroethane	21 ppb
Toluene	24 ppb
2-hexanone	19 ppb
Chloroform	<5 ppb
4-methyl-2-pentanone	<10 ppb

Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).

Waste Codes

This is a wastewater treatment residue coded as follows:

Listed Components:

P029 Copper cyanide
P030 Cyanide salts
P098 Potassium cyanide
P106 Sodium cyanide
P120 Vanadium pentoxide
U123 Formic acid

Characteristics:

D001 Reactive - oxidizer (nitrates)
D007 Extraction procedure (EP) toxicity (chromium)

State Codes:

WT01 Toxic extremely hazardous waste (EHW) (for fluoride, copper nitrate, and copper sulfate)

NOTE: The original waste designation was performed in the closure plan; the D001 code was added later.

References: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988); WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990); SWITS database.

Hazardous Characteristics

The consolidated liquids were tested for toxicity characteristic testing using the EP toxicity method; the only table constituent concentrations in waste extract (CCWE) wastewater concentration limits for toxic metals that was exceeded was D007 (chromium). This testing was performed prior to allowing evaporation of the liquids which resulted in the precipitation of the crystalline solids (Stream 1B), and prior to solidification of the liquids. Toxicity testing was apparently not performed on the miscellaneous liquids, and toxicity testing was not performed on any of the wastes after they had been solidified.

Hazardous Components

Listed waste codes are by virtue of the mixture rule; most listed components are expected to be non-detectable.

PACKAGING DESCRIPTION

Container Type

U.S. Department of Transportation 17H 55-gal drums. NOTE: At least two different suppliers for these drums were used; some drums had two rolling hoops and some had three rolling hoops.

Internal Packaging

10-mil polyethylene liner. Drums are expected to be filled with solidified waste to within 2 to 4 in. of the top of the drum. A layer of diatomaceous earth was added to retain any residual moisture.

NOTE: The liners were reportedly not long enough to use the normal "pigtail" sealing method so they were instead folded over and the "gap closed with tape."

Venting Mechanism

None.

Gross Weight

Average approximately 800 lb; minimum 400 lb and maximum 800 lb.

Closure Mechanism

Bolted lock ring. NOTE: Up to 50% of the drums were distorted ("egg-shaped") during the filling and handling process and "some lids had to be pounded on."

Table D-2. Specification for Feed Stream 1B, Crystalline 183-H Basin Solids, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	1B
Common Name	Crystalline 183-H Basin Solids
Subset(s)	None.

GENERATION

Narrative Description	The four 183-H basins were used from 1973-85 for solar evaporation of neutralized acid etch solutions from N Reactor fuel fabrication activities. Liquids from all four basins were consolidated into a single lined basin. As water evaporated off, some material precipitated out of the liquid in the form of crystalline sodium nitrate solids. This waste stream contains those crystalline solids which were mechanically removed from the basin floors and packaged into drums in 1990.
Generator(s)	Westinghouse Hanford Company; Decontamination and Decommissioning Program
Existing Volume	A total of 4,436 55-gal drums that equates to a volume of 32,580 ft^3.
Forecast	No further generation of this waste is forecast.

PHYSICAL CHARACTERISTICS

Narrative Description	The crystal solids (sodium nitrate) were packaged directly into lined drums. Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).
Physical State	Dry solids intermixed with diatomaceous earth that was added to absorb residual liquid.
Density	75 to 140 lb/ft^3.
Moisture Content	Expected to be dry solids.
Particle Size	Ranges from lumps of material to fine particulate (diatomaceous earth).
Hardness	Ranges from friable to hard salt cake (value of 2 on a scale of 1 to 10 where 1 is talc or soapstone and 10 is diamond).

RADIOLOGICAL CHARACTERISTICS

Waste Class

Class I.

Radionuclide Content

Nominal curie values per drum for drums containing radionuclides:

^{99}Tc	2.8 E-04
^{237}Np	3.8 E-10
U	1.9 E-05

Enriched uranium (1% enriched) content ranges from 5 to 55 g/drum with an average of 54 g/drum.

Total curie inventory:

^{99}Tc	1.2 E+00
^{237}Np	1.7 E-06
U	8.5 E-02

Reference: SWITS database.

Dose Rate

<1 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description

The waste originally consisted of inorganic acid etching solutions that were overneutralized with caustic.

Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).

Primary Components

This waste is expected to consist primarily of sodium nitrate with minor concentrations of other constituents including diatomaceous earth.

Waste Codes

Listed Components:

P029 Copper cyanide
P030 Cyanide salts
P098 Potassium cyanide
P106 Sodium cyanide
P120 Vanadium pentoxide
U123 Formic acid

Characteristics:

D001 Reactive oxidizer (nitrates)
D007 EP toxicity (chromium)

State Codes:

WT01 Toxic EHW (for fluoride, copper nitrate, and copper sulfate)

NOTE: The original waste designation was performed in the closure plan for the consolidated liquids; the D001 code was added later.

References: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988); SWITS database.

Hazardous Characteristics: Toxicity characteristic testing was performed using the EP toxicity method on the consolidated liquids prior to precipitation of the crystals; no toxicity testing has been done on the crystalline solid waste itself.

Hazardous Components: Listed waste codes are by virtue of the mixture rule, most listed waste components are expected to be non-detectable.

PACKAGING DESCRIPTION

Container Type: U.S. Department of Transportation 17H 55-gal drums.

Reference: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990).

Internal Packaging: 90-mil rigid polyethylene liner. Approximately 1 ft^3 of diatomaceous earth was placed in the bottom of the lined drum, followed by approximately 4.5 ft^3 of waste. Approximately 1.5 ft^3 of "mixed diatomaceous earth absorbents" were placed on top of the waste.

Reference: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990).

Venting Mechanism: None.

Gross Weight: Average 500 lb; minimum 130 lb and maximum 570 lb.

Closure Mechanism: Bolted lock ring. NOTE: Several different brands of rigid liners may have been used, each having a different closure mechanism.

Table D-3. Specification for Feed Stream 1C, 183-H Basin Sludge, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	1C
Common Name	183-H Basin Sludge Waste
Subset(s)	1 - Basin 3 sludge 2 - Basin 4 sludge 3 - Basin 3 or 4 sludge

GENERATION

Narrative Description	The four 183-H basins were used from 1973-85 for solar evaporation of neutralized acid etch solutions from N Reactor fuel fabrication activities. Sludge subsequently precipitated to the bottom of each of the basins. A relatively dry crystalline solid comprised a distinct strata on the interior edges of Basins 1, 3, and 4. All the solids from Basins 1 and 2 were packaged in 1985 and 1986 (before the *Resource Conservation and Recovery Act of 1976* was applied to mixed waste); these wastes are considered disposed and are not candidates for the Waste Receiving and Processing (WRAP) Module 2A facility. The sludge and crystal solids from Basins 3 and 4 were packaged together indiscriminantly. This waste stream consists of solids from Basin 3, which were packaged in 1987, and solids from Basin 4, which were packaged in 1988.
Generator(s)	Westinghouse Hanford Company; Decontamination and Decommissioning Program
Existing Volume	1 - Basin 3 sludge: 3,182 55-gal drums 2 - Basin 4 sludge: 1,407 55-gal drums NOTE: An additional 81 drums may be from either Basin 3 or 4 (i.e., they cannot be specifically traced to one basin or the other). The total volume is 34,299 ft^3.
Forecast	No further generation of this waste is forecast.

PHYSICAL CHARACTERISTICS

Narrative Description	The sludge was manually shovelled or scooped using a 5-gal bucket into 10-mil bags within 90-mil drum liners (in 55-gal drums) over a layer of diatomaceous earth. When the drum was approximately 80% full, more diatomaceous earth was added. It is probable

that the highly caustic nature of the sludge (pH >10) has resulted in some of the diatomaceous earth (predominately calcium silicate) being converted to sodium silicate (or metasilicate) which would be expected to be crystalline (lumps) rather than amorphous.

Reference: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990)

Physical State — Wet to semidry sludge.

Density — Approximately 100 lb/ft^3.

Moisture Content — Basin 3 sludge: Range 35% to 51% by weight; median 42% by weight.

Basin 3 crystalline solids: Range 0.55% to 1.8% by weight; median 1.1% by weight.

Basin 4 sludge: Range 43% to 51% by weight; median 46% by weight.

Basin 4 crystalline solids: Range 1.1% to 25%; median 6.6% by weight.

Reference: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988).

Particle Size — Ranges from lumps to fine particulate (diatomaceous earth).

Hardness — Not applicable.

RADIOLOGICAL CHARACTERISTICS

Waste Class — Class I.

Radionuclide Content — Nominal curie values per drum for drums containing radionuclides:

^{99}Tc	3.7 E-04
^{237}Np	2.1 E-09
U	1.0 E-04

Uranium

1 - Basin 3 sludge: 870 pCi/g dry weight (average), 320 to 1,560 pCi/g dry weight (range), 278 g/drum average

2 - Basin 4 sludge: 520 pCi/g dry weight (average), 44 to 820 pCi/g dry weight (range), 350 g/drum average: 10 g/drum minimum and 375 g/drum maximum

3 - Basin 3/4 sludge: <1 g/drum

Total curie inventory:

^{99}Tc	1.7 E+00
^{237}Np	9.6 E-06
U	4.9 E-01

References: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988); SWITS database.

Dose Rate

<1 mR/h at drum surface.

CHEMICAL CHARACTERISTICS

Narrative Description

The waste originally consisted of inorganic acid etching solutions that were overneutralized with caustic.

Reference: WHC-SD-DD-TI-059, *Choice of Sorbond LPC II as a Solidifying Agent for 183-H Liquid Wastes* (Galbraith 1991).

Primary Components

The primary components of the sludge waste are as follows:

Constituent	Basin 3 sludge Median	Range
Nitrate ion:	26%	17-29%
Sodium:	23%	20-30%
Sulfate ion:	3.7%	1.9-5.3%
Fluoride ion:	1.3%	0.98-1.5%
Copper:	11.2%	8.8-14%
Zirconium:	8.7%	2.2-22%
Aluminum:	8,900 ppm	1,100-17,000 ppm
Iron:	710 ppm	540-1,000 ppm
Vanadium:	<30 ppm	<30 ppm
Barium:	6 ppm	<1-22 ppm
Cadmium:	6 ppm	3.6-<9 ppm
Chromium:	390 ppm	290-530 ppm
Lead:	<80 ppm	<80 ppm
Mercury:	not analyzed	
Selenium:	not analyzed	
Silver:	190 ppm	120-290 ppm

Basin 3 crystalline solids

Constituent	Median	Range
Nitrate ion:	<1%	all <1%
Sodium:	42%	35-55%
Sulfate ion:	20%	16-26%
Fluoride ion:	3.6%	2.9-4.9%
Copper:	9,900 ppm	4,200-18,000 ppm
Zirconium:	6,200 ppm	560-15,000 ppm
Aluminum:	810 ppm	780-880 ppm
Iron:	97 ppm	48-180 ppm
Vanadium:	not analyzed	
Barium:	8 ppm	2.5-<10 ppm
Cadmium:	not analyzed	
Chromium:	21 ppm	6.6-40 ppm
Lead:	<30 ppm	<30 ppm
Mercury:	not analyzed	
Selenium:	not analyzed	
Silver:	11 ppm	<5-17 ppm

Basin 4 sludge

Constituent	Median	Range
Nitrate ion:	22%	20-24%
Sodium:	24%	23-26%
Sulfate ion:	1.9%	1.3-3.9%
Fluoride ion:	1.1%	0.98-1.2%
Copper:	10.3%	9.7-12%
Zirconium:	4.4%	0.34-13%
Aluminum:	430 ppm	390-490 ppm
Iron:	2,100 ppm	1,200-3,800 ppm
Vanadium:	4 ppm	<2-<10 ppm
Barium:	24 ppm	<1-39 ppm
Cadmium:	3.8 ppm	2.9-4.5 ppm
Chromium:	260 ppm	210-340 ppm
Lead:	36 ppm	14-<50 ppm
Mercury:	not analyzed	
Selenium:	not analyzed	
Silver:	170 ppm	140-220 ppm

Basin 4 crystalline solids

Constituent	Median	Range
Nitrate ion:	46.6%	7.1-71%
Sodium:	38%	30-50%
Sulfate ion:	13%	1.5-31%
Fluoride ion:	2.2%	0.28-5.8%
Copper:	2,600 ppm	1,700-4,500 ppm
Zirconium:	1,300 ppm	290-3,300 ppm
Aluminum:	440 ppm	200-610 ppm
Iron:	77 ppm	42-150 ppm
Vanadium:	not analyzed	

Basin 4 crystalline solids

Constituent	Median	Range
Barium:	2.3 ppm	0.96-3.4 ppm
Cadmium:	not analyzed	
Chromium:	5.8 ppm	3.4-11 ppm
Lead:	14 ppm	<5-<20 ppm
Mercury:	not analyzed	
Selenium:	not analyzed	
Silver:	11.6 ppm	1.6-32 ppm

Reference: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988).

Waste Codes

Listed Components:

P029 Copper cyanide
P030 Cyanide salts
P098 Potassium cyanide
P106 Sodium cyanide
P120 Vanadium pentoxide
U123 Formic acid

Characteristics:

D001 Reactive - oxidizer (nitrates)

State Codes:

WT01 Toxic EHW (for fluoride, copper nitrate, and copper sulfate)

NOTE: The original waste designation performed in the closure plan did not include the D001 code.

Refererces: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988); SWITS database.

Hazardous Characteristics

Toxicity characteristic testing was performed on these wastes using the EP toxicity method; wastes were below table CCWE nonwastewater concentration limits for all toxic metals D004 through D011.

Hazardous Components

Listed waste codes are by virtue of the mixture rule; most listed constituents other than vanadium are expected to be nondetectable.

PACKAGING DESCRIPTION

Container Type

U.S. Department of Transportation 17H 55-gal drums.

Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

Reference: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990).

Internal Packaging

90-mil rigid polyethylene liner and 10-mil plastic liner. Approximately 1 ft^3 of diatomaceous earth was placed in the bottom of the lined drum, followed by approximately 4.5 ft^3 of waste. Approximately 1.5 ft^3 of "mixed diatomaceous earth absorbents" were placed on top of the waste.

Reference: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990).

Venting Mechanism

None.

Gross Weight

Average 750 lb; minimum 250 lb and maximum 800 lb.

Closure Mechanism

Bolted lock ring. NOTE: Several different brands of rigid liners were used, each having a different closure mechanism.

Table D-4. Specification for Feed Stream 1D, Miscellaneous 183-H Basin Waste, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	1D
Common Name	Miscellaneous 183-H Basin Waste
Subset(s)	1 - Drums of sandblast grit 2 - Drums of miscellaneous waste and liner material 3 - Boxes of miscellaneous waste and liner material

GENERATION

Narrative Description	The four 183-H basins were used from 1973-85 for solar evaporation of neutralized acid etch solutions from N Reactor fuel fabrication activities. Miscellaneous wastes generated during the waste removal and cleanout process between 1985 and 1990 included old basin liner material, solidified liquids, sandblast grit, and expendable equipment and protective clothing.
Generator(s)	Westinghouse Hanford Company; Decontamination and Decommissioning Program
Existing Volume	1 - Sandblast grit: 189 55-gal drums 2 - Miscellaneous waste: 220 55-gal drums 3 - Miscellaneous waste: 14 5-ft high by 4-ft wide by 8-ft long boxes The total volume is 5,243 ft^3.
Forecast	No further generation of this waste is forecast.

PHYSICAL CHARACTERISTICS

Narrative Description	All types of miscellaneous contaminated trash, old Hypalon* liner, gloves, boots, cloth, shovels, sand, concrete, crushed tumbleweeds, and 5-gal buckets. Reference: DOE/RL 88-09, *Final Status Post-Closure Permit Application 183-H Solar Evaporation Basins* (DOE-RL 1988).
Physical State	Dry sand, small pieces of concrete, plastic, pieces of rubber, metal, and other dry heterogeneous solids.
Density	Sandblast grit: Approximately 100 lb/ft^3 Drums/boxes: 44 lb/ft^3

*Hypalon is a trademark of E.I. DuPont DeNemours & Co., Inc.

Moisture Content — Expected to be dry.

Particle Size — Sandblast grit: 0.1 to 0.4 mm
Miscellaneous waste: Not applicable

Hardness — Sandblast grit: Not applicable
Miscellaneous waste: May include some steel tools, such as shovels

RADIOLOGICAL CHARACTERISTICS

Waste Class — Class I.

Radionuclide Content — Nominal curie values per drum for drums containing radionuclides:

^{99}Tc	4.8 E-06
^{237}Np	7.9 E-12
U	4.0 E-07

Uranium

1 - Sandblast grit: 1.4 g/drum average; 1 g/drum minimum and 2 g/drum maximum
2 - Miscellaneous waste: Approximately 1 g/drum average; 7 g/drum maximum

Total curie inventory:

^{99}Tc	2.0 E-03
^{237}Np	3.9 E-09
U	2.0 E-04

Dose Rate — <1 mR/h at drum surface

CHEMICAL CHARACTERISTICS

Narrative Description — The Hypalon liner had been used to contain supernatant liquids which were consolidated from all the basins. Sandblasting was performed on the emptied basins to remove the surface layer of concrete which was in contact with the waste. Other miscellaneous materials primarily include the tools and equipment used to decommission the basins.

Reference: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990).

Primary Components — Sandblast grit and miscellaneous heterogeneous solids.

Waste Codes

Listed Components:

P029 Copper cyanide
P030 Cyanide salts
P098 Potassium cyanide
P106 Sodium cyanide
P120 Vanadium pentoxide
U123 Formic acid

Characteristics:

D001 Reactive - oxidizer (presumably because of nitrates originally contained in the basins)
D007 EP toxicity (chromium) - Basin 2 only

State Codes:

WT01 Toxic EHW (for fluoride, copper nitrate, and copper sulfate) - Basins 1, 3, and 4 only
WT02 Toxic dangerous waste (DW) for fluoride - Basin 2 only

Reference: SWITS database.

Hazardous Characteristics

The sandblast grit and heterogeneous solids were apparently not tested for toxicity characteristic.

Hazardous Components

Listed waste codes are by virtue of the mixture rule; actual concentrations of listed components (e.g., cyanides) are expected to be negligible.

PACKAGING DESCRIPTION

Container Type

U.S. Department of Transportation 17H 55-gal drums. Boxes have dimensions of 4 by 3 by 5 ft.

References: WHC-SA-0705-FP, *RCRA Closure Experience with Radioactive Mixed Waste 183-H Solar Evaporation Basins at the Hanford Site* (Powers et al. 1990); SWITS database.

Internal Packaging

Two 10-mil plastic liners in drums. Lining in boxes unknown.

Venting Mechanism

None.

Gross Weight

	Average (lb)	Minimum (lb)	Maximum (lb)
Sandblast grit drums:	745	575	1,040
Miscellaneous waste drums:	240	75	750
Miscellaneous waste boxes:	2,725	2,000	3,795

Closure Mechanism

Bolted lock ring.

Table D-5. Specification for Feed Stream 2A, Ammonium Sulfate Powder, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	2A
Common Name	Ammonium Sulfate Powder
Subset(s)	1 - Ammonium sulfate powder 2 - Sodium sulfate powder

GENERATION

Narrative Description	The 200 Area Effluent Treatment Facility (ETF) will treat acidified (sulfuric acid) process condensate from the 242-A Evaporator, primarily to remove dissolved solid contaminants. The ETF will operate at 150 gpm for its first 4 months to work off 242-A Evaporator process condensate that will have accumulated in the Liquid Effluent Retention Facility basins (covered surface impoundments). Thereafter, the ETF will treat process condensate from the 242-A Evaporator at a rate of 75 gpm, removing undissolved solids (particulates), dissolved solids, organics (destroyed by ultraviolet oxidation), and radionuclides. Secondary wastes will be dried to a powder in a thin-film dryer. Other wastes also may be treated in the ETF because it will have a total capacity of 150 gpm.
Generator(s)	Westinghouse Hanford Company; 200 Area ETF
Existing Volume	None.
Forecast	A total of 229,000 ft^3 (31,180 drums) are expected to be generated through the year 2022. This amount assumes that the ETF operates at an average of 75 gpm for most of its life. Past the year 2000, the total output is hard to predict. It is possible that after the year 2000 the ETF will be used to its full capacity. This would result in a potential doubling of the secondary solid waste production.

PHYSICAL CHARACTERISTICS

Narrative Description	Powdered solids are produced from a thin-film dryer, which is used to dry liquid wastes, including brine, from reverse osmosis separation (up to 99% by weight) and mixed bed ion-exchange regenerate (as little as 1% by weight). Blowdown from rough (>2 μm) and fine (0.5 to 2.0 μm) filters contributes a negligible amount.

Reference: *Design Construction Specification Project C-018H 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility*, V-C018HC1-001 (Kelly 1991).

Physical State — Dry powder.

Density — Assumed to be 62 lb/ft^3.

Moisture Content — The free liquid content is expected to be zero; there may be some hydrated water content.

Particle Size — Majority is expected to be less than 200 Mesh (Tyler) with the consistency of flour. There may be some agglomeration to larger sizes due to the likely hygroscopic nature of the solids.

Hardness — Not applicable (expected to be a fine powder).

RADIOLOGICAL CHARACTERISTICS

Waste Class — Class I.

Radionuclide Content — The following table summarizes the expected range of radionuclide activity in the secondary waste. The numbers are based on two cases. With ammonia in the influent to the ETF, as much as 83% of the secondary waste will be ammonium sulfate. Without ammonia in the influent to the ETF, there will be 0% ammonium sulfate in the secondary waste. Actual values will be dependent upon the character of the influent to the ETF. Therefore, actual values may deviate significantly from the tabulated values. For calculations, a drum of waste contains 1.89 E+05 g.

Radionuclide or activity type	Activity (nCi/g) given 83% ammonium sulfate	Activity (nCi/g) given 0% ammonium sulfate
Beta	2.0	12.0
Alpha	0.15	0.9
^{3}H	none	none
^{79}Se*	13	76
^{79}Se**	67	390
^{90}Sr	3.4	20.0
^{90}Y	3.4	20.0
^{99}Tc*	110	630
^{99}Tc**	1,800	10,000
^{103}Ru	7.9	47.0
^{103m}Rh	7.9	47.0
^{106}Ru	4.9	29.0
^{106}Rh	4.9	29.0
^{113}Sn	0.34	2.0
^{113m}In	0.34	2.0

Radionuclide or activity type	Activity (nCi/g) given 83% ammonium sulfate	Activity (nCi/g) given 0% ammonium sulfate
^{129}I***	none	none
^{134}Cs	none	none
^{137}Cs	2.4	14.0
^{137m}Ba	2.4	14.0
^{147}Pm	0.71	4.2
^{155}Eu	none	none
^{237}Np*	0.054	0.32
^{237}Np**	0.94	5.5
^{241}Pu	none	none
U (gross)	0.015	0.09
^{238}Pu	none	none
^{239}Pu	3.0 E-7	1.8 E-6
^{241}Am	none	none
Total activity	38.0	224

*Not routinely analyzed for in 242-A process condensate. Normal operation per WHC-SD-WM-SAR-023, *242-A Evaporator Crystallizer Safety Analysis Report*, Table 4-11 (Lavender 1992). For ^{99}Tc the actual value is dependent on pre-treatment processing and could be lower based on evaluation of available inventory and possible adjustments to tank waste pretreatment.

**Bounding source term per WHC-SD-WM-SAR-023, *242-A Evaporator Crystallizer Safety Analysis Report*, Table 4-11 (Lavender 1992).

***^{129}I is expected to be volatile and removed in ETF.

Reference: *Design Construction Specification Project C-018H 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility*, V-C018HC1-001 (Kelly 1991).

Dose Rate

Dose rates will be up to 100 mR/h at contact.

CHEMICAL CHARACTERISTICS

Narrative Description

The powdered solids are generated in a dryer from a concentrate that is pH 4.

Reference: *Design Construction Specification Project C-018H 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility*, V-C018HC1-001 (Kelly 1991).

Primary Components

Up to 83% will be ammonium sulfate with as little as 7% being sodium sulfate. At the other extreme, 0% will be ammonium sulfate with 41% being sodium sulfate. The sodium sulfate originates primarily from the regeneration of the ion-exchange columns.

Minor cations include hydrogen ion, potassium, and calcium. Minor anions include silicate, nitrate, excess sulfate, carbonate, chloride, fluoride, and phosphate.

The following table (based on upper level 90% confidence intervals and maximums where a 90% confidence level is not available) summarizes the expected range of constituents in the secondary waste. The numbers are based on two cases. With ammonia in the influent to the ETF, as much as 83% of the secondary waste will be ammonium sulfate. Without ammonia in the influent to the ETF, there will be 0% ammonium sulfate in the secondary waste. Note that a drum of waste is expected to weigh about 420 lb. Actual values will be dependent upon the character of the influent to the ETF. Therefore, actual values may deviate significantly from the tabulated values.

Constituent	Wt fraction in secondary waste (83% ammonium sulfate)	Wt fraction in secondary waste (0% ammonium sulfate)
Na	0.023	0.135
K	0.0029	0.017
Ca	0.0012	0.0007
NH_4	0.226	0.0
Si	0.0107	0.065
Nitrate	0.0010	0.006
Sulfate	0.730	0.746
Carbonate	0.0035	0.0021
Chloride	0.00069	0.004
Fluoride	0.00043	0.003
Phosphate	0.0012	0.007
Minor Constituents		
Al	5.9 E-4	3.5 E-3
Ba	3.2 E-6	1.9 E-5
B	4.3 E-5	2.5 E-4
Cr	2.9 E-5	1.7 E-4
Cu	3.0 E-5	1.7 E-4
Fe	5.8 E-5	3.4 E-4
Mg	6.8 E-5	4.0 E-4
Mn	2.2 E-6	1.3 E-5
Hg	1.4 E-7	8.1 E-7
Ni	6.6 E-6	3.9 E-5
V	3.0 E-6	1.7 E-5

References: *Design Construction Specification Project C-018H 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility*, V-C018HC1-001 (Kelly 1991).

Waste Codes	Listed Codes: F001 1,1,1 Trichloroethane F002 Methylene chloride F003 Acetone; butyl alcohol; methyl isobutyl ketone F004 Cresylic acid F005 Methylethyl ketone; pyridine Characteristics: D007 Toxicity (chrome) D009 Toxicity (mercury) State Codes: WT02 Toxic DW (ammonia) NOTE: This waste may well be coded for toxic metals; the concentrations of toxic metals, such as barium, cadmium, and mercury, have not yet been verified or designated. Verification is expected to occur during initial operations of the ETF. However, based on the above table, chromium and mercury probably will be present in the secondary waste in sufficient concentrations to assign the codes D007 and D009. It also should be noted that the secondary waste is ultimately derived from the double-shell tank wastes which are coded for D001 through D011, D018, D019, D022, D028 through D030, D033 through D036, D038 through D041, D043, and F001 through F005.
Hazardous Characteristics	Listed codes are by the derived-from rule; the actual concentrations for many of these constituents is expected to be nondetectable.
Hazardous Components	Listed waste codes are by the derived-from rule; most constituents are expected to be nondetectable.

PACKAGING DESCRIPTION

Container Type	U.S. Department of Transportation 17H or 17C 55-gal drums.
Internal Packaging	90-mil rigid polyethylene liner.
Venting Mechanism	None.
Gross Weight	Average 500 lb.
Closure Mechanism	Bolted lock ring on drum. Snap-on lids for drums under evaluation.

Table D-6. Specification for Feed Stream 2B, Ion-Exchange Resin, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	2B
Common Name	Ion-Exchange Resin
Subset(s)	1 - 200 Area ETF also designated Project C-018H 2 - 300 Area Treated Effluent Disposal Facility (TEDF) also designated Project L-045H

GENERATION

Narrative Description	This waste stream consists of spent resins generated by facilities that treat liquid waste. Resins may be regenerated several times prior to being discarded, but will probably not be regenerated the last time used. Any of several types of cation, anion, or mixed-bed resins may be generated. Resins will be of the styrene-divinyl benzene type.
Generator(s)	Westinghouse Hanford Company; 300 Area TEDF and 200 Area ETF
Existing Volume	None.
Forecast	TEDF: A total of 8,400 ft^3 (1,144 drums) through 2022 ETF: A total of 5,900 ft^3 (803 drums) through 2022 Totals: 14,300 ft^3 (1,947 drums) through 2022 The volume projected for TEDF is based on routine operating flows. Maximum operating conditions would be expected to result in an additional volume of 2,644 ft^3 (360 drums). Note that each batch of resin from the 200 Area ETF will be 167.4 ft^3 in volume. If the ETF operates at 150 gpm, three batches will be generated each year.

PHYSICAL CHARACTERISTICS

Narrative Description	All resins will be versions of cross-linked styrene-divinyl benzene polymer; functional groups will vary with specific resin. Waste resin will be sluiced from the columns and drained prior to packaging. Currently, predictions are that TEDF will use Duolite* GT-73 resin. Ionac C-250 and Ionac ASB-1P

*Duolite is a trademark of Rohm and Haas Company.

(cation and anion exchange resins sold by Sybron Chemicals, Inc.) have been specified for the 200 Area ETF.

Reference: Vendor publication.

Physical State — Solid beads.

Density — 54 lb/ft^3.

Reference: Vendor publication

Moisture Content — 50% to 70% internal. It is assumed that nearly all the drainable water will be removed prior to shipment to WRAP 2A. NOTE: The complete removal of all drainable water may be difficult to attain. The degree of attainment is unknown at this time.

Reference: Vendor publication.

Particle Size — Depends on resin type and is expected to range from 0.3 to 1.2 mm.

Reference: Vendor publication.

Hardness — Unknown.

RADIOLOGICAL CHARACTERISTICS

Waste Class — Class I.

Reference: WHC-SD-L045H-SAD-001, *300 Area Treated Effluent Disposal Facility Preliminary Safety Analysis Document* (Bendixsen 1993) with some modifications to reflect latest design information.

Radionuclide Content — TEDF resin: Contains 18.5 pCi/g alpha and 0.017 pCi/g beta with the following concentrations:

Constituent	Concentration (pCi/L)
^{3}H	136
^{60}Co	0.034
^{90}Sr	0.254 (Sr total 0.714)
^{106}Ru	1.02
^{137}Cs	15.4
^{147}Pm	3.02
Radium total	0.051
U total	0.136
^{238}Pu	8.5 E-4
$^{239/240}Pu$	3.4 E-3
^{241}Pu	0.68
^{241}Am	0.01

Reference: WHC-SD-L045H-SAD-001, *300 Area Treated Effluent Disposal Facility Preliminary Safety Analysis Document* (Bendixsen 1993) with some modifications to reflect latest design information.

ETF resin: The following table is based on design information supplied by *Design Construction Specification Project C-018H 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility*, V-C018HC1-001 (Kelly 1991). Actual values will be dependent upon the character of the influent to the ETF. Therefore, actual values may deviate significantly from the tabulated values. It is conceivable that radionuclide concentrations could be 20 times higher or greater.

Radionuclide or activity type	Ci/m^3 of resin
Beta	3.6 E-5
Alpha	2.7 E-6
^{3}H	6.3 E-3
^{90}Sr	5.7 E-5
^{90}Y	5.7 E-5
^{103}Ru	1.4 E-4
^{103m}Rh	1.4 E-4
^{106}Ru	8.6 E-5
^{106}Rh	8.6 E-5
^{113}Sn	5.7 E-5
^{113m}In	5.7 E-5
^{129}I	none
^{134}Cs	none
^{137}Cs	4.1 E-5
^{137m}Ba	4.1 E-5
^{147}Pm	1.2 E-5
^{155}Eu	none
^{241}Pu	none
U (gross)	2.5 E-7
^{238}Pu	none
^{239}Pu	5.2 E-12
^{241}Am	none
Total activity	6.7 E-4

Dose Rate

TEDF - probably below background.
ETF - up to 100 mR/h.

CHEMICAL CHARACTERISTICS

Narrative Description

TEDF: Chemical characteristics of resins will vary according to specific resin type. For example, Duolite GT-73 is a macroporous ion-exchange resin based on a cross-linked polystyrene matrix with functional groups being thiol (-SH) and minor quantities of sulfonic acid groups.

ETF: Ionac C-250 is a bead form strong acid gel polystyrene-sulfonated cation exchange resin. It derives its exchange capacity from sulfonate functional groups. Ionac ASB-1P is a strong base anion exchange resin with a gel structure of polystyrene cross-linked with divinyl benzene. It derives its exchange capacity from quarternary ammonium functional groups.

Primary Components

TEDF: The concentrations are ppb. Only major constituents are listed for normal (non-city) operations.

Cd 1.4 E+5 ppb
Pb 3.9 E+3 ppb
Hg 9.5 E+4 ppb
Ni 1.0 E+5 ppb
Ag 1.6 E+5 ppb

ETF: The following table contains the constituents expected to be on the ion-exchange resins used in the 200 Area ETF. NOTE: If the concentration of influent ammonia is reduced from the design basis, ammonium and sulfate loadings will be lower while all other constituent loadings will be higher. The degree to which they will be higher is unknown and will not be known until the actual waste is produced. However, it is not inconceivable the constituent concentrations could be 20 times higher or greater. Actual values will be dependent upon the character of the influent to the ETF. Therefore, actual values may deviate significantly from the tabulated values.

Inorganic constituent	Loading in g/m^3 of resin
Na	39,000
K	50
Ca	21
Ammonium	4,100 (if present in ETF feed)
Si	none
Nitrate	18
Sulfate	93,000 (if ammonia in feed to ETF)
Carbonate	4,300
Chloride	310
Fluoride	7.6
Phosphate	21

Minor constituents	Loading in g/m^3 of resin
Al	2.1
Ba	0.012
B	0.16
Cr	0.11
Cu	0.11
Fe	0.21
Mg	0.25
Mn	0.008
Hg	0.000051
Ni	0.024
V	0.011

Waste Codes

TEDF: Unknown until toxic characteristics leach procedure (TCLP) test can be performed on the spent ion-exchange resin.

ETF: Listed Components:

F001 1,1,1 Trichloroethane
F002 Methylene chloride
F003 acetone; butyl alcohol; methyl isobutyl ketone
F004 Cresylic acid
F005 Methylethyl ketone; pyridine

State Codes:

WT02 DW (ammonia)

NOTE: Although this waste is not coded for toxic metals, the concentrations of toxic metals such as barium, cadmium, and mercury have not yet been verified. Verification is expected to occur during the initial operation of ETF. NOTE: The secondary waste is ultimately derived from the double-shell tank wastes which are coded for D001 through D011, D018, D019, D022, D028 through D030, D033 through D036, D038 through D041, D043, and F001 through F005.

Hazardous Characteristics

Unknown.

Hazardous Components

L-045: Arsenic, barium, beryllium, cadmium, lead, selenium, silver
C-018: See above table

PACKAGING DESCRIPTION

Container Type

U.S. Department of Transportation 17C or 17H 55-gal drums for TEDF. The container and closure mechanism have not been determined for the ETF spent ion-exchange resin.

Internal Packaging	90-mil polyethylene liner and absorbent mixed with the sludge.
Venting Mechanism	None.
Gross Weight	250 to 300 lb.
Closure Mechanism	Snap-on lid for liner; lock ring for drum.

Table D-7. Specification for Feed Stream 2C, Ferric Hydroxide Sludge, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	2C
Common Name	Ferric Hydroxide Sludge
Subset(s)	None.

GENERATION

Narrative Description	The 300 Area TEDF will treat process wastewater. The wastewater is generated in 300 Area laboratories, office buildings, fabrication and maintenance buildings, and utilities facilities. The wastewater will be treated by ferric hydroxide coprecipitation, clarification, filtration, ion exchange, and ultraviolet light oxidation. The coprecipitation step in the process produces a large quantity of metal hydroxide solids. The solids are transferred from the clarifier to a thickener tank prior to dewatering. Water is removed from the sludge in a filter press. After being pressed, the sludge is approximately 20% to 30% solids and 70% to 80% water. Reference: WHC-SD-L045H-ER-002, *Engineering Summary Report Hanford 300 Area Treated Effluent Disposal Facility Project L-045H* (Stordeur 1992).
Generator(s)	Liquid Waste Disposal is the operating organization.
Existing Volume	None.
Forecast	As of March 1993, there are two possible waste forecasts: normal TEDF operation and if process wastewater is sent to the City of Richland for processing. If wastewater is sent to the city, the plant will be used for training and to pretreat as required. A final treatment decision is expected by fiscal year 1994. Normal operation: A total of 140,000 ft^3 (19,062 drums) through 2022 are expected to be generated based on routine operating flows. Maximum operating conditions would be expected to result in an additional volume of 81,880 ft^3 (11,000 drums). City option: A total of 11,200 ft^3 (1,524 drums) through 2022.

References: WHC-SD-L045H-FDC-001, *Functional Design Criteria for the 300 Area Treated Effluent Disposal Facility Project L-045H - Draft* (Muller 1992a); WHC-SD-L045H-ER-001, *Project L-045H, 300 Area Treated Effluent Disposal Facility Technology Selection Engineering Report - Draft Report* (Muller 1992b). Volume projections include some modification of reference data to reflect latest design information.

PHYSICAL CHARACTERISTICS

Narrative Description

The metal hydroxide sludge removed from the filter press will be a solid cake that has the appearance and texture of clay. Free liquid is not expected until after the sludge has been in the disposal container for a while.

Physical State

Solid that is a clay-like substance.

Reference: WHC-SD-L045H-ER-001, *Project L-045H, 300 Area Treated Effluent Disposal Facility Technology Selection Engineering Report - Draft Report* (Muller 1992b).

Density

140 lb/ft^3.

Reference: Design documents.

Moisture Content

70% to 80%.

Reference: WHC-SD-L045H-ER-002, *Engineering Summary Report Hanford 300 Area Treated Effluent Disposal Facility Project L-045H* (Stordeur 1992).

Particle Size

The sludge breaks into chunks as it falls from the filter press. Further fracturing occurs as it is loaded into drums. Currently, there are no facilities to dry the solids. If the solids are dried, at WRAP, to 50% solids 50% water a very fine powder is produced.

Hardness

Not applicable.

RADIOLOGICAL CHARACTERISTICS

Waste Class

Class I if not unconditionally releasable. Based on a preliminary safety analysis document flowsheet, the sludge will be 0.08 pCi/g alpha and 0.35 pCi/g beta.

Reference: WHC-SD-L045H-SAD-001, *300 Area Treated Effluent Disposal Facility Preliminary Safety Analysis Document* (Bendixsen 1993).

Radionuclide Content

Constituent	Concentration (pCi/L)
^{3}H	267
^{60}Co	1,700
^{90}Sr	471
Sr total	1,320
^{106}Ru	1,890
^{137}Cs	897
^{147}Pm	175
Radium total	94.3
U total	14,300
^{238}Pu	89.5
$^{239/240}Pu$	358
^{241}Pu	71,600
^{241}Am	1,070

Reference: WHC-SD-L045H-SAD-001, *300 Area Treated Effluent Disposal Facility Preliminary Safety Analysis Document* (Bendixsen 1993).

Dose Rate

Probably not above background.

CHEMICAL CHARACTERISTICS

Narrative Description

The sludge will be mostly composed of ferric hydroxide. It will be stable and nonreactive.

Reference: WHC-SD-L045H-SAD-001, *300 Area Treated Effluent Disposal Facility Preliminary Safety Analysis Document* (Bendixsen 1993).

Primary Components

The concentrations are ppb. Total constituents that precipitate = 1.86 E+8. Only major constituents are listed.

Ca	3.79 E+7
Fe	7.27 E+7
Mg	6.31 E+6
Si	4.24 E+6
Bicarbonate	1.17 E+8
Hydroxide	3.48 E+6
Polymer	1.16 E+7

Reference: WHC-SD-L045H-SAD-001, *300 Area Treated Effluent Disposal Facility Preliminary Safety Analysis Document* (Bendixsen 1993).

Waste Codes

Unknown until TCLP test can be performed on sludge.

Hazardous Characteristics

None anticipated. The TCLP test may show some toxicity.

Hazardous Components

Arsenic, barium, beryllium, cadmium, lead, cyanide, silver, selenium, ammonia.

PACKAGING DESCRIPTION

Container Type	U.S. Department of Transportation 17C or 17H 55-gal drums.
Internal Packaging	90-mil rigid polyethylene liner and absorbent mixed with the sludge.
Venting Mechanism	None.
Gross Weight	700 to 1,100 lb (the actual weight will depend on the ratio of sludge and absorbent).
Closure Mechanism	Snap lid on liner; lock ring on drum.

Table D-8. Specification for Feed Stream 5A1, Elemental Mercury, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM	
CDR Identification Number	5A1
Common Name	Elemental Mercury
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.
GENERATION	
Narrative Description	Mercury was used throughout the Hanford Site and U.S. Department of Energy complex in vacuum pumps, gauges, and other applications.
Generator(s)	Most of the existing mercury waste comes from the Hanford Site but other U.S. Department of Energy sites also have forecasted small amounts of this waste type.
Existing Volume	Approximately 61 ft^3 or 8 drum equivalents (DE) are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 395 ft^3 or 54 DEs. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.
PHYSICAL CHARACTERISTICS	
Narrative Description	The elemental mercury is in glass or polyethylene containers surrounded by absorbent (diatomaceous earth or similar material) and possibly some packing.
Physical State	Mercury metal. The actual mercury content of the drums is only 128 lb or about 7% by weight and 0.2% by volume of the existing waste.
Density	845 lb/ft^3 for the elemental mercury. The existing drums have an average density of about 30 lb/ft^3.
Moisture Content	None.
Particle Size	Not applicable.
Hardness	Not applicable.

RADIOLOGICAL CHARACTERISTICS

Waste Class	Primarily Class I.
Radionuclide Content	Existing waste does not contain significant curies of ^{99}Tc, ^{129}I, ^{79}Se, or ^{237}Np. The total enriched uranium content of existing waste is 1 E-03 g and the projected curie inventory is approximately 3 E-09.
Dose Rate	Existing waste drums are <1 mR/h at drum surface. Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description	Toxic fluid metallic substance.
Primary Components	Mercury with absorbent and packaging material. Existing waste containers have a mercury content ranging from 0.5 to 24.1 kg with an average of 9.9 kg of mercury per container.
Waste Codes	The codes shown below are for existing waste. Forecast waste could have additional codes. Listed Components: U151 Mercury Characteristics: D009 Mercury State Codes: WT01 Toxic EHW (mercury) Reference: SWITS database.
Hazardous Characteristics	Toxic.
Hazardous Components	Elemental mercury.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums. Two 8-gal drums also are shown in the SWITS database. The maximum size of the existing mercury containers within the 55-gal drums is estimated to be about one-half gal.

Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners. There is no evidence indicating the drums are concrete lined.
Venting Mechanism	None.
Gross Weight	All mercury containers are expected to be <1,000 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-9. Specification for Feed Stream 5A2, Mercury Chemicals/Solutions, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM	
CDR Identification Number	5A2
Common Name	Mercury Chemicals/Solutions
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.
GENERATION	
Narrative Description	Mercury chemical/solution waste is generated from a variety of sources throughout the Hanford Site. The mercury and other component contents of the waste are widely variable. About 99% of existing waste are lab packs.
Generator(s)	Most of the existing mercury waste comes from the Hanford Site but other U.S. Department of Energy sites also have forecasted this type of waste.
Existing Volume	Approximately 156 ft^3 or 21 DEs are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 1,003 ft^3 or 137 DEs. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.
PHYSICAL CHARACTERISTICS	
Narrative Description	Mercury chemicals (solutions, salts, reagents, standards), sludge, batteries, light tubes, paints, and liquids in any combination with absorbent (diatomaceous earth or similar material and padding), polyethylene, glass, and possibly some metal.
Physical State	Primarily liquid/solid containers (lab packs) and absorbent, batteries, and light tubes. The actual mercury content of the drums is <1% by weight.
Density	Average density of existing drums is about 66 lb/ft^3.
Moisture Content	Dry waste except for a few containers of mercury solutions.
Particle Size	Not applicable.
Hardness	Not applicable.

RADIOLOGICAL CHARACTERISTICS

Waste Class — Primarily Class I.

Radionuclide Content — Existing waste does not contain significant curies of ^{99}Tc, ^{129}I, ^{79}Se, or ^{237}Np. The total enriched uranium content of existing waste is 12 g and the projected curie inventory is approximately 4 E-05.

Dose Rate — Existing waste drums are <1 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description — Mercury chemicals, salts, and solutions combined with other toxic substances.

Primary Components — Primarily mercury chemicals with absorbent and other materials. The following list of constituent contents in existing containers is provided for information:

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
As	N/A	0.0002	0.0002
Ba	0.0005-0.01	0.4495	0.026441
Cr	0.0017-0.014	0.1847	0.011544
Pb	0.013-0.024	0.307	0.020467
Se	0.0002-0.0003	0.0036	0.00024
Ag	0.0004-0.003	0.0338	0.002113
$Fe(NO_3)_3 \bullet 9H_2O$	N/A	0.0105	0.0105
$Hg(SCN)_2$	N/A	0.0004	0.0004
NO_3	N/A	0.1974	0.1974
HNO_3	N/A	0.0315	0.0315
HCl	N/A	0.2933	0.2933
BaO_2	N/A	2	2
Sb	N/A	0.02	0.02
Cd	0.0003-0.01	0.0103	0.00515
$CaCl_2FPO_3$	N/A	0.9398	0.9398
Mn	N/A	0.02	0.02

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
BaF_3	N/A	0.0045	0.0045
NH_4Cl	0.119-0.1638	0.2828	0.1414
MnO_2	N/A	0.9557	0.9557
Zn	0.046-0.4912	0.5372	0.2686
$ZnCl_2$	0.076-0.1911	0.2671	0.13355
NiOH	0.0005-0.173	0.1735	0.08675
KOH	N/A	0.371	0.371

[1]Constituents shown as elements may be present as salts.
[2]For containers where specific constituent has been identified.
N/A = Not applicable. Constituent present in one drum or quantity is too low to provide range.

Reference: SWITS database.

Waste Codes

The codes shown below are for existing waste. Forecast waste could have additional codes.

Listed Components:

U151 Mercury

Characteristics:

D001 Ignitable
D002 Corrosive
D003 Reactive
D004 Arsenic
D005 Barium
D006 Cadmium
D007 Chromium
D008 Lead
D009 Mercury
D010 Selenium
D011 Silver

State Codes:

WC01 Carcinogenic
WT01 Toxic EHW
WT02 Toxic DW

Reference: SWITS database.

Hazardous Characteristics	Toxic, corrosive, reactive, and carcinogenic. No individual drums have been identified to date with all three codes of D001, D002, and D003.
Hazardous Components	See previous list. Mercury concentration is expected in high and low subcategories.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums. One 30- and three 5-gal drums are shown in the SWITS database. There is no indication of the size of the inner containers; however, the maximum size is not expected to be much >1 gal.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners.
Venting Mechanism	None.
Gross Weight	All mercury containers are expected to be <1,000 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-10. Specification for Feed Stream 5A3, Mercury-Contaminated Heterogeneous Solids, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	5A3
Common Name	Mercury-Contaminated Heterogeneous Solids
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.

GENERATION

Narrative Description	Mercury waste is generated from a variety of sources throughout the Hanford Site. The mercury and other components are widely variable in composition.
Generator(s)	Most of the existing mercury waste comes from the Hanford Site but other U.S. Department of Energy sites also have forecasted this type of waste.
Existing Volume	Approximately 261 ft^3 or 35 DEs are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 1,677 ft^3 or 228 DEs. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	The drums contain any combination of cloth, diatomaceous earth or similar adsorbent, metal, paper, polyethylene, wood, glass, floor tile, rubber, cement, conwed* pads, rock, and/or batteries, contaminated with mercury mostly via incidental contact.
Physical State	Primarily heterogeneous solid waste including debris. The actual mercury content of the drums is <1% by weight.
Density	Average density of existing drums is about 36 lb/ft^3.
Moisture Content	None.
Particle Size	Not available.

*Conwed is a trademark of Leucadia, Inc.

Hardness — Not available.

RADIOLOGICAL CHARACTERISTICS

Waste Class — Primarily Class I.

Radionuclide Content — Nominal curie values per drum for drums of existing waste containing the radionuclide:

^{99}Tc 6.1 E-13
^{129}I 1.2 E-15
U 1.2 E-06
No ^{79}Se or ^{197}Np are reported.

The total curie inventories of ^{99}Tc, ^{129}I, and uranium are projected to be 9.6 E-12, 1.8 E-14, and 9.2 E-06, respectively.

Dose Rate — Existing waste drums are <1 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description — Wide variety of materials.

Primary Components — Debris-type materials. The following list of constituent contents in existing containers is provided for information:

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
Ba	0.035-38.0018	71.5523	5.504023077
Pb	N/A	0.1134	0.1134
Sb	N/A	0.06	0.06
Cd	0.0006-13.2902	33.7731	2.25154
$CaCl_2FPO_3$	0.6001-5.0711	26.9865	2.9985
Mn	N/A	0.06	0.06
NH_4Cl	0.04-0.35	0.39	0.195
Zn	N/A	0.25	0.25
$ZnCl_2$	0.028-0.22	0.248	0.124
NiOH	N/A	0.38	0.38
KOH	0.02-0.085	0.105	0.0525
CdOH	N/A	0.205	0.205

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
NaOH	N/A	0.085	0.085
CoOH	N/A	0.02	0.02

[1]Constituents shown as elements may be present as salts.
[2]For containers where specific constituent has been identified.
N/A = Not applicable. Constituent present in one drum or quantity is too low to provide range.

Reference: SWITS database

Waste Codes

The code shown below is for existing waste. Forecast waste could have additional codes.

Listed Components:

U151 Mercury

Characteristics:

D002 Corrosive
D005 Barium
D006 Cadmium
D008 Lead
D009 Mercury

State Codes:

WT01 Toxic EHW
WT02 Toxic DW
WC01 Carcinogenic EHW
WC02 Carcinogenic DW

Reference: SWITS database.

Hazardous Characteristics

Toxic, corrosive, and carcinogenic.

Hazardous Components

See above list. Mercury concentration is expected in high and low subcategories.

PACKAGING DESCRIPTION

Container Type

Primarily U.S. Department of Transportation 17H 55-gal drums. One 20-, one 30-, and two 8-gal drums are shown in the SWITS database.

Internal Packaging

90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners.

Venting Mechanism

None.

Gross Weight	All mercury-contaminated waste containers are expected to be <1,000 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-11. Specification for Feed Stream 5C1, Elemental Lead, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	5C1
Common Name	Elemental Lead
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.

GENERATION

Narrative Description	Lead waste is generated from a variety of sources throughout the Hanford Site and other U.S. Department of Energy sites.
Generator(s)	The majority of the elemental lead waste in storage is from the Hanford Site and a one-time shipment from the Shippingport Reactor (not forecasted as a future generator). The Hanford Site is expected to be the major generator but other U.S. Department of Energy sites have forecasted a small amount of this waste.
Existing Volume	Approximately 3,880 ft^3 (includes 182 drums and 18 boxes) are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 25,741 ft^3 or 3,159 DEs and 18 boxes. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	Drums or boxes that have lead coding with a description showing major physical characteristics of lead or metal are considered to contain elemental lead.
Physical State	Actual lead content of the existing drums is 274,589 lb (84% by weight) and about 12% by volume. The majority of the material in the drums and boxes is expected to be lead shielding and pipe. The remaining small percentage of material is any combination of adsorbent, polyethylene, paper, acids, metal, asbestos, rubber, or cloth.
Density	Average densities of existing drums and boxes are about 97 and 74 lb/ft^3, respectively.

Moisture Content	None.
Particle Size	Not applicable.
Hardness	Soft metal.

RADIOLOGICAL CHARACTERISTICS

Waste Class	Classes I and III.
Radionuclide Content	Existing waste does not contain significant curies of ^{99}Tc, ^{129}I, ^{79}Se, or ^{237}Np. The total enriched uranium content of existing waste is 1.2 g and the projected curie inventory is approximately 3.3 E-06.
Dose Rate	Existing waste drums range from 0.1 to 90 mR/h at drum surface. Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description	Primarily elemental lead.
Primary Components	Lead metal.
Waste Codes	Characteristics: D008 Lead State Codes: WT01 Toxic EHW Reference: SWITS database.
Hazardous Characteristics	Toxic.
Hazardous Components	Lead.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums. Thirty-two 85-, one 10-, one 8-, and one 2-gal drums are shown in the SWITS database. A total of eighteen 4- by 4- by 8-ft boxes also are in storage.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners.
Venting Mechanism	None.

Gross Weight	Thirteen of the existing 85-gal drums and 18 of the 55-gal drums are heavier than 1,000 lb. Minimum weight is 200 lb, maximum weight is 1,460 lb, and the average weight is 343 lb. The existing boxes have a minimum weight of about 3,000 lb, a maximum weight of about 7,000 lb, and an average weight of 6,270 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-12. Specification for Feed Stream 5C2, Lead Chemicals/Solutions, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM	
CDR Identification Number	5C2
Common Name	Lead Chemicals/Solutions
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.
GENERATION	
Narrative Description	Lead waste is generated from a variety of sources throughout the Hanford Site and other U.S. Department of Energy sites.
Generator(s)	The majority of the lead chemicals/solutions waste in storage is from the Hanford Site but other U.S. Department of Energy sites also have forecasted this waste type.
Existing Volume	Approximately 7 ft^3 or 1 DE are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 48 ft^3 or 6 DEs. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.
PHYSICAL CHARACTERISTICS	
Narrative Description	Drums that have lead and other hazardous constituents in a chemical form, i.e., lead oxide, lead salts, and/or lead chemicals and solutions.
Physical State	Actual lead content of the drums is <1% by weight. The remaining high percentage of material is any combination of adsorbent (diatomaceous earth or similar material), polyethylene, glass, and other materials. Existing waste is about 50% lab packs and 50% absorbed or free liquids.
Density	Average density of existing drums is about 26 lb/ft^3. The maximum lead content of the drums is slightly >1 lb.
Moisture Content	Dry waste except for a few containers of lead solutions.
Particle Size	Not applicable.

Hardness — Not applicable.

RADIOLOGICAL CHARACTERISTICS

Waste Class — Classes I and III.

Radionuclide Content — Nominal curie values per drum for drums of existing waste containing the radionuclide:

^{99}Tc	6 E-10
^{129}I	1 E-12
^{79}Se	1.6 E-11
U	3.7 E-10

No ^{197}Np is reported.

The total curie inventories for ^{99}Tc, ^{129}I, ^{79}Se, and uranium are projected to be 4.6 E-09, 8.3 E-12, 1.3 E 10, and 3 E-09, respectively.

Dose Rate — Existing waste drums range from 0.01 to 3.5 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description — Various types of lead chemicals, salts, solutions, etc.

Primary Components — Primarily contained chemical reagents and standards. The following list of maximum amount of constituents in existing waste is provided for information:

Constituent	Total quantity (kg)
$Ce(NO_3)_3 \cdot 5H_2O$	0.11
PbO_2	0.45
$KBrO_3$	0.45
$KClO_3$	0.45
KNO_3	0.45
KIO_4	0.22
$KMnO_4$	0.9
$Th(NO_3)_4 \cdot 4H_2O$	0.45

Waste Codes — The codes shown below are for existing waste. Forecast waste could have additional codes.

Characteristics:

D001 Ignitable
D008 Lead

State Codes:

WC01 Carcinogenic EHW
WT02 Toxic DW

Reference: SWITS database.

Hazardous Characteristics	Ignitable, carcinogenic, and toxic.
Hazardous Components	Lead.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners. There is no indication of the size of the inner containers; however, the maximum size is not expected to be much >1 gal.
Venting Mechanism	None.
Gross Weight	The 55-gal drums are expected to be <1,000 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-13. Specification for Feed Stream 5C3, Lead-Contaminated Heterogeneous Solids, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	5C3
Common Name	Lead-Contaminated Heterogeneous Solids
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.

GENERATION

Narrative Description	Lead waste is generated from a variety of sources throughout the Hanford Site and other U.S. Department of Energy sites.
Generator(s)	The majority of the lead contaminated heterogeneous solid waste in storage is from the Hanford Site but other U.S. Department of Energy sites also have forecasted this type of waste.
Existing Volume	Approximately 611 ft^3 or 83 DEs are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 4,055 ft^3 or 552 DEs. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	Drums that have lead-contaminated waste/debris in any combination of cloth, absorbent (diatomaceous earth or similar material), metal, paper, polyethylene, wood, glass, rubber, conwed pads, stainless steel, filters, or wire.
Physical State	Actual lead chemical content of the drums is about 59% by weight. The remaining percentage consists of other materials and debris.
Density	The average density of existing drums is about 35 lb/ft^3. The lead content of existing drum waste is a maximum of about 840 lb, a minimum of <1 lb, and an average of about 340 lb.
Moisture Content	None.
Particle Size	Not applicable.

Hardness — Not applicable.

RADIOLOGICAL CHARACTERISTICS

Waste Class — Classes I and III.

Radionuclide Content — Nominal curie values per drum for drums of existing waste containing the radionuclide:

^{99}Tc	9.5 E-07
^{129}I	1.8 E-06
U	9.6 E-08

The total curie inventories for ^{99}Tc, ^{129}I, and uranium are projected to be 9 E-05, 1.4 E-05, and 1.8 E-06, respectively.

Dose Rate — Existing waste drums range from 0.02 to 70 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description — Mostly debris-type materials.

Primary Components — Lead-contaminated waste. The following list of constituent contents in existing containers is provided for information:

Constituent	Range (kg)*	Total (kg)*	Average (kg)*
Pb	0.064	321.55	146.89
$PbCrO_4$	0.064-1.99	2.13	0.71
BF_3	N/A	0.1	0.1

*For containers where specific constituent has been identified.
N/A = Not applicable. Constituent present in one drum or quantity is too low to provide range.

Waste Code — The codes shown below are for existing waste. Forecast waste could have additional codes.

Characteristics:

D002 Corrosive
D003 Reactive
D007 Chromium
D008 Lead

State Codes:

WC01 Carcinogenic EHW
WP01 Persistent EHW
WT01 Toxic EHW

Reference: SWITS database.

Hazardous Characteristics	Corrosive, reactive, toxic, carcinogenic, and persistent.
Hazardous Components	Lead and chromium.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners.
Venting Mechanism	None.
Gross Weight	The 55-gal and smaller container are expected to be <1,000 lb. The box has a gross weight of about 2,900 lb, and the lead content of the box is about 300 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-14. Specification for Feed Stream 7, Thermal Treatment Ash, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	7
Common Name	Thermal Treatment Ash
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.

GENERATION

Narrative Description	Ash waste is CH MLLW that has been treated by the specific incineration technology but still contains hazardous constituents that must be immobilized.
Generator(s)	All the ash waste will be generated by the proposed Hanford Thermal Treatment Facility.
Existing Volume	None
Forecast	Feed to the Hanford Thermal Treatment Facility is still being characterized. The design basis for drum input to the Thermal Treatment Facility is approximately ten 55-gal drums per day. The volume-based ratio of ash to feed in the Thermal Treatment Facility will be 0.2. Therefore, the ash flow rate will be two 55-gal drums per day for 9 months of operation. The total amount of ash waste to be processed in WRAP 2A is estimated to be 72,200 ft^3 or 9,831 DEs. References: 1992 forecast data; SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	The ash or slag will derive from the following three sources in the feed: • Residue of inorganic materials in the feed • Ash from the incineration of combustible materials in the feed • Steel from drums (only of drums that are shredded).
Physical State	The principal inorganic materials in the feed after treatment are expected to be as follows: • Dirt/soil

- Absorbent (kitty litter/vermiculite/diatomaceous earth)
- Metal/iron/galvanized sheet
- Glass
- Concrete/cement
- Rock/gravel
- Sand.

The state of these components in the ash will depend on incineration conditions. If incineration temperatures are below the melting points of the materials, the inorganic materials will be scorched (surface oxidation), but the physical consistency of the materials will be maintained. If incineration temperatures are such that a slag is formed, the inorganic components will contribute to the chemical and mineral composition of the slag.

The ash from the incineration of combustible materials should be a typical powdered incineration ash.

Density	Ash density will vary appreciably but is expected to average in the range of 100 to 250 lb/ft^3. Average density of drum contents will be less than ash density.
Moisture Content	None.
Particle Size	Will range from fine particulate to solid chunks of ash and metal.
Hardness	Not available.

RADIOLOGICAL CHARACTERISTICS

Waste Class	Classes I and III.
Radionuclide Content	Expected to be about a factor of 5 greater than the radionuclide content of the heterogeneous solid/debris waste stream.
Dose Rate	Expected to range up to 100 mR/h at drum surface.

CHEMICAL CHARACTERISTICS

Narrative Description

Typical incinerator ash intermixed with metal pieces.

Primary Components

If the steel drums are shredded and fed to the thermal treatment unit, the proportion of iron and steel in the ash or slag will increase. The following table shows the weight percentages of components in the ash with and without the steel from the drums.

The ash constituents will be mostly silica and iron oxides. The proportion of these two constituents will depend on whether the drum steel is included in the ash. The weight ratios of silica to iron oxide with and without the drum steel are as follows.

	Weight SiO_2/weight Fe_2O_3
With drum steel	0.85
Without drum steel	4.7

Component	Wt% Without drum steel	Wt% With drum steel
Dirt/soil/diatomaceous earth	55.1	32.5
Absorbent/kitty litter/vermiculite	15.4	9.1
Metal/iron/galvanized sheet	15.2	49.8
Glass	4.7	2.8
Concrete	4.0	2.4
Rock/gravel	2.5	1.5
Sand	1.6	1.0
Combustion ash and miscellaneous	1.5	0.8
Total	100.0	100.0

Waste Codes

Codes are expected to be similar to those for heterogeneous solid waste. Forecast waste could have additional codes.

Listed Components:

P029 Copper cyanide
P030 Cyanide salts
P120 Vanadium oxide

Characteristics:

D002 Corrosive
D004 Arsenic
D005 Barium
D006 Cadmium
D007 Chromium
D008 Lead

D009 Mercury
D010 Selenium
D011 Silver

State Codes:

WC01 Carcinogenic EHW
WC02 Carcinogenic DW
WT01 Toxic EHW
WT02 Toxic DW

Hazardous Characteristics	Toxic, corrosive, carcinogenic, and reactive.
Hazardous Components	Listed components are expected to be coded by the derived-from rule.

PACKAGING DESCRIPTION

Container Type	U.S. Department of Transportation 17H 55-gal drums.
Internal Packaging	90-mil rigid polyethylene liner for 55-gal drums.
Venting Mechanism	None.
Gross Weight	The 55-gal drums are expected to have a gross weight of <1,000 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. Rigid polyethylene lined should have only one type of closure mechanism.

Table D-15. Specification for Feed Stream 9A, Particulate/Sludge, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	9A
Common Name	Particulate/Sludge
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.

GENERATION

Narrative Description	Particulate/sludge waste is generated from a variety of sources throughout the Hanford Site.
Generator(s)	Most of the existing particulate/sludge waste comes from the Hanford Site but other U.S. Department of Energy sites also have forecasted this type of waste.
Existing Volume	Approximately 979 ft^3 or 133 DEs are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 146,047 ft^3 or 19,885 DEs. The grout facility accounts for 58,161 ft^3 of the forecast waste. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	This waste stream encompasses a wide range of materials including sludge, absorbed liquids (acids, alkalies, pesticides, etc.), particulate (ash, soot, powder), absorbent (diatomaceous earth or similar material), soil, spent resin (excluding Liquid Effluent Treatment Facilities [LETF]), and some asbestos. These materials may be combined with small amounts of glass, polyethylene, paper, metal, etc.
Physical State	Ranges from fine particles to paste-type material.
Density	Average density of existing drums is about 68 lb/ft^3.
Moisture Content	Primarily dry waste with water of hydration or retained moisture (unknown quantity).
Particle Size	Consistency of soil and caked sludge including lumps.
Hardness	Not available.

RADIOLOGICAL CHARACTERISTICS

Waste Class

Primarily Class I but a small portion may be Class III.

Radionuclide Content

Nominal curie values per drum for drums of existing waste containing the radionuclide:

^{99}Tc	4.1 E-08
^{129}I	7.8 E-13
^{79}Se	1.2 E-11
U	8.9 E-04

No ^{197}Np has been reported. The total curie inventories for ^{99}Tc, ^{129}I, ^{79}Se, and uranium are projected to be 1.2 E-05, 1.2 E-10, 1.8 E-09, and 2.5 E-00, respectively. This projection does not take into account special-case wastes of high-enriched uranium that are forecast to be received from Portsmouth or other U.S. Department of Energy sites. Efforts are being made to obtain the estimated total curie inventory of ^{99}Tc for the Portsmouth waste. The ^{235}U content of some Portsmouth drums is expected to range from <15 g/drum to several hundred g/drum but would not exceed the limit of 350 g for shipping.

Dose Rate

Existing waste drums range from 0.1 to 15 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description

The majority of this waste is sludge, soils, resins, and other particulate waste contaminated with toxic metals. Absorbents may contain acids or alkalies.

Primary Components

Toxic metals, acids, nitrates, alkalies, pesticides, and other similar contaminants. The hazardous material content of the existing waste is about 46% by weight. The following list of constituent contents in existing containers is provided for information:

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
Cr	0.09-0.23	11.51	3.836667
Cu	26.76-32.2	1,872.88	624.2933
NaF	0.9-50.8	3,064.826	340.5362
NaOH	5.75-37.19	2,193.002	548.2504

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
$NaNO_3$	0.67-32.66	2,031.15	203.115
Zr	0.59-0.86	46.61	15.53667
KOH	10.0-56.25	66.2517	33.12585
FeO_2	N/A	5.62	5.62
NaO_2	0.51-48.26	48.761	24.3805
Cd	0.0014-0.11	0.1114	0.0557
$CrSO_4$	N/A	0.52	0.52
$CuSO_4$	N/A	0.1	0.1
NaCl	10.99-199.9	4,328.972	166.4989
$NaCO_3$	N/A	1.7	1.7
$NaPO_3$	N/A	1.7	1.7
Na_2SiO_3	N/A	1.7	1.7
Asbestos	0.25-23.6	239.1467	14.94667
HNO_3	0.01-0.09	1.15	0.052273
$UO_2(NO_3)_2 \bullet 6H_2O$	N/A	1.3898	1.3898
$Al(NO_3)_3 \bullet 9H_2O$	N/A	0.2	0.2
H_2O_2	N/A	0.1	0.1
$Mg(ClO_4)_2$	N/A	0.1	0.1
$KMnO_4$	N/A	0.8	0.8
$AgNO_3$	N/A	0.1	0.1
Ba	N/A	0.4999	0.4999
Se	N/A	1.002	1.002
CdO_2	N/A	0.44	0.44
CrO_2	N/A	1.49	1.49
AgO_2	N/A	0.39	0.39
NiOH	0.002-0.135	0.137	0.0685
Ethylene glycol	N/A	36.29	36.29
CaO_2	N/A	0.5	0.5

[1]Constituents shown as elements may be present as salts.
[2]For containers where specific constituent has been identified.
N/A = Not applicable. Constituent present in one drum or quantity is too low to provide range.

Waste Codes	The codes shown below are for existing waste. Forecast waste could have additional codes. Characteristics: D001 Ignitable D002 Corrosive D004 Arsenic D005 Barium D006 Cadmium D007 Chromium D010 Selenium D011 Silver State Codes: WC01 Carcinogenic EHW WC02 Carcinogenic DW WP02 Persistent DW WT01 Toxic EHW WT02 Toxic DW Reference: SWITS database.
Hazardous Characteristics	Toxic, corrosive, reactive, persistent, and carcinogenic.
Hazardous Components	Toxic metals and salts.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums. Three 85-, one 30-, and two 10-gal drums are shown in the SWITS database. Some of the forecast waste will be in 4- by 4- by 8-ft boxes.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners.
Venting Mechanism	None.
Gross Weight	The 55-gal drums are expected to be <1,000 lb. The maximum gross weight of the existing drums is 760 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-16. Specification for Feed Stream 9B, Heterogeneous Solids/Debris, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	9B
Common Name	Heterogeneous Solids/Debris
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums. One subset will be reverse osmosis filters from the LETF C-018 facility and another subset will be high-efficiency particulate air (HEPA) filter packages in drums and boxes.

GENERATION

Narrative Description	Heterogeneous solids/debris waste is generated from a variety of sources throughout the Hanford Site.
Generator(s)	Most of the existing heterogeneous solids/debris waste comes from the Hanford Site but other U.S. Department of Energy sites also have forecasted this type of waste.
Existing Volume	Approximately 935 ft^3 or 127 DEs are in the SWITS database.
Forecast	This stream represents one of the greatest uncertainties with regard to forecast volumes because of the impacts of the "Debris Rule" (57 FR 37194) and regulatory/U.S. Department of Energy issues surrounding startup of specific facilities. The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is estimated to be 450,540 ft^3 or 61,34- DEs. The grout facility accounts for about 171,716 ft^3 of the forecast waste. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	This waste stream encompasses any combination of cloth, metal, paper, polyethylene, wood, glass, absorbent, rubber, conwed pads, HEPA and reverse osmosis filters, concrete, biological waste, and other materials or debris.
Physical State	All shapes but generally >2.5 in. Most of the metal is stock, scrap, or equipment <0.5 in. in thickness but some metal will be much larger in cross-section.

Density	Average density of existing drums is about 31 lb/ft^3.
Moisture Content	None.
Particle Size	Not available.
Hardness	Not available.

RADIOLOGICAL CHARACTERISTICS

Waste Class	Primarily Class I but a small portion may be Class III.
Radionuclide Content	Nominal curie values per drum for drums of existing waste containing the radionuclide: ^{99}Tc 4.2 E-06 ^{129}I 4.4 E-06 U 4.6 E-02 No ^{97}Se or ^{197}Np has been reported. The total curie inventories for ^{99}Tc, ^{129}I, and uranium are projected to be 5.0 E-02, 5.1 E-02, and 2.4 E+01, respectively. This projection does not take into account special-case wastes of high-enriched uranium that are forecast to be received from Portsmouth or other U.S. Department of Energy sites. Efforts are being made to obtain the estimated total curie inventory of ^{99}Tc for the Portsmouth waste. The ^{235}U content of some Portsmouth drums is expected to range from <15 g/drum to several hundred g/drum but would not exceed the limit of 350 g for shipping.
Dose Rate	Existing waste drums range from 0.01 to 95 mR/h at drum surface. Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description	All types of hazardous constituents may be present in this waste including small amounts of surface contamination from organics.
Primary Components	Toxic metals, acids, nitrates, alkalies, pesticides, organics, and other similar contaminants. The hazardous material content of the existing waste is about 6% by weight. The following list of constituent contents in existing containers is provided for information:

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
NaOH	0.1-10.99	21.3649	3.052129
HCl	N/A	0.4999	0.4999
HNO_3	0.9-4.0	5.3992	1.799733
H_2SO_4	N/A	0.2	0.2
KOH	0.899-47.35	114.3403	19.05672
$FeNO_3$	N/A	0.1	0.1
$NaNO_3$	N/A	0.265	0.265
HF	N/A	0.1	0.1
Soda ash	N/A	3	3
NH_4F	2.99-7.89	18.32	6.106667
$(NH_4)_2ZrF_6$	7.48-19.73	45.81	15.27
NH_4NO_3	2.99-7.89	18.32	6.106667
$C_2H_2O_4$	0.1-0.3	0.4	0.2
$AlNO_3$	N/A	2.2702	2.2702
Cu	N/A	625.6	625.6
Be	N/A	0.0005	0.005
Ag	N/A	4.1998	4.1998
Asbestos	N/A	0.1	0.1
$UO_2(NO_3)_2 \bullet 6H_2O$	0.05-0.699	0.8399	0.279967
$ZrCrO_4$	N/A	1.5998	1.5998
Cd	N/A	0.03	0.03
Co	N/A	0.002	0.002
Ni	N/A	0.05	0.05
K	N/A	0.004	0.004
Cr	N/A	0.002	0.002
H_3PO_4	N/A	11.9984	11.9984
Ni/Cd	N/A	7.7382	7.7382
$CdNO_3$	0.55-1.25	1.8003	0.90015
Cresote	N/A	0.0013	0.0013
Tar	N/A	0.0001	0.0001
Benzene	N/A	0	0

Constituent[1]	Range (kg)[2]	Total (kg)[2]	Average (kg)[2]
Acetone	N/A	0.0025	0.0025
MEK	N/A	0.0025	0.0025
MIK	N/A	0.0025	0.0025
Hexone	N/A	0	0
Isobutanol	N/A	0	0
Pyridine	N/A	0	0
Toluene	N/A	0	0
1,1,1 trichloroethylene	N/A	0.0001	0.0001
Methylene chloride	N/A	0.0016	0.0016

[1]Constituents shown as elements may be present as salts.
[2]For containers where specific constituent has been identified.
N/A = Not applicable. Constituent present in one drum or quantity is too low to provide range.

Waste Codes

The codes shown below are for existing waste. Forecast waste could have additional codes.

Listed Components:

F001 Halogenated solvent
F002 Halogenated solvent
F003 Nonhalogenated solvent
F005 Nonhalogenated solvent

Characteristics:

D001 Ignitable
D002 Corrosive
D003 Reactive
D006 Cadmium
D007 Chromium
D011 Silver
D018 Benzene

State Codes:

WC01 Carcinogenic EHW
WC02 Carcinogenic DW
WT01 Toxic EHW
WT02 Toxic DW

Reference: SWITS database.

Hazardous Characteristics	Toxic, corrosive, reactive, ignitable, and carcinogenic. No individual drums have been identified to date with all three codes D001, D002, and D003.
Hazardous Components	Toxic metals, salts, and small concentrations of organics.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums and 4- by 4- by 8-ft boxes. Two 85-, one 5-, and eleven 30-gal drums are shown in the SWITS database.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners.
Venting Mechanism	None.
Gross Weight	The 55-gal drums are expected to have a gross weight of <1,000 lb. The maximum gross weight of the existing drums is 820 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

Table D-17. Specification for Feed Stream 9C, Contained Liquid, Including Physical, Chemical, and Radiological Characteristics.

FEED STREAM

CDR Identification Number	9C
Common Name	Contained Liquid
Subset(s)	Subset lot definition is expected to be based on similar waste codes for a specific group of drums.

GENERATION

Narrative Description	Liquid waste is generated from a variety of sources throughout the Hanford Site and other U.S. Department of Energy sites.
Generator(s)	The majority of the contained liquid waste in storage is from the Hanford Site but other U.S. Department of Energy sites also have forecasted this type of waste.
Existing Volume	Approximately 328 ft^3 or 45 DEs are in the SWITS database.
Forecast	The total amount of this waste, including the existing volume and forecasts from various generators and WRAP 1, is approximately 15,018 ft^3 or 2,045 DEs. References: 1992 forecast data (see Appendixes A, B, and C); SWITS database.

PHYSICAL CHARACTERISTICS

Narrative Description	All the existing contained liquid waste is either lab packs or containers that have been identified from the descriptions of the waste in the drums. These lab packs/containers contain a wide range of chemicals excluding mercury and lead that will require special processing. The liquid containers are expected to be either glass or polyethylene vessels and are expected to be surrounded by absorbent (diatomaceous earth or similar material) and/or conwed padding. About 83% of the forecast waste are lab packs and the remainder are other contained liquids.
Physical State	Hazardous constituents are only about 9% by weight of the existing drums. The remaining materials are absorbent and possibly some heterogeneous solid waste mixed in with the contained liquid.
Density	Average density of existing drums is about 37 lb/ft^3.

Moisture Content — Liquid.

Particle Size — Not available.

Hardness — Not available.

RADIOLOGICAL CHARACTERISTIC

Waste Class — Mostly Class I. Only a very small portion of this waste is expected to be Class III.

Radionuclide Content — Nominal curie values per drum for drums of existing waste containing the radionuclide:

^{99}Tc	1.8 E-10
^{129}I	3.3 E-13
^{79}Se	9.4 E-12
U	2.4 E-06

The total curie inventories for ^{99}Tc, ^{129}I, ^{79}Se, and uranium are projected to be 3.4 E-08, 6.3 E-11, 9.1 E-10, and 8 E-04, respectively.

Dose Rate — Existing waste drums range from 0.01 to 42 mR/h at drum surface.

Reference: SWITS database.

CHEMICAL CHARACTERISTICS

Narrative Description — Chemicals consist of acids, alkalies, various dissolved salts (including toxic metals), nitrates, and water-reactive substances.

Primary Components — All types of chemicals containing hazardous constituents. The following list of constituent contents in existing containers is provided for information:

Constituent	Range (kg)[1]	Total (kg)[1]	Average (kg)[1]
KCl	N/A	1.5	1.5
Cr (in solution)[2]	0.0015-0.4	0.7345	0.091813
H_3PO_4	0.045-49.98	304.1154	20.27436
FeOH	N/A	0.2	0.2
NaCl	0.6-0.92	1.5201	0.76005
NH_4SO_4	N/A	1.18	1.18
$CHNaO_3$	N/A	11.3	11.3

Constituent	Range (kg)[1]	Total (kg)[1]	Average (kg)[1]
HCl	0.826-1.139	4.0882	1.02205
$K_2S_2O_7$	N/A	0.45	0.45
HNO_3	0.06-24.59	32.6551	3.628344
$Na_3PO_4 \bullet 10H_2O$	N/A	34.1	34.1
HF	0.003-52.34	76.8956	25.63187
$AgNO_3$	N/A	0.0122	0.0122
$NaCO_3$	N/A	0.0275	0.0275
NaOH	0.157-0.749	0.9073	0.45365
$C_6H_6AsH_3O_4Na_2$ (salt)	N/A	0.21	0.21
Ba^2	N/A	0.2	0.2
Ag^2	0.1-0.2	0.3	0.15
$BaCO_3$	N/A	0.1	0.1
Cu (in solution)	N/A	0.1	0.1
NiOH	N/A	0.3	0.3
Zn (in solution)	N/A	0.25	0.25
$NaNO_3$	N/A	0.7498	0.7498
Acid	N/A	1.002	1.002
H_3PO_4Cl solution	N/A	19.0009	19.0009
H_2SO_4	0.0063-0.09	0.1076	0.035867
Na (in solution)	N/A	2.5601	2.5601
H_2O	N/A	0.3904	0.8904
$UO_2(NO_3)_2 \bullet 6H_2O$	N/A	0.14	0.14
Na_2CrO_4	N/A	0.9	0.9

[1]For containers where specific constituent has been identified.
[2]Furnace tube with Ba, Cr, and Ag.
N/A = Not applicable. Constituent present in one drum or quantity is too low to provide range.

Waste Codes	The codes shown below are for existing waste. Forecast waste could have additional codes. Characteristics: D001 Ignitable D002 Corrosive D004 Arsenic D005 Barium D007 Chromium D010 Selenium D011 Silver State Codes: WC01 Carcinogenic EHW WT01 Toxic EHW WT02 Toxic DW Reference: SWITS database.
Hazardous Characteristics	Ignitable, corrosive, carcinogenic, and toxic.
Hazardous Components	Chromium, barium, arsenic, selenium, silver, and other hazardous constituents.

PACKAGING DESCRIPTION

Container Type	Primarily U.S. Department of Transportation 17H 55-gal drums. Small containers in existing storage consist of four 30-gal drums, one 15-gal drum, five 10-gal drums, and two 5-gal drums.
Internal Packaging	90-mil rigid polyethylene liner for most 55-gal drums but some drums could have 10-mil flexible polyethylene liners. There is no indication of the size of the inner containers; however, the maximum size is not expected to be much >1 gal.
Venting Mechanism	None.
Gross Weight	The 55-gal and smaller containers are expected to be <1,000 lb. The maximum gross weight of the existing drums is 970 lb.
Closure Mechanism	Bolted lock ring for 55-gal drums. NOTE: Several different types of rigid liners are available for use, each having a different closure mechanism.

D.1 REFERENCES

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D.2 GLOSSARY

ABBREVIATIONS AND ACRONYMS

CCWE	constituent concentrations in waste extract
CDR	conceptual design report
CH_MLLW	contact-handled mixed low-level waste
DE	drum equivalent
DW	dangerous waste
EHW	extremely hazardous waste
EP	extraction procedure
ETF	Effluent Treatment Facility
HEPA	high-efficiency particulate air
LETF	Liquid Effluent Treatment Facility
RCRA	Resource Conservation and Recovery Act
SWITS	solid waste information and tracking system
TCLP	toxic characteristics leach procedure
TEDF	Treated Effluent Disposal Facility
WRAP	Waste Receiving and Processing

APPENDIX E

RADIOLOGICAL DATA FOR FEED STREAMS 5 THROUGH 9

LIST OF TABLES

E-1 Radiological Data for Feed Stream 5A1, Elemental Mercury E-3

E-2 Radiological Data for Feed Stream 5A2, Mercury Chemicals/Solutions . E-5

E-3 Radiological Data for Feed Stream 5A3, Mercury-Contaminated Heterogeneous Solids E-7

E-4 Radiological Data for Feed Stream 5C1, Elemental Lead E-9

E-5 Radiological Data for Feed Stream 5C2, Lead Chemicals/Solutions . . E-11

E-6 Radiological Data for Feed Stream 5C3, Lead-Contaminated Heterogeneous Solids E-13

E-7 Radiological Data for Feed Stream 9A, Particulate/Sludge E-15

E-8 Radiological Data for Feed Stream 9B, Heterogeneous Solids/Debris E-17

E-9 Radiological Data for Feed Stream 9C, Contained Liquid E-19

Table E-1. Radiological Data for Feed Stream 5A1, Elemental Mercury.
(sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	6.0 E-05 to 1.27 E-02	0.01545	0.001405
^{3}H	--	0	--
^{14}C	--	0	--
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	5.0 E-05 to 3.2 E-04	0.00037	0.000185
^{60}Ni	--	0	--
^{63}Ni	--	0	--
^{79}Se	--	0	--
^{90}Sr	1.0 E-05 to 1.0 E-04	0.00022	0.000044
^{90}Y	1.0 E-05 to 1.0 E-04	0.00022	2.44 E-05
^{99}Tc	--	0	--
^{106}Ru	--	0.00038	0.000127
^{106}Rh	1.0 E-05 to 3.2 E-04	0.00038	4.22 E-05
^{129}I	--	0	--
^{134}Cs	N/A	0.00003	0.00003
^{135}Cs	--	0	--
^{137}Cs	3.0 E-05 to 6.29 E-03	0.00646	0.001615
^{137}Ba	3.0 E-05 to 6.29 E-03	0.00646	0.000646
^{141}Ce	--	0	--
^{144}Ce	N/A	0.00001	0.00001
^{144}Pr	--	0	0
^{147}Pm	--	0	--
^{151}Sm	--	0	--
^{152}Eu	--	0	--
^{154}Eu	N/A	0.00001	0.00001

Table E-1. Radiological Data for Feed Stream 5A1, Elemental Mercury. (sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	0	--
^{226}Ra	--	0	--
^{232}Th	--	0	--
^{233}Pa	--	0	--
^{233}U	--	0	--
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	N/A	2.16 E-09	2.16 E-09
^{236}U	--	0	--
^{238}U	--	0	--
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	--	0	--
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	--	0	--
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-2. Radiological Data for Feed Stream 5A2, Mercury Chemicals/Solutions. (sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	1.00 E-05 to 6.60 E-03	0.00796	0.000332
^{3}H	--	--	--
^{14}C	--	--	--
^{40}K	--	--	--
^{57}Co	--	--	--
^{60}Co	1.50 E-04 to 2.0 E-04	0.0005	0.000167
^{60}Ni	--	--	--
^{63}Ni	--	--	--
^{79}Se	--	--	--
^{90}Sr	N/A	0.0003	0.0003
^{90}Y	N/A	0.0003	0.0003
^{99}Tc	--	--	--
^{106}Ru	N/A	0.0004	0.0004
^{106}Rh	N/A	0.0004	0.0004
^{129}I	--	--	--
^{134}Cs	N/A	--	--
^{135}Cs	--	--	--
^{137}Cs	1.00 E-05 to 3.0 E-04	0.00045	2.81 E-05
^{137}Ba	1.00 E-05 to 3.0 E-04	0.00045	2.81 E-05
^{141}Ce	--	--	--
^{144}Ce	N/A	0.0017	0.0017
^{144}Pr	N/A	0.0017	0.0017
^{147}Pm	N/A	0.0008	0.0008
^{151}Sm	N/A	0.0004	0.0004
^{152}Eu	--	--	--
^{154}Eu	N/A	--	--

Table E-2. Radiological Data for Feed Stream 5A2, Mercury Chemicals/Solutions. (sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	--	--
^{226}Ra	--	--	--
^{232}Th	--	--	--
^{233}Pa	--	--	--
^{233}U	--	--	--
^{234}Th	--	--	--
^{234}U	--	--	--
^{235}Th	--	--	--
^{235}U	N/A	2.68 E-05	2.68 E-05
^{236}U	--	--	--
^{238}U	--	--	--
^{241}Pu	--	--	--
^{237}Np nCi/g	--	--	--
^{238}Pu nCi/g	--	--	--
^{239}Pu nCi/g	--	--	--
^{240}Pu nCi/g	--	--	--
^{241}Am nCi/g	1.16 E-01 to 3.35 E-01	3.277	0.218467
^{243}Am nCi/g	--	--	--
^{243}Cm nCi/g	--	--	--
^{244}Cm nCi/g	--	--	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-3. Radiological Data for Feed Stream 5A3, Mercury-Contaminated Heterogeneous Solids. (sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	8.31 E-09 to 1.61 E-01	0.29008	0.007438
^{3}H	8.00 E-12 to 4.0 E-05	4E-05	1.33 E-05
^{14}C	3.28 E-18 to 6.56 E-18	9.84 E-18	4.92 E-18
^{40}K	--	--	--
^{57}Co	--	--	--
^{60}Co	3.0 E-05 to 1.4 E-04	0.0002	6.67 E-05
^{60}Ni	--	--	--
^{63}Ni	--	--	--
^{79}Se	--	--	--
^{90}Sr	1.93 E-09 to 7.3 E-03	0.01202	0.001002
^{90}Y	1.93 E-09 to 7.3 E-03	0.01202	0.001002
^{99}Tc	4.06 E-13 to 8.12 E-13	1.22 E-12	6.09 E-13
^{106}Ru	3.0 E-05 to 1.02 E-02	0.01676	0.001676
^{106}Rh	3.0 E-05 to 1.02 E-02	0.01676	0.001676
^{129}I	--	--	--
^{134}Cs	--	--	--
^{135}Cs	8.08 E-15 to 1.62 E-14	2.43 E-14	1.21 E-14
^{137}Cs	2.0 E-05 to 8.5 E-03	0.01383	0.001257
^{137}Ba	2.0 E-05 to 8.5 E-03	0.01383	0.001257
^{141}Ce	--	--	--
^{144}Ce	1.73 E-03 to 4.23 E-02	0.0691	0.008638
^{144}Pr	1.7 E-03 to 4.23 E-02	0.0691	0.008638
^{147}Pm	8.0 E-04 to 1.99 E-02	0.0326	0.004075
^{151}Sm	N/A	0.0084	0.00084
^{152}Eu	--	--	--
^{154}Eu	--	--	--

Table E-3. Radiological Data for Feed Stream 5A3, Mercury-Contaminated Heterogeneous Solids. (sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	--	--
^{226}Ra	--	--	--
^{232}Th	--	--	--
^{233}Pa	--	--	--
^{233}U	--	--	--
^{234}Th	--	--	--
^{234}U	--	--	--
^{235}Th	--	--	--
^{235}U	N/A	1.08 E-07	1.08 E-07
^{236}U	--	--	--
^{238}U	6.78 E-13 to 1.35 E-12	2.03 E-12	1.01 E-12
^{241}Pu	N/A	8.03 E-07	8.03 E-07
^{237}Np nCi/g	--	--	--
^{238}Pu nCi/g	--	--	--
^{239}Pu nCi/g	2.85 E-05 to 6.4 E-01	1.555085	0.311017
^{240}Pu nCi/g	1.83 E-06 to 3.64 E-06	5.47 E-06	2.74 E-06
^{241}Am nCi/g	--	--	--
^{243}Am nCi/g	--	--	--
^{243}Cm nCi/g	--	--	--
^{244}Cm nCi/g	--	--	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-4. Radiological Data for Feed Stream 5C1, Elemental Lead.
(sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	1.0 E-05 to 1.03 E-00	6.49053	0.027386
^{3}H	N/A	0.0004	0.0001
^{14}C	--	0	--
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	1.0 E-04 to 5.6 E-03	0.0362	0.000862
^{60}Ni	1.0 E-04 to 5.0 E-03	0.0068	0.000358
^{63}Ni	--	0	--
^{79}Se	--	0	--
^{90}Sr	1.0 E-05 to 2.57 E-02	0.19212	0.004366
^{90}Y	1.0 E-05 to 2.57 E-02	0.19212	0.004366
^{99}Tc	--	0	--
^{106}Ru	1.0 E-04 to 3.58 E-02	0.2593	0.004395
^{106}Rh	1.0 E-04 to 3.58 E-02	0.2593	0.004395
^{129}I	--	0	--
^{134}Cs	N/A	0.0002	0.0001
^{135}Cs	--	0	--
^{137}Cs	1.0 E-04 to 5.1 E-01	1.0432	0.010329
^{137}Ba	1.0 E-04 to 5.1 E-01	1.0432	0.010329
^{141}Ce	--	0	--
^{144}Ce	3.4 E-03 to 1.01 E-01	0.9565	0.030855
^{144}Pr	3.4 E-03 to 1.01 E-01	0.9565	0.030855
^{147}Pm	1.6 E-03 to 6.97 E-02	0.4502	0.014523
^{151}Sm	4.0 E-04 to 1.15 E-02	0.1095	0.003532
^{152}Eu	--	0	--
^{154}Eu	1.0 E-04 to 2.0 E-04	0.0005	0.000125

Table E-4. Radiological Data for Feed Stream 5C1, Elemental Lead.
(sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	0	--
^{226}Ra	--	0	--
^{232}Th	--	0	--
^{233}Pa	--	0	--
^{233}U	--	0	--
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	2.16 E-07 to 1.0 E-06	2.81 E-06	3.12 E-07
^{236}U	--	0	--
^{238}U	N/A	3.36 E-10	3.36 E-10
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	--	0	--
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	--	0	--
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-5. Radiological Data for Feed Stream 5C2, Lead Chemicals/Solutions. (sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	1.0 E-05	0.00001	0.00001
^{3}H	--	0	--
^{14}C	--	0	--
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	--	0	--
^{60}Ni	--	0	--
^{63}Ni	--	0	--
^{79}Se	--	0	--
^{90}Sr	--	0	--
^{90}Y	--	0	--
^{99}Tc	--	0	--
^{106}Ru	--	0	--
^{106}Rh	--	0	--
^{129}I	--	0	--
^{134}Cs	--	0	--
^{135}Cs	--	0	--
^{137}Cs	--	0	--
^{137}Ba	--	0	--
^{141}Ce	--	0	--
^{144}Ce	--	0	--
^{144}Pr	--	0	--
^{147}Pm	--	0	--
^{151}Sm	--	0	--
^{152}Eu	--	0	--
^{154}Eu	--	0	--

Table E-5. Radiological Data for Feed Stream 5C2, Lead Chemicals/Solutions. (sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	0	--
^{226}Ra	--	0	--
^{232}Th	--	0	--
^{233}Pa	--	0	--
^{233}U	--	0	--
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	--	0	--
^{236}U	--	0	--
^{238}U	N/A	3.66 E-10	3.66 E-10
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	--	0	--
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	--	0	--
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-6. Radiological Data for Feed Stream 5C3, Lead-Contaminated Heterogeneous Solids. (sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	1.0 E-05 to 6.18 E-02	0.23633	0.003581
^{3}H	N/A	0.0011	0.0011
^{14}C	--	0	--
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	1.4 E-03 to 2.0 E-04	0.0034	0.000567
^{60}Ni	--	0	--
^{63}Ni	--	0	--
^{79}Se	--	0	--
^{90}Sr	1.0 E-04 to 9.8 E-03	0.0171	0.001555
^{90}Y	1.0 E-04 to 9.8 E-03	0.0171	0.001555
^{99}Tc	--	0	--
^{106}Ru	1.0 E-04 to 2.2 E-03	0.0129	0.000921
^{106}Rh	1.0 E-04 to 2.2 E-03	0.0129	0.000921
^{129}I	--	0	--
^{134}Cs	--	0	--
^{135}Cs	--	0	--
^{137}Cs	1.0 E-05 to 2.0 E-02	0.02851	0.002193
^{137}Ba	1.0 E-05 to 2.0 E-02	0.02851	0.002193
^{141}Ce	--	0	--
^{144}Ce	1.7 E-03 to 9.3 E-03	0.0389	0.006483
^{144}Pr	1.7 E-03 to 9.3 E-03	0.0389	0.006483
^{147}Pm	8.0 E-04 to 4.3 E-03	0.0203	0.0029
^{151}Sm	5.0 E-04 to 7.0 E-03	0.011	0.001833
^{152}Eu	--	0	--
^{154}Eu	--	0	--

Table E-6. Radiological Data for Feed Stream 5C3, Lead-Contaminated Heterogeneous Solids. (sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	0	--
^{226}Ra	--	0	--
^{232}Th	N/A	1.1 E-06	5.5 E-07
^{233}Pa	--	0	--
^{233}U	--	0	--
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	N/A	2.16 E-07	2.16 E-07
^{236}U	--	0	--
^{238}U	N/A	7.05 E-06	7.05 E-07
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	N/A	0.5	0.5
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	N/A	--	--
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-7. Radiological Data for Feed Stream 9A, Particulate/Sludge.
(sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	1.0 E-05 to 5.0 E-02	3.667121	0.024126
^{3}H	--	0	--
^{14}C	N/A	0.0001	0.0001
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	2.0 E-05 to 2.0 E-04	0.00342	0.000122
^{60}Ni	--	0	--
^{63}Ni	--	0	--
^{79}Se	--	0	--
^{90}Sr	1.09 E-06 to 7.0 E-03	0.025661	0.001025
^{90}Y	1.09 E-06 to 7.0 E-03	0.025661	0.001025
^{99}Tc	--	0	--
^{106}Ru	2.0 E-07 to 1.7 E-03	0.0272	0.001183
^{106}Rh	2.0 E-07 to 1.7 E-03	0.0272	0.001183
^{129}I	--	0	--
^{134}Cs	--	0	--
^{135}Cs	--	0	--
^{137}Cs	1.26 E-06 to 8.0 E-03	0.029731	0.001191
^{137}Ba	1.26 E-06 to 8.0 E-03	0.029731	0.001191
^{141}Ce	--	0	--
^{144}Ce	4.67 E-07 to 7.0 E-03	0.1111	0.00505
^{144}Pr	4.67 E-07 to 7.0 E-03	0.1111	0.00505
^{147}Pm	2.87 E-06 to 3.3 E-03	0.054203	0.002357
^{151}Sm	6.0 E-04 to 7.0 E-03	0.0234	0.001064
^{152}Eu	--	0	--
^{154}Eu	--	0	--

Table E-7. Radiological Data for Feed Stream 9A, Particulate/Sludge.
(sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	0	--
^{226}Ra	--	0	--
^{232}Th	--	0	--
^{233}Pa	--	0	--
^{233}U	--	0	--
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	2.16 E-10 to 1.38 E-03	0.049336	0.000633
^{236}U	--	0	--
^{238}U	7.59 E-05 to 3.43 E-03	0.009854	0.000896
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	N/A	0.118	0.118
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	--	0	--
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-8. Radiological Data for Feed Stream 9B, Heterogeneous Solids/Debris. (sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	1.0 E-05 to 1.5 E-01	0.814992	0.007477
^{3}H	1.0 E-05 to 2.3 E-04	0.000851	4.25 E-05
^{14}C	--	0	--
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	9.0 E-05 to 4.3 E-02	0.17039	0.004369
^{60}Ni	--	0	--
^{63}Ni	--	0	--
^{79}Se	--	0	--
^{90}Sr	1.0 E-05 to 6.8 E-03	0.031437	0.000456
^{90}Y	1.0 E-05 to 6.8 E-03	0.031437	0.000456
^{99}Tc	N/A	0.0001	0.0001
^{106}Ru	2.3 E-05 to 2.15 E-02	0.119818	0.002605
^{106}Rh	2.3 E-05 to 2.15 E-02	0.119818	0.002605
^{129}I	N/A	0.0001	0.0001
^{134}Cs	--	0	--
^{135}Cs	N/A	0.0001	0.0001
^{137}Cs	1.0 E-05 to 1.5 E-02	0.056287	0.000722
^{137}Ba	1.0 E-05 to 1.5 E-02	0.056287	0.000722
^{141}Ce	--	0	--
^{144}Ce	3.1 E-03 to 3.94 E-2	0.0833	0.007573
^{144}Pr	3.1 E-03 to 3.94 E-2	0.0833	0.007573
^{147}Pm	1.0 E-05 to 1.85 E-02	0.04036	0.001552
^{151}Sm	1.0 E-04 to 8.0 E-04	0.0094	0.000855
^{152}Eu	--	0	--
^{154}Eu	--	0	--

Table E-8. Radiological Data for Feed Stream 9B, Heterogeneous Solids/Debris. (sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	--	0	--
^{226}Ra	--	0	--
^{232}Th	--	0	--
^{233}Pa	--	0	--
^{233}U	--	0	--
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	1.08 E-06 to 2.27 E-02	0.022705	0.005676
^{236}U	--	0	--
^{238}U	3.36 E-12 to 1.56 E-08	3.94 E-08	1.23 E-09
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	1.28 E-02 to 3.03 E-01	91.7021	10.18912
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	N/A	0.927	0.927
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

Table E-9. Radiological Data for Feed Stream 9C, Contained Liquid.
(sheet 1 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
Total beta/gamma	2.0 E-05 to 4.34 E-01	0.57008	0.011634
^{3}H	N/A	0.00041	0.00041
^{14}C	--	0	--
^{40}K	--	0	--
^{57}Co	--	0	--
^{60}Co	2.0 E-05 to 1.0 E-02	0.05599	0.00224
^{60}Ni	--	0	--
^{63}Ni	N/A	0.00023	0.00023
^{79}Se	--	0	--
^{90}Sr	2.0 E-5 to 8.6 E-03	0.00904	0.001507
^{90}Y	2.0 E-5 to 3.0 E-04	0.00904	0.001507
^{99}Tc	--	0	--
^{106}Ru	N/A	0.0004	0.0004
^{106}Rh	N/A	0.0004	0.0004
^{129}I	--	0	--
^{134}Cs	N/A	0.005	0.005
^{135}Cs	--	0	--
^{137}Cs	3.0 E-05 to 3.0 E-04	0.00056	0.000112
^{137}Ba	3.0 E-05 to 3.0 E-04	0.00056	0.000112
^{141}Ce	--	0	--
^{144}Ce	N/A	0.0017	0.0017
^{144}Pr	N/A	0.0017	0.0017
^{147}Pm	N/A	0.0008	0.0008
^{151}Sm	N/A	0.0004	0.0004
^{152}Eu	--	0	--
^{154}Eu	--	0	--

Table E-9. Radiological Data for Feed Stream 9C, Contained Liquid.
(sheet 2 of 2)

Radionuclide	Radionuclide content (Ci)*		
	Range	Total	Average
^{155}Eu	N/A	0.00018	0.00006
^{226}Ra	--	0	--
^{232}Th	N/A	0.001728	0.000576
^{233}Pa	--	0	--
^{233}U	N/A	0.000203	6.75 E-05
^{234}Th	--	0	--
^{234}U	--	0	--
^{235}Th	--	0	--
^{235}U	--	0	--
^{236}U	--	0	--
^{238}U	4.0 E-11 to 2.65 E-04	0.000281	3.52 E-05
^{241}Pu	--	0	--
^{237}Np nCi/g	--	0	--
^{238}Pu nCi/g	--	0	--
^{239}Pu nCi/g	N/A	1.38	1.38
^{240}Pu nCi/g	--	0	--
^{241}Am nCi/g	--	0	--
^{243}Am nCi/g	--	0	--
^{243}Cm nCi/g	--	0	--
^{244}Cm nCi/g	--	0	--

*For containers where specific radionuclide has been identified.
N/A = Not applicable

PROCESS CONDITIONS OF SERVICE EQUIPMENT DATA SHEETS

PARTICULATE/SLUDGE PROCESSING
PFD H-2-140628 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SN-05-524	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 02/23/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	02/23/94 SAS	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
VIBRATING SCREEN	1

PFD REF: H-2-140628 Sheet 1

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SCREEN HARD ITEMS FROM MLLW PARTICULATE/SLUDGE PRIOR TO IMMOBILIZATION IN POLYETHYLIZER
MESH SIZE:	3 MM
CAPACITY:	90 Ft^3/HOUR (NOTE 1)
LOCATION:	PARTICULATE/SLUDGE PROCESSING ENCLOSURE
DUTY:	3 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L
WEIGHT LIMIT:	4000 LBS

NOTES:

1. THE SCREEN CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE SCREEN OVER A CYCLE TIME OF 5 MINUTE CYCLE. THIS INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE OVERALL THROUGHPUT REQUIREMENT OF 18,000 Ft^3 (SINGLE SHIFT).

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SN-05-523	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 02/23/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	02/23/94 SAS	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
VIBRATING SCREEN	1

PFD REF: H-2-140628 Sheet 1

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SCREEN HARD ITEMS FROM MLLW PARTICULATE/SLUDGE PRIOR TO IMMOBILIZATION IN POLYETHYLIZER
MESH SIZE:	3 MM
CAPACITY:	90 Ft^3/HOUR (NOTE 1)
LOCATION:	PARTICULATE/SLUDGE PROCESSING ENCLOSURE
DUTY:	3 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L
WEIGHT LIMIT:	4000 LBS

NOTES:

1. THE SCREEN CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE SCREEN OVER A CYCLE TIME OF 5 MINUTE CYCLE. THIS INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE OVERALL THROUGHPUT REQUIREMENT OF 18,000 Ft^3 (SINGLE SHIFT).

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER EM-05-521	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93 SAS	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SORTING MANIPULATOR	1

PFD REF: H-2-140628

PROCESS CONDITIONS OF SERVICE

APPLICATION:	REMOVAL OF ITEMS FROM DRUMS, REMOTE WASTE SORTING, TRANSFER OF ITEMS WITHIN ENCLOSURE
UNIT LOAD DESCRIPTION:	PACKETED WASTE (FLASKS, BRICKS, ETC.)
UNIT LOAD SIZE:	L 10" X W 6" X H 28" MAXIMUM
UNIT LOAD WEIGHT:	60 LBS AT FULL EXTENSION
LOCATION:	INSIDE PARTICULATE/SLUDGE PROCESSING ENCLOSURE
RATED CAPACITY:	60 LBS AT FULL EXTENSION
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
REPEATABILITY:	TITANIUM
END EFFECTOR:	REPLACEABLE TOOLS (GRASPING DEVICES, RAKE, SCOOP, ELECTRIC KNIFE)

NOTES:

1. MUST BE ABLE TO GRASP CONTAINERS FROM 22 ML GLASS VIALS TO 1 LITER GLASS BOTTLES WITHOUT CAUSING BREAKAGE.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SN-05-521	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 02/23/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/83 SAS	B	12/30/93 SAS	C	02/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
COARSE VIBRATING SCREEN	1

PFD REF: H-2-140628 Sheet 1

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SCREEN DEBRIS FROM MLLW PARTICULATE/SLUDGE
MESH SIZE:	60 MM
WEIGHT LOAD CAPACITY:	2000 LBS
SCREEN TABLE SIZE:	10 Ft^3 4 Ft X 10Ft
CAPACITY:	90 Ft^3/HOUR (NOTE 1)
LOCATION:	PARTICULATE/SLUDGE PROCESSING ENCLOSURE
DUTY:	3 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L

NOTES:

1. THE SCREEN CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE SCREEN OVER A CYCLE TIME OF 5 MINUTE CYCLE. THIS INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE OVERALL THROUGHPUT REQUIREMENT OF 18,000 Ft^3 (SINGLE SHIFT).

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER DR-05-521	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93 SAS	C	2/23/92 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SLUDGE DRYER/MIXER LIFT TABLE	1

PFD REF: H-2-140628 Sheet 1

PROCESS CONDITIONS OF SERVICE

APPLICATION:	MLLW SLUDGE DRYING/MIXING
FEED DESCRIPTION:	DRY POWDER, CAKE, SLUDGE WITH MOISTURE CONTENT UP TO 70% BY WEIGHT. MAXIMUM PARTICLE SIZE OF THE WASTE = 3 mm
PRODUCT SPECIFICATION:	< 10% MOISTURE CONTENT BY WEIGHT OF THE DRIED PRODUCT
DRIER CAPACITY:	25 Ft^3 TOTAL = 15 Ft^3 SLUDGE TO DRIED + 10 Ft^3 CALCIUM OXIDE ADDITIVE
WEIGHT LOAD CAPACITY:	4,300 LB
BATCH CYCLE:	40 MINUTES/BATCH, INCLUDING HEATING, DRYING AND COOL DOWN CYCLE, 7 BATCHES/SHIFT
LOCATION:	PARTICULATE/SLUDGE PROCESSING ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L
HEAT INPUT:	ELECTRIC POWER, MAX SHELL TEMPERATURE NOT TO EXCEED 550° F
HEAT CAPACITY:	810,000 BTU/HR
CONTROLS:	A PROGRAMMABLE LOGIC CONTROLLER TO BE PROVIDED TO CONTROL TEMPERATURE
DESIGN PRESSURE:	1.0" WC VAC
FEED WASTE DENSITY:	50 TO 120 LBS/Ft^3
AIR INLET:	HEPA FILTER RATED MAXIMUM 10 ACFM
OFFGAS:	FILTERED AIR, 500° F

NOTES:

1. DRIER MUST HAVE THE CAPABILITY TO TRANSFER DRY MATERIAL (<10% MOISTURE CONTENT BY WEIGHT) THROUGH THE DRIER WITHOUT THE APPLICATION OF HEAT.
2. THE DRYER MUST ALSO HAVE THE CAPABILITY TO MIX WASTE.
3. THE DRYER MUST HAVE THE CAPABILITY TO INTRODUCE CALCIUM OXIDE TO THE WASTE.
4. DRYER SHELL TO SERVE AS MLLW CONFINEMENT ENCLOSURE.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SH-05-521	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)								
	A	12/13/93 SAS	B	12/30/93 SAS	C	2/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
CRUSHER	1

PFD REF: H-2-140628 Sheet 1

PROCESS CONDITIONS OF SERVICE

APPLICATION:	CRUSH HARD ITEMS WITHIN MLLW PARTICULATE/SLUDGE
WASTE DESCRIPTION:	SMALL QUANTITIES OF ROCKS, METAL, CLASS, PAPER, POLYETHYLENE LESS THAN APPROXIMATELY 60 mm IN SIZE
WEIGHT LOAD CAPACITY:	2000 LBS
FEED HOPPER SIZE:	10 Ft^3
CAPACITY:	90 Ft^3/HOUR (NOTE 2)
CRUSHER PRODUCT:	< 3 mm
LOCATION:	PARTICULATES/SLUDGE PROCESSING ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L
FEED WASTE DENSITY:	40 TO 120 LBS/Ft^3
DESIGN PRESSURE:	1.0" WC VAC

NOTES:

1. CRUSHER SHELL TO SERVE AS MLLW CONFINEMENT ENCLOSURE.
2. THE CRUSHER CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE CRUSHER OVER A CYCLE TIME OF 5 MINUTE CYCLE. THIS INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE THROUGHPUT OF 18,000 Ft^3/YEAR (SINGLE SHAFT).

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SN-05-522	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93 SAS	C	2/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
VIBRATING SCREEN	1

PFD REF: H-2-140628 Sheet 1

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SCREEN HARD ITEMS FROM MLLW PARTICULATE/SLUDGE PRIOR TO IMMOBILIZATION IN GROUT
MESH SIZE:	13 MM
WEIGHT LOAD CAPACITY:	2000 LBS
SCREEN SIZE:	10 Ft^3
CAPACITY:	90 Ft^3/HOUR (NOTE 1)
LOCATION:	PARTICULATE/SLUDGE PROCESSING ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L

NOTES:

1. THE SCREEN CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE SCREEN OVER A CYCLE TIME OF 5 MINUTES. THE INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE OVERALL THROUGHPUT REQUIREMENT OF 18,000 Ft^3/YEAR (SINGLE SHIFT).

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER V-05-521	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 01/07/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
CONDENSATE RECEIVER	1

PFD REF: H-2-140628, Sheet 1

PROCESS CONDITIONS OF SERVICE

OPERATING CONDITIONS: 10" W.C., 52°F

DESIGN CONDITIONS: FULL VACUUM TO 15 PSIG, 250°F

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

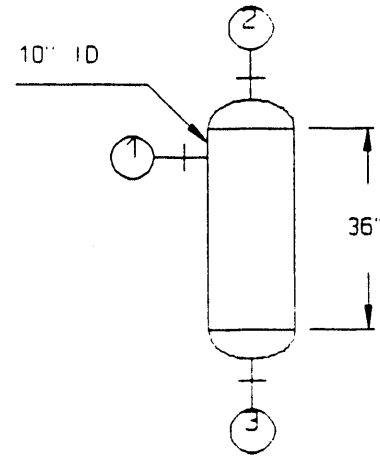
CORROSION ALLOWANCE: NONE

NOZZLES	QTY.	SIZE - RATING - FACE
1. GAS INLET	1	2" - 150 - RF
2. GAS OUTLET	1	2" - 150 - RF
3. WATER OUTLET	1	1" - 150 - RF
4.		
5.		
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1.
2.
3.
4.
5.
6.

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-521	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/30/93 SAS	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
DRYER/MIXER ADDITIVE FEED HOPPER	1

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

APPLICATION: FEEDING DRY ADDITIVE POWDERS DRYER DR-05-521

LOCATION: PARTICLE SLUDGE ADDITIVE PREPARATION AREA

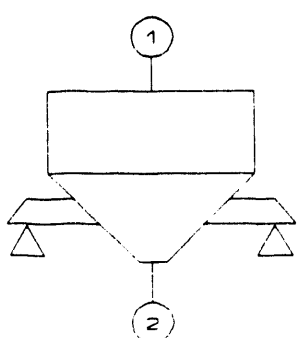
WORKING CAPACITY: 40 Ft^3	DESIGN/OPERATING TEMPERATURE: AMBIENT
UNIT LOAD WEIGHT: 2400 LB	DESING/OPERATING PRESSURE: AMBIENT
PARTICLE SIZE RANGE: FINE POWDERS	MATERIALS TO BE HANDLED: DRY ADDITIVE POWDERS
ANGLE OF REPOSE: 60°F	
DUTY: 3 SHIFTS/DAY, 175 DAYS/YR. 30 YEAR LIFE	
MATERIALS OF CONSTRUCTION: S.S. GRADE 304L	

NOZZLES	QTY.	SIZE - RATING - FACE
1. POWDER INLET	1	
2. POWDER OUTLET	1	
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1.
2.
3.
4.
5.
6.

NOTES:



EMPTY DRUM COMPACTION
PFD H-2-140628 SHT. 2

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER CM-05-581	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)								
	A	12/13/93 SAS	B	12/30/93 SAS	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
EMPTY DRUM COMPACTOR	1

PFD REF: H-2-140628 Sheet 2

PROCESS CONDITIONS OF SERVICE

APPLICATION:	COMPACT EMPTY DRUMS
DRUM SIZE:	55 GALLON 25" DIA X 36" HIGH
DRUM WEIGHT:	60 LB
COMPACT SIZE:	26" DIA X 4" HIGH
CAPACITY:	6 DRUMS/HOUR
LOCATION:	EMPTY DRUM COMPACTION ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	CARBON STEEL

NOTES:

DEBRIS PROCESSING
PFD H-2-140628 SHT. 3

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER EM-05-501	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)								
	A	12/13/93 SAS	B	12/30/93 SAS	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SORTING MANIPULATOR	1

PFD REF: H-2-140628 Sheet 3

PROCESS CONDITIONS OF SERVICE

APPLICATION: REMOVAL OF ITEMS FROM DRUMS, REMOTE WASTE SORTING, TRANSFER OF ITEMS WITHIN ENCLOSURE

UNIT LOAD DESCRIPTION: DEBRIS WASTE (FLASKS, BRICKS, ETC.)

UNIT LOAD SIZE: 10" X 6" X 28" MAXIMUM

UNIT LOAD WEIGHT: 60 LBS MAXIMUM

LOCATION: INSIDE DEBRIS PROCESSING ENCLOSURE

RATED CAPACITY: 60 LBS AT FULL EXTENSION

DUTY: 3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

MATERIAL: TITANIUM

END EFFECTOR: REPLACEABLE TOOLS (GRASPING DEVICES, RAKE, SCOOP, ELECTRIC KNIFE)

NOTES:

1. MUST BE ABLE TO GRASP CONTAINERS FROM 22 ML GLASS VIALS TO 1 LITER GLASS BOTTLES WITHOUT CAUSING BREAKAGE.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SN-05-501	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93	C	2/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
COARSE VIBRATING SCREEN	1

PFD REF: H-2-140628 Sheet 3

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SCREEN MLLW PARTICULATES/SLUDGE FROM DEBRIS
WASTE DESCRIPTION:	60 mm
WEIGHT LOAD CAPACITY:	2000 LB
SCREEN TABLE SIZE:	10 Ft^2 4 Ft X 10 Ft
CAPACITY:	222 Ft^3 (NOTE 1)
LOCATION:	DEBRIS PROCESSING ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L

NOTES:

1. THE SCREEN CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE SCREEN OVER A CYCLE TIME OF 2 MINUTES. THE INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE OVERALL THROUGHPUT REQUIREMENT OF 12,500 FT^3/YEAR (SINGLE SHIFT).

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SH-05-501	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93 SAS	C	2/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SHREDDER	1

PFD REF: H-2-140628 Sheet 3

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SHREDDING MLLW DEBRIS
UNIT LOAD DESCRIPTION:	CLOTH, PAPER, POLYETHYLENE, WOOD, GLASS, RUBBER, CONWED PADS, HEPA AND REVERSE OSMOSIS FILTERS, METAL SECTIONS GENERALLY < 0.5", EMPTY 55 GAL DRUMS, SUPERCOMPACTED DRUMS
WEIGHT LOAD CAPACITY:	2000 LB
HOPPER SIZE:	10 Ft^3 3 Ft X 4 Ft OPENING
CAPACITY:	90 Ft^3/HOUR (NOTE 3)
SHREDDED PRODUCT:	2" - 6" NOMINAL SIZE
LOCATION:	DEBRIS PROCESSING ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L
INERT PERGE:	1610 LIT/MINUTE INERT GAS 5 MINUTE PURGE CYCLE
FEED WASTE DENSITY:	25 TO 100 LBS/Ft^3 (BULK DENSITY)
DESIGN PRESSURE:	1.0" WC VAC

NOTES:

1. SHREDDER SHALL TO SERVE AS MLLW CONFINEMENT ENCLOSURE.

2. THE SHREDDER AND FEED HOPPER WILL HAVE AN INERT GAS PURGING TO PREVENT COMBUSTIBLES FROM BURNING. THE FEED HOPPER WILL HAVE AN INLET SLIDING COVER TO MINIMIZE THE INERT GAS REQUIREMENTS. THE FEED HOPPER SLIDING COVER WILL BE CLOSED AND THE SHREDDER AND FEED HOPER PURGES ONLY IF COMBUSTIBLES ARE PRESENT.

3. THE SHREDDER CAPACITY IS BASED ON AN INSTANTANEOUS THROUGHPUT REQUIREMENT OF 1 X 55 GALLON DRUM BATCH OF WASTE BEING PROCESSED BY THE SHREDDER OVER A CYCLE TIME OF 5 MINUTES. THE INSTANTANEOUS THROUGHPUT REQUIREMENT IS NECESSARY IN ORDER TO MEET THE OVERALL THROUGHPUT REQUIREMENT OF 12,500 FT^3/YEAR (SINGLE SHIFT).

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Centimeter

Inches

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BY APPLIED IMAGE, INC.

BOX BREAKDOWN
PFD H-2-140628 SHT. 4

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SN-05-561	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)								
	A	12/13/93 SAS	B	12/30/93	C	2/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SCREEN	1

PFD REF: H-2-140628 Sheet 4

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SCREEN OVERSIZE MLLW FROM CRUSHED WASTE
WASTE DESCRIPTION:	60 mm
WEIGHT LOAD CAPACITY:	1000 LB
CAPACITY:	17 Ft^3 (NOTE 1)
LOCATION:	BOX BREAKDOWN ENCLOSURE
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L

NOTES:

1. THE INSTANTANEOUS OPERATING RATE OF THE SCREEN IS SIZED IN LINE WITH THE INSTANTANEOUS OPERATING RATE OF THE SHREDDER SH-05-561

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SH-05-561	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93 SAS	C	2/23/94 SAS	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
CRUSHER	1

PFD REF: H-2-140628 Sheet 4

PROCESS CONDITIONS OF SERVICE

APPLICATION:	CRUSH PRODUCT CONTAINER GROUT AND POLYETHYLENE MATRIX WASTE AND FEEDSTREAM 1A.
UNIT LOAD DESCRIPTION:	GROUT BLOCKS 6" X 6" C6" NOMINAL POLYETHYLENE BLOCKS 6" X 6" X 6" NOMINAL
WEIGHT LOAD CAPACITY:	1500 LBS
HOPPER SIZE:	10 FT^3 2.5 Ft X 2.5 Ft OPENING
CAPACITY:	17 Ft^3/HOUR (NOTE 3)
LOCATION:	BOX BREAKDOWN
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	STAINLESS STEEL GRADE 304L
SHREDDER PRODUCT:	60 MM

NOTES:

1. THE INSTANTANEOUS OPERATING RATE OF THE CRUSHER IS SIZED THAT IT WILL PROCESS THE SAME QUANTITY OF WASTE AS THE MANIPULATOR, IN HALF THE TIME.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER EM-05-561 A, B	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/13/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: SAS

REVISIONS (DATE & BY)	A	12/13/93 SAS	B	12/30/93 SAS	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SIZE REDUCTION AND REPACKING MANIPULATOR	2

PFD REF: H-2-140628 Sheet 4

PROCESS CONDITIONS OF SERVICE

APPLICATION:	SIZE REDUCTION AND REPACKING BOXED WASTE AND OVERPACK DRUMS
WASTE DESCRIPTION:	WASTE BOXES - 5 Ft (H) X 5 Ft (W) X 9 Ft (L) (DEBRIS) PRODUCT BOXES - 4 Ft (H) X 4 Ft (W) X 4 Ft (L) (GROUT OR POLYMER) OVERWEIGHT 55 GAL DRUM OVERPACK - 85 GAL DRUM (CONCRETE)
UNIT LOAD WEIGHT:	3000 LBS MAXIMUM
LOCATION:	BOX BREAKDOWN ENCLOSURE
CAPACITY:	1 WASTE BOX/ 8 HOURS 1 PRODUCT BOX/ 11 HOURS 1 OVERPACK OR 55 GAL DRUM / 2.5 HOURS
PRODUCT SIZE:	WASTE BOX - 1Ft - 1.5Ft NOMINAL PRODUCT BOX - 6" X 6" X 6" NOMINAL OVERPACK - 6" X 6" X 6" NOMINAL
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
END EFFECTOR:	REMOTE TOOL CHANGE SYSTEM (GRASPING DEVICES, SCOOP, SHEAR)

NOTES:

SAMPLE MANAGEMENT AREA
PFD H-2-140633 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER GB-05-601 A & B	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO. 6237.006	DATE: 09/28/93
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2A	ACCOUNT NO.	BY: RV

REVISIONS (DATE & BY)	A	12/17/93 RV	B	2/23/94 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
INACTIVE SAMPLE ANALYSIS/REPACKAGING	2

PFD REF: H2-140633

PROCESS CONDITIONS OF SERVICE

APPLICATION:	FUME HOOD ENCLOSURES FOR ACTIVE SAMPLE ANALYSIS/REPACKAGING
UNIT LOAD DESCRIPTION:	SOLID AND LIQUID SAMPLES FOR ANALYSIS/REPACKAGING
UNIT LOAD SIZE:	1 LITER (MINIMUM) SAMPLES IN SHIELDED SAMPLE BOMBS
UNIT LOAD WEIGHT:	115 LBS
LOCATION:	SAMPLE MANAGEMENT AREA
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	304L STAINLESS STEEL
WORKING PRESSURE:	0.7" WG VACUUM

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER GB-05-601 C & D	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO. 6237.006	DATE: 09/28/93
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2A	ACCOUNT NO.	BY: RV

REVISIONS (DATE & BY)	A	12/17/93 RV	B	2/23/94 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
INACTIVE SAMPLE ANALYSIS/REPACKAGING	2

PFD REF: H2-140633

PROCESS CONDITIONS OF SERVICE

APPLICATION:	FUME HOOD ENCLOSURES FOR ACTIVE SAMPLE ANALYSIS/REPACKAGING
UNIT LOAD DESCRIPTION:	SOLID AND LIQUID SAMPLES FOR ANALYSIS/REPACKAGING
UNIT LOAD SIZE:	1 LITER (MINIMUM) SAMPLES
UNIT LOAD WEIGHT:	15 LBS
LOCATION:	SAMPLE MANAGEMENT AREA
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	304L STAINLESS STEEL
WORKING PRESSURE:	0.7" WG VACUUM

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER RT-05-612	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 9/28/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A	12/20/93 RV	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
CORE SAMPLER	1

PFD REF: H-2-140633

PROCESS CONDITIONS OF SERVICE

APPLICATION:	REMOVE A CORE SAMPLE FROM IMMOBILIZED PRODUCT CONTAINERS
UNIT LOAD DESCRIPTION:	GROUT OR POLYETHYLENE PRODUCT CORE SAMPLE
CORE SIZE:	TBD
DRILL SPEED:	TBD
LOCATION:	INSIDE CONTAINER SAMPLING ENCLOSURE IN SAMPLE MANAGEMENT AREA
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	304L STAINLESS STEEL

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER RT-05-613	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/20/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
GRAB SAMPLER	1

PFD REF: H-2-140633

PROCESS CONDITIONS OF SERVICE

APPLICATION:	REMOVE A SAMPLE FROM 55 GALLON WASTE DRUMS
UNIT LOAD DESCRIPTION:	MANIPULATOR OR SAMPLE THIEF ATTACHMENTS TO SAMPLE INCOMING WASTE DRUMS
SAMPLE SIZE:	TBD
LOCATION:	INSIDE CONTAINER SAMPLING ENCLOSURE IN SAMPLE MANAGEMENT AREA
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	304L STAINLESS STEEL

NOTES:

BULK POWDER STORAGE
PFD H-2-140636 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-106	PAGE 1 OF 2

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
BULK POWDER STORAGE PACKAGE	1

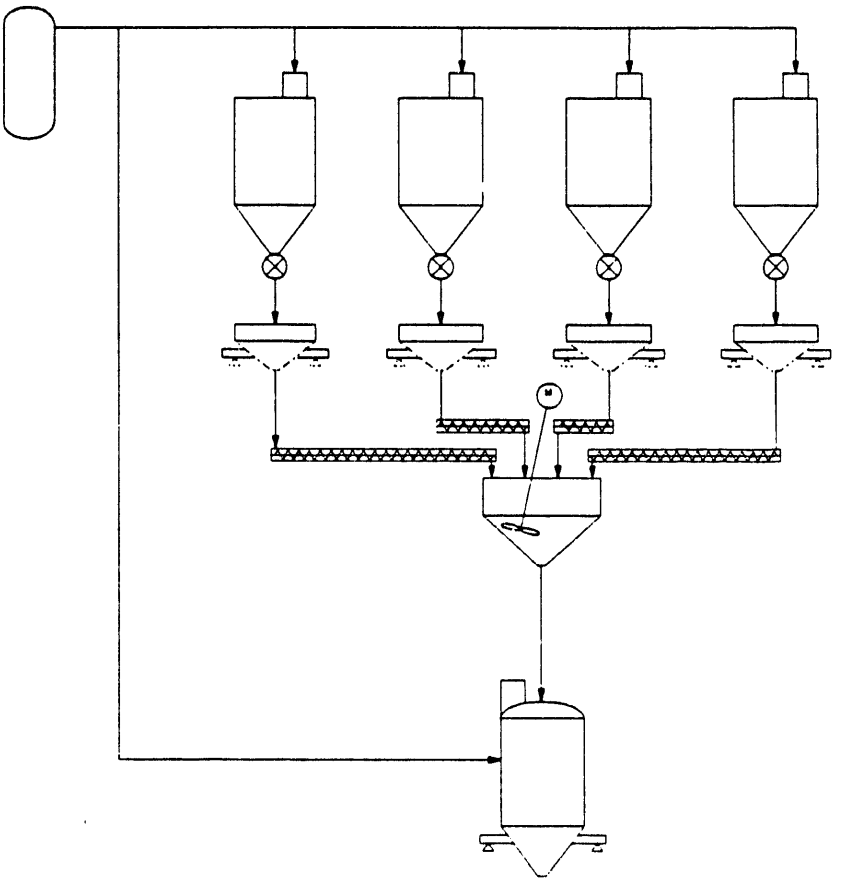
PFD REF: H-2-140636

PROCESS CONDITIONS OF SERVICE

APPLICATION:	STORAGE, BLENDING AND PNEUMATIC TRANSFER OF GROUT POWDERS
UNIT LOAD DESCRIPTION:	PORTLAND CEMENT SPECIFICATION TBD GRANULATED BLAST FURNACE SLAG SPECIFICATION TBD PULVERIZED FLY ASH SPECIFICATION TBD GROUT ADDITIVE POWDER SPECIFICATION TBD
UNIT LOAD SIZE:	PORTLAND CEMENT SILO 7,600 FT^3 BLAST FURNACE SLAG SILO 13,700 FT^3 PULVERIZED FLY ASH SILO 13,700 FT^3 GROUT ADDITIVE SILO 7,600 FT^3 POWDER BLENDER 420 FT^3 WEIGH HOPPERS (4 IN TOTAL), COMPRESSED AIR RECEIVER AND PNEUMATIC DENSE PHASE PUMP - TO BE SIZED BY VENDOR
UNIT LOAD WEIGHT:	PORTLAND CEMENT SILO 688000 LB BLAST FURNACE SLAG SILO 930000 LB PULVERIZED FLY ASH SILO 930000 LB GROUT ADDITIVE SILO 688000 LB POWDER BLENDER 30000 LB
LOCATION:	ADJACENT TO THE MAIN PROCESS BUILDING
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	CARBON STEEL
ADDITIONAL ITEMS:	POWDER STORAGE SILO BIN ACTIVATORS AND AIR PADS - TO BE SPECIFIED BY VENDOR. SCREW CONVEYORS - TO BE SPECIFIED BY VENDOR SILO OUTLET ROTARY VALVES (BY VENDOR) SILO VENT FILTERS (BY VENDOR)

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-106	PAGE 2 OF 2
CUSTOMER & LOCATION DOE-RL HANFORD, WA	PROJECT WRAP FACILITY MODULE 2A	UE&C JOB NO. 6237.008	DATE: 10/05/93 BY: RV



VIBRO GROUT SYSTEM
PFD H-2-140637 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-201	PAGE 1 OF 2

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWDER HANDLING PACKAGE (VIBROGROUT)	1

PFD REF: H-2-140637

PROCESS CONDITIONS OF SERVICE

APPLICATION:	DAY STORAGE OF BLENDED GROUT POWDERS	
UNIT LOAD DESCRIPTION:	PORTLAND CEMENT	SPECIFICATION TBD
	GRANULATED BLAST FURNACE SLAG	SPECIFICATION TBD
	PULVERIZED FLY ASH	SPECIFICATION TBD
	GROUT ADDITIVE POWDER	SPECIFICATION TBD
UNIT LOAD SIZE:	BLENDED POWDER SILO	140 FT^3
UNIT LOAD WEIGHT:	BLENDED POWDER SILO	10,000 LB
LOCATION:	GROUT POWDER PREPARATION AREA (ZONE 3)	
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE	
MATERIAL:	CARBON STEEL	
ADDITIONAL ITEMS:	SCREW CONVEYOR RATE: TBD - LENGTH: TBD SILO VENT FILTER	

NOTES:

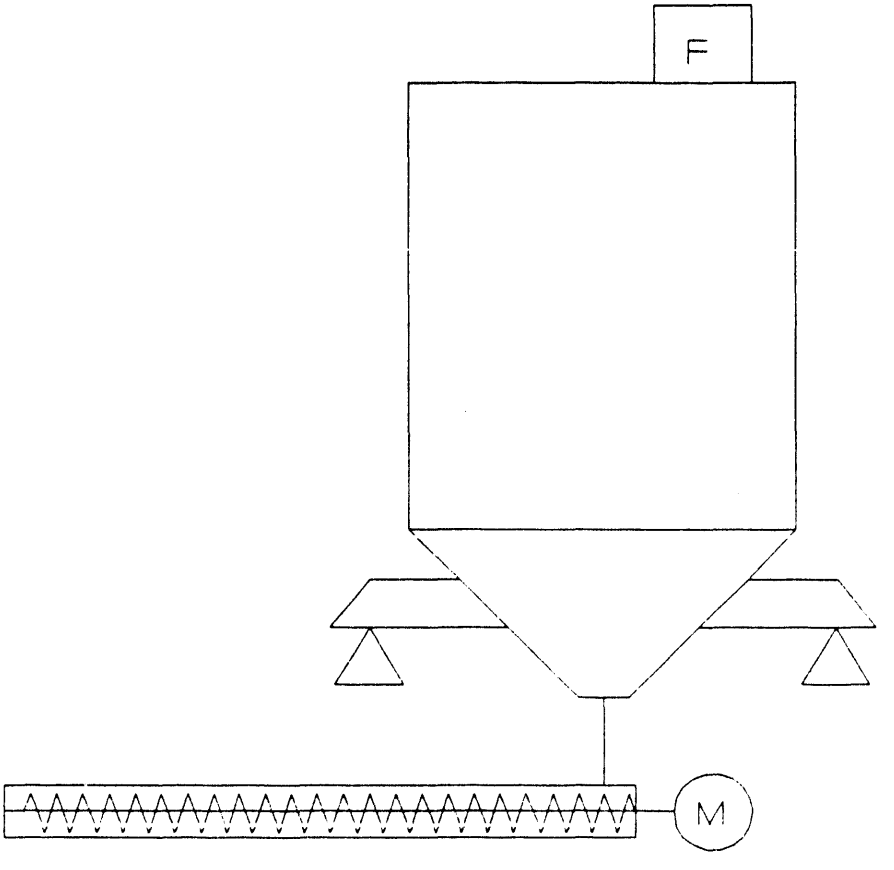
UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-201	PAGE 2 OF 2

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWDER HANDLING PACKAGE (VIBROGROUT)	1

PFD REF: H-2-140637



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-212	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WPAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
WET GROUT MIXING TANK	1

PFD REF: H-2-140637

PROCESS CONDITIONS OF SERVICE

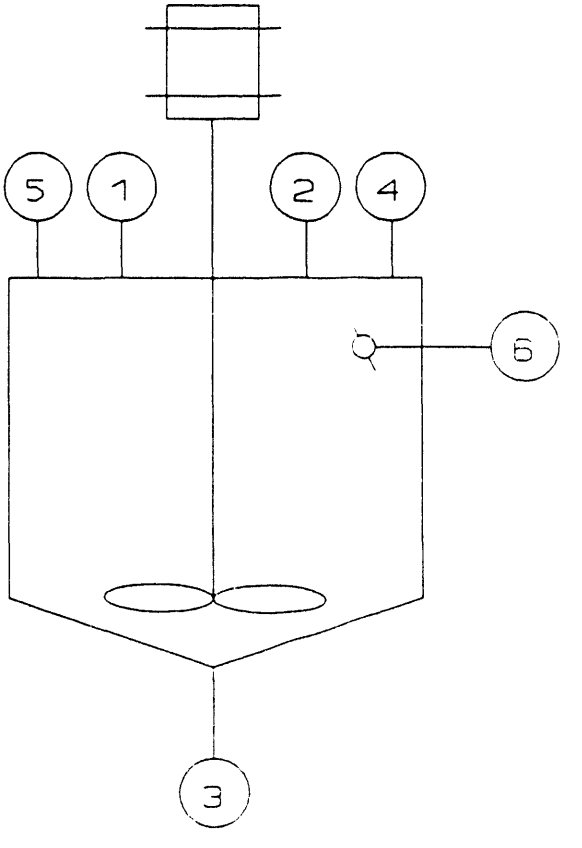
DESIGN/OPERATING CONDITIONS:	AMBIENT PRESS./AMBIENT PRESS 150°F/70°F
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL
CORROSION ALLOWANCE:	NONE
WORKING CAPACITY:	80 FT^3
UNIT LOAD WEIGHT:	12,000 LB
MATERIALS TO BE HANDLED:	WATER, PORTLAND CEMENT, GROUND GRANULATED BLAST FURNACE SLAG, PULVERIZED FLY ASH, OTHER GROUT ADDITIVES.
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

NOZZLES	QTY.	SIZE - RATING - FACE
1. WATER INLET	1	
2. POWDER INLET	1	
3. MIX OUTLET	1	
4. RECYCLE INLET	1	
5. LEVEL INSTR.	1	
6. TANK CLEANING	1	
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1. AGITATOR WITH MOTOR
2. ORBITAL TANK CLEANING MACHINE

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-219	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 2/28/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A		B	1	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
GROUT WASHING TANK (INACTIVE)	1

PFD REF: H-2-14063

PROCESS CONDITIONS OF SERVICE

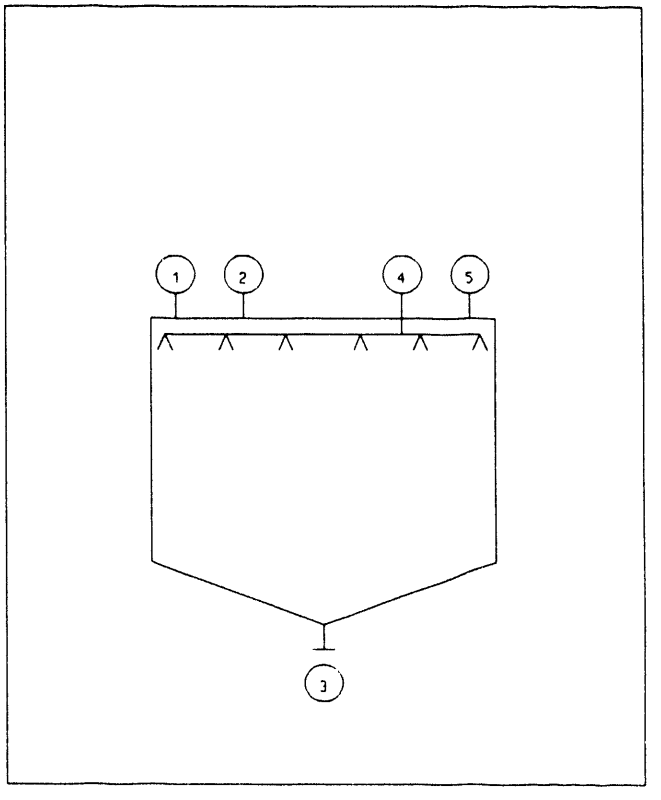
DESIGN/OPERATING CONDITIONS:	AMBIENT PRESS./AMBIENT PRESS 150°F/70°F
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL
CORROSION ALLOWANCE:	NONE
WORKING CAPACITY:	80 FT^3
UNIT LOAD WEIGHT:	12,000 LB
MATERIALS TO BE HANDLED:	WATER, PORTLAND CEMENT, GROUND GRANULATED BLAST FURNACE SLAG, PULVERIZED FLY ASH, OTHER GROUT ADDITIVES.
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

NOZZLES	QTY	SIZE-RATING-FACE
1. WASHING INLET	1	
2. BLEED WATER OUTLET	1	
3. SOLIDS OUTLET	1	
4. TANK CLEANING	1	
5. LEVEL INSTR.	1	
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1. WASH SPRAY RING

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-220	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 2/28/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

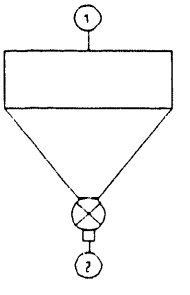
SERVICE	NO. REQ'D.
DRY ADDITIVE HOPPER	1

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

APPLICATION:	FEEDING DRY ADDITIVE POWDERS TO THE BATCH MIXING TANK T-05-212		
LOCATION:	INSIDE SLUDGE/PARTICULATE GROUT POWDER PREPARATION AREA		
WORKING CAPACITY:	15 FT^3	DESIGN/OPERATING TEMPERATURE:	100°F/70°F
UNIT LOAD WEIGHT:	2,300 LB	DESIGN/OPERATING PRESSURE:	AMBIENT/AMBIENT
PARTICLE SIZE RANGE:	FINE POWDERS	MATERIALS TO BE HANDLED:	DRY ADDITIVE POWDERS
ANGLE OF REPOSE:	60°		
DUTY:	3 SHIFTS/DAY, 175 DAYS/YR, 30 YEAR LIFE		
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL		

NOZZLES	QTY.	SIZE - RATING - FACE
1. POWDER INLET	1	
2. POWDER OUTLET	1	
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		



INTERNALS & ACCESSORIES:

1. OUTLET ROTARY VALVE

NOTES:

SLUDGE/PARTICULATE GROUT SYSTEM
PFD H-2-140638 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-213	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)								
	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

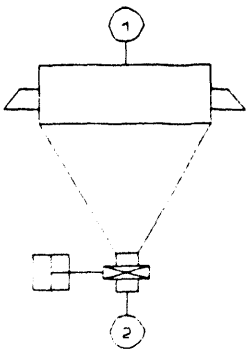
SERVICE	NO. REQ'D.
WASTE RECEIPT HOPPER	1

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

APPLICATION:	RECEIPT OF MATERIAL FROM SLUDGE/PARTICULATE CONDITIONING		
LOCATION:	INSIDE SLUDGE/PARTICULATE GROUT IMMOBILIZATION AREA		
WORKING CAPACITY:	80 FT^3	DESIGN/OPERATING TEMPERATURE:	100°/70°F
UNIT LOAD WEIGHT:	11,500 LB	DESIGN/OPERATING PRESSURE:	5" WC VAC./AMBIENT
PARTICLE SIZE RANGE:	FINE PARTICULATE/SLUDGE (< 6mm)	MATERIALS TO BE HANDLED:	SLUDGE/PARTICULATE MATERIALS
ANGLE OF REPOSE:	60°		
DUTY:	3 SHIFTS/DAY, 175 DAYS/YR, 30 YEAR LIFE		
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL		

NOZZLES	QTY.	SIZE - RATING - FACE
1. WASTE INLET	1	
2. WASTE OUTLET	1	
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		



INTERNALS & ACCESSORIES:

1. OUTLET VALVE WITH PNEUMATIC ACTUATOR

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-214 A/B	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)								
	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
BATCH MIXING TANK	2

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

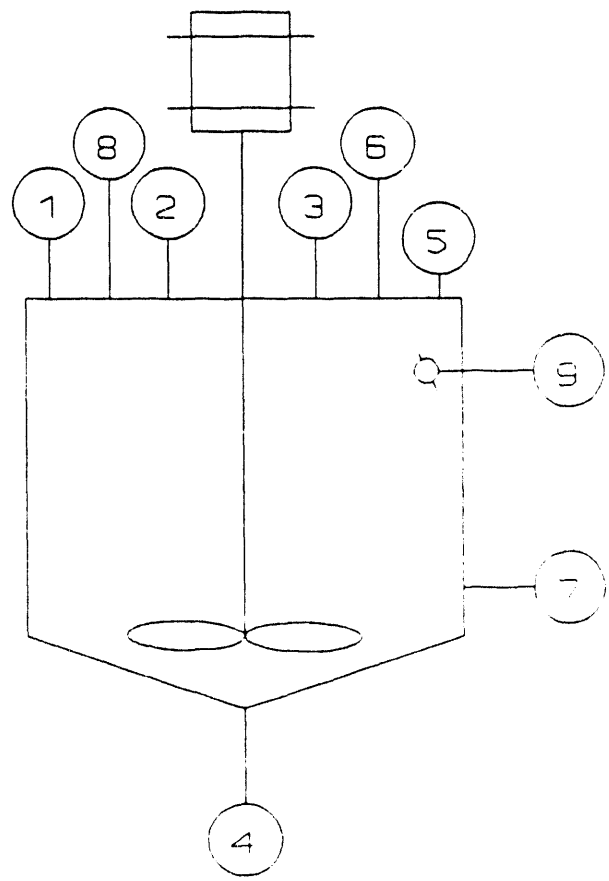
DESIGN/OPERATING CONDITIONS:	5" W.C. VACUUM/1" W.C. VACUUM 150°F/70°F
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL
CORROSION ALLOWANCE:	NONE
WORKING CAPACITY:	80 FT^3
UNIT LOAD WEIGHT:	12,000 LB
MATERIAL TO BE HANDLED:	SLUDGE/PARTICULATE WASTES - PARTICLE SIZE < 6mm, WATER, PORTLAND CEMENT, GROUND GRANULATED BLAST FURNACE SLAG, PULVERIZED FLY ASH, OTHER GROUT ADDITIVES.
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

NOZZLES	QTY.	SIZE - RATING - FACE
1. WATER INLET	1	
2. WASTE INLET	1	
3. POWDER INLET	1	
4. MIX OUTLET	1	
5. DRY ADDITIVE	1	
6. LIQ. ADDITIVE	1	
7. SAMPLE	1	
8. LEVEL INSTR.	1	
9. TANK CLEANING	1	
10.		

INTERNALS & ACCESSORIES:

1. AGITATOR WITH MOTOR
2. ROTARY TANK CLEANING MACHINE

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-218	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 2/28/94
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A		B	1	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
GROUT WASHING TANK (ACTIVE)	1

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

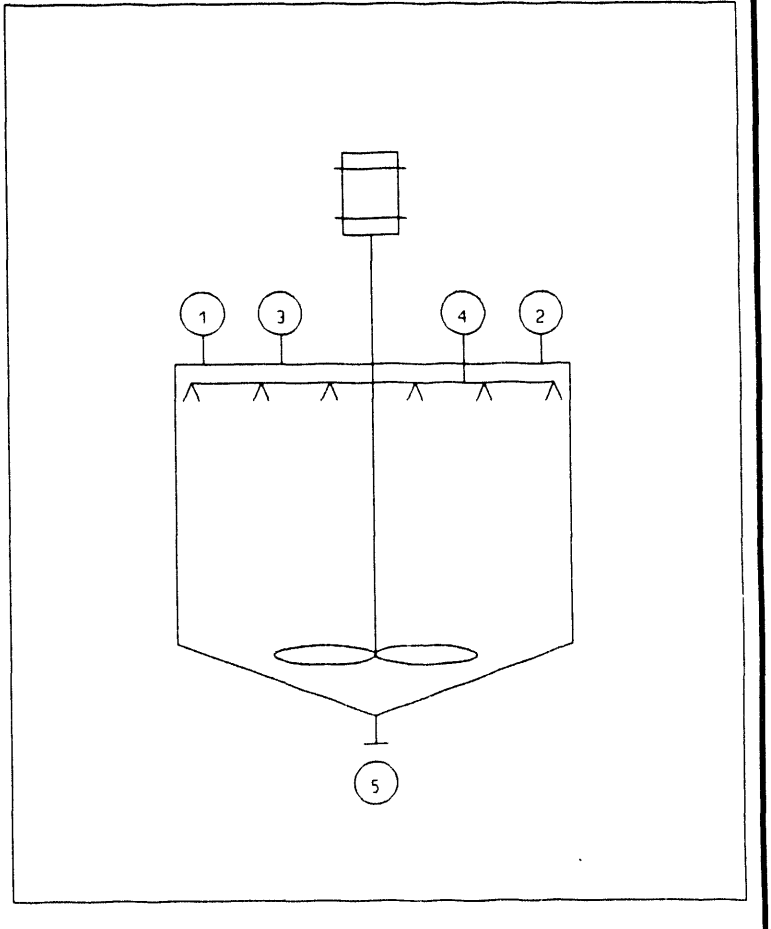
DESIGN/OPERATING CONDITIONS:	AMBIENT PRESS./AMBIENT PRESS 150°F/70°F
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL
CORROSION ALLOWANCE:	NONE
WORKING CAPACITY:	80 FT^3
UNIT LOAD WEIGHT:	12,000 LB
MATERIALS TO BE HANDLED:	WATER, PORTLAND CEMENT, GROUND GRANULATED BLAST FURNACE SLAG, PULVERIZED FLY ASH, OTHER GROUT ADDITIVES.
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

NOZZLES	QTY	SIZE-RATING-FACE
1. WASHINGS INLET	1	
2. RECYCLE INLET	1	
3. LEVEL INSTR.	1	
4. TANK CLEANING	1	
5. WASHINGS OUTLET	1	
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1. AGITATOR WITH MOTOR
2. WASH SPRAY RING

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-216 A,B	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/31/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

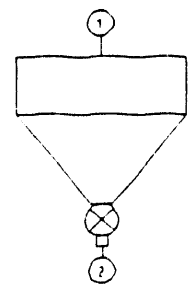
SERVICE	NO. REQ'D.
DRY ADDITIVE HOPPER	2

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

APPLICATION:	FEEDING DRY ADDITIVE POWDERS TO THE BATCH MIXING TANKS T-05-214 A & B		
LOCATION:	INSIDE SLUDGE/PARTICULATE GROUT POWDER PREPARATION AREA		
WORKING CAPACITY:	15 FT^3	DESIGN/OPERATING TEMPERATURE:	100°F/70°F
UNIT LOAD WEIGHT:	2,300 LB	DESIGN/OPERATING PRESSURE:	AMBIENT/AMBIENT
PARTICLE SIZE RANGE:	FINE POWDERS	MATERIALS TO BE HANDLED:	DRY ADDITIVE POWDERS
ANGLE OF REPOSE:	60°		
DUTY:	3 SHIFTS/DAY, 175 DAYS/YR, 30 YEAR LIFE		
MATERIALS OF CONSTRUCTION:	304 STAINLESS STEEL		

NOZZLES	QTY.	SIZE - RATING - FACE
1. POWDER INLET	1	
2. POWDER OUTLET	1	
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		



INTERNALS & ACCESSORIES:

1. OUTLET ROTARY VALVE

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-202	PAGE 1 OF 2

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWDER HANDLING PACKAGE (SLUDGE/PARTICULATE)	1

PFD REF: H-2-140638

PROCESS CONDITIONS OF SERVICE

APPLICATION:	DAY STORAGE OF BLENDED GROUT POWDERS	
UNIT LOAD DESCRIPTION:	PORTLAND CEMENT	SPECIFICATION TBD
	GRANULATED BLAST FURNACE SLAG	SPECIFICATION TBD
	PULVERIZED FLY ASH	SPECIFICATION TBD
	GROUT ADDITIVE POWDER	SPECIFICATION TBD
UNIT LOAD SIZE:	BLENDED POWDER SILO	420 FT^3
UNIT LOAD WEIGHT:	BLENDED POWDER SILO	30,000 LB
LOCATION:	GROUT POWDER PREPARATION AREA (ZONE 3)	
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE	
MATERIAL:	CARBON STEEL	
ADDITIONAL ITEMS:	SCREW CONVEYOR RATE: TBE - LENGTH: TBD SILO VENT FILTER	

NOTES:

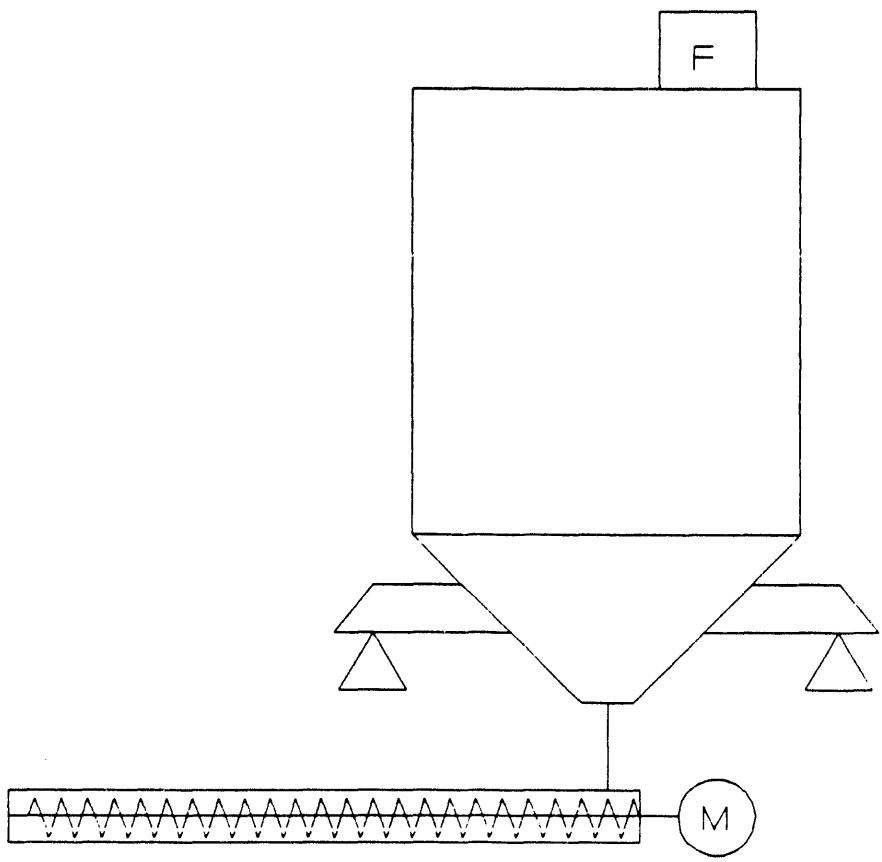
UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-202	PAGE 2 OF 2

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 10/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: RV

REVISIONS (DATE & BY)								
	A	12/09/93 RV	B	12/31/93 RV	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWDER HANDLING PACKAGE (SLUDGE/PARTICULATE)	1

PFD REF: H-2-140638



POLYETHYLENE BULK STORAGE
PFD H-2-140640 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-301	PAGE 1 OF 2

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POLYETHYLENE/ADDITIVE BULK STORAGE PACKAGE	1

PFD REF: H-2-140640

PROCESS CONDITIONS OF SERVICE

APPLICATION: STORAGE AND PNEUMATIC TRANSFER OF POLYETHYLENE (PE) PELLETS AND OF ADDITIVE

	POLYETHYLENE PELLETS	ADDITIVE (CALCIUM OXIDE POWDER)
BULK SILO: TAG NUMBER	T-05-302	T-05-301
WORKING CAPACITY (Ft^3)	8000	1200
DENSITY BULK/TRUE (LB/Ft^3)	31-35 / 57	60-80 / 209
PARTICLE SIZE	3 MM	TBD
TRANSFER INCREMENT (LBS)	6990	2995
TRANSFER DURATION	< 1 HR	< 1 HR
TRANSFER DISTANCE (Ft)	TBD	TBD

LOCATION: OUTDOORS

DUTY: 3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

MATERIAL: CARBON STEEL

ADDITIONAL ITEMS: AIR RECEIVER (SIZED BY VENDOR; INSTR. QUALITY AIR AVAILABLE AT 90 PSIG)
VENT AIR FILTERS ON BULK SILOS

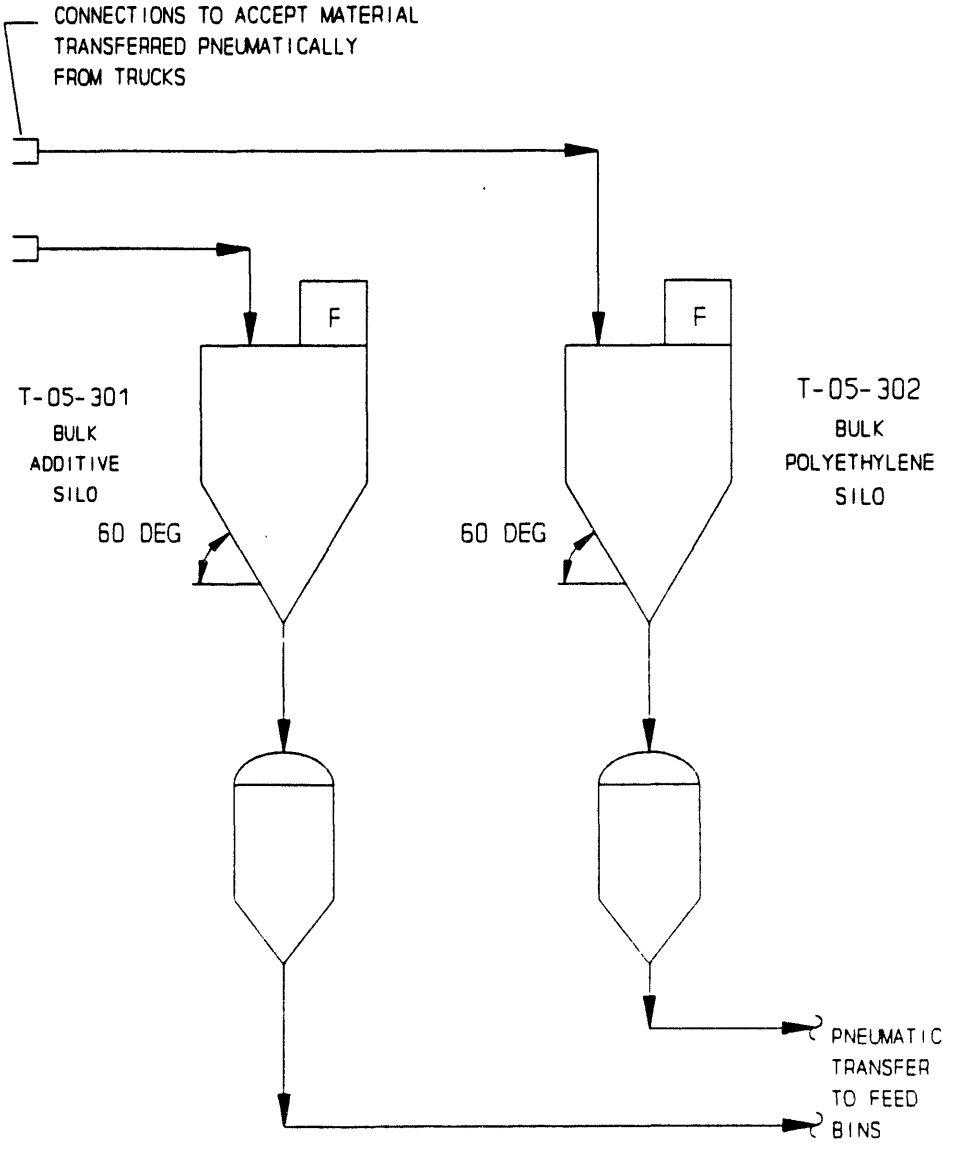
NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-301	PAGE 2 OF 2
CUSTOMER & LOCATION DOE-RL HANFORD, WA	PROJECT WRAP FACILITY MODULE 2A	UE&C JOB NO. 6237.008	DATE: 12/30/93 BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE POLYETHYLENE/ADDITIVE BULK STORAGE PACKAGE	NO. REQ'D. 1

PFD REF: H-2-140640



POLYETHYLENE ENCAPSULATION
PFD H-2-140641 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER U-05-401	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

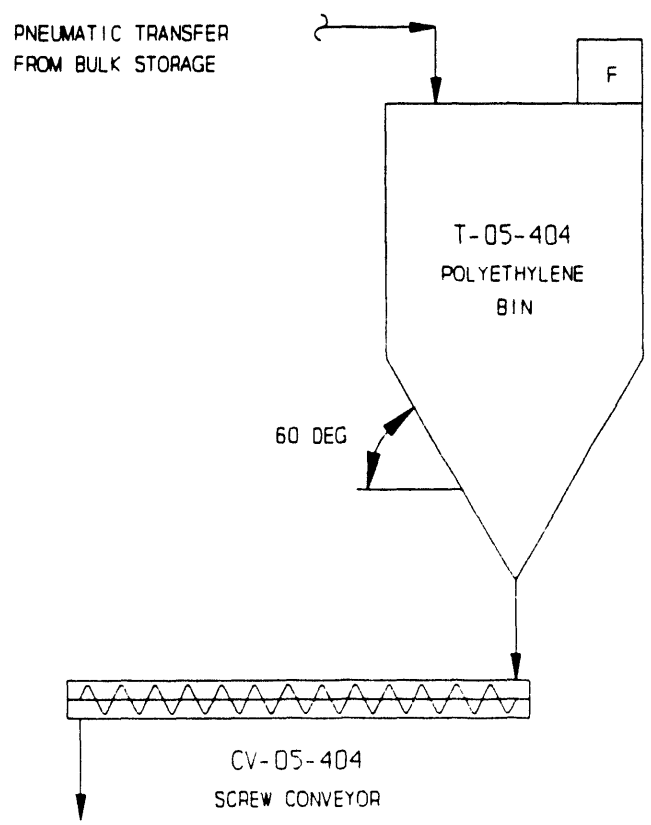
SERVICE	NO. REQ'D.
POLYETHYLENE FEED PACKAGE	1

PFD REF: H-2-140641

PROCESS CONDITIONS OF SERVICE

APPLICATION:	DAY STORAGE AND FEED TO EXTRUDER OF POLYETHYLENE PELLETS
PACKAGE EQUIPMENT:	T-05-404 POLYETHYLENE BIN (1 EACH): WORKING CAPACITY: 265 Ft^3 CV-05-404 SCREW CONVEYOR (1 EACH): LENGTH: TBD DESIGN THROUGHPUT: 1398 LB/HR
POLYETHYLENE PROPERTIES:	31-35 LB/FT^3 (BULK); 3 MM PELLET SIZE
LOCATION:	INDOORS (ZONE 3)
DUTY:	3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE
MATERIAL:	CARBON STEEL
ADDITIONAL ITEMS:	AIR VENT FILTER ON BIN; BIN VIBRATOR; VARIABLE SPEED DRIVE FOR CONVEYOR

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER X-05-401	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POLYETHYLENE/WASTE EXTRUDER	1

PFD REF: H-2-140641

PROCESS CONDITIONS OF SERVICE

APPLICATION: MELT POLYETHYLENE PELLETS & MIX WASTE INTO THE MOLTEN POLYETHYLENE (PE)

THROUGHPUT REQUIRED:

	PROCESS NEED	EQUIPMENT DESIGN BASIS	
TOTAL:	2185	3995	LB/HR
WASTE:	1311	2597	LB/HR
PE:	874	1398	LB/HR

WASTE PROPERTIES: 54 - 105 LB/FT^3 (BULK), 68 - 140 LB/FT^3 (TRUE); .3 MM MAX. PARTICLE SIZE; ABRASIVE; 0.2 - 0.3 BTU/LB °F SPECIFIC HEAT

PE PROPERTIES: 31-35 LB/FT^3 (BULK), 57 LB/FT^3 (TRUE); 3 MM PELLET SIZE; 0.55 BTU/LB - °F (SOLID), 0.70 BTU/LB - °F (MOLTEN) SPECIFIC HEAT; LATENT HEAT TBD BTU/LB

DUTY: 3 SHIFTS/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

MATERIAL: BARREL: TBD SCREW SHAFT/FLIGHTS: TBD

NOTES:

1. WASTE SHALL BE FED INTO THE EXTRUDER AT A POINT WHERE THE PE HAS ALREADY MELTED.

2. EXTRUDER SHALL INCLUDE ELECTRIC HEATING ELEMENTS FOR PRIMARY HEAT INPUT. COOLING MEDIUM (PROPYLENE GLYCOL/WATER) IS AVAILABLE AT 42°F FOR TEMPERATURE TRIM CONTROL.

3. EXTRUDER HEAT INPUT BASIS:

   BASE CASE: HEAT PE AND WASTE FROM 60°F TO 325°F. WASTE MAY CONTAIN UP TO 10 WT% WATER, WHICH WILL BE DRIVEN OFF AS STEAM.

   ALTERNATE CASE: HEAT PE ONLY FROM 60°F TO 450°F.

4. EXTRUDER SHALL INCLUDE VAPOR DISENGAGEMENT CAPABILITY (THREE ZONES MINIMUM) TO SEPARATE WATER VAPOR, ENTRAINED AIR, AND SMALL AMOUNTS OF OTHER VOLATILES FROM WASTE/MOLTEN PE PRODUCT. VAPOR SEPARATION ZONES SHALL OPERATE AT 2" HG ABSOLUTE PRESSURE.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-05-405	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/31/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
WASTE HOPPER	1

PFD REF: H-2-140641

PROCESS CONDITIONS OF SERVICE

APPLICATION: DAY BIN FOR WASTE FEED TO PE/WASTE EXTRUDER

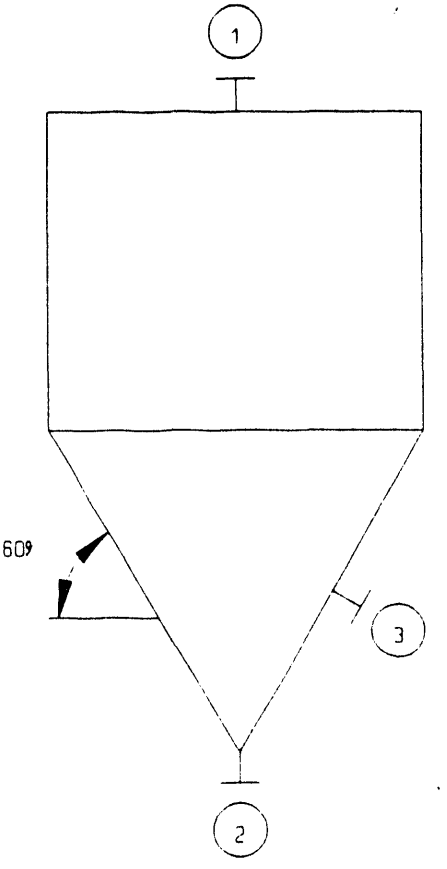
LOCATION: INDOORS	
WORKING CAPACITY: 264 Ft^3	DESIGN/OPERATING TEMPERATURE: 300/60 TO 250°F
UNIT LOAD WEIGHT: 26,400 LB	DESING/OPERATING PRESSURE: 5" WC VAC/1" WC VAC.
PARTICLE SIZE RANGE: 3 MM MAX.	MATERIALS TO BE HANDLED: DRY PARTICULATE WASTE
ANGLE OF REPOSE: 60°	
DUTY: 3 SHIFTS/DAY, 175 DAYS/YR. 30 YEAR LIFE	
MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL	

NOZZLES	QTY.	SIZE - RATING - FACE
1. INLET	1	
2. OUTLET	1	
3. SAMPLE	1	
4.		
5.		
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1. BIN VIBRATOR
2.
3.
4.
5.
6.

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER V-05-401	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE: CONDENSATE RECEIVER

NO. REQ'D.: 1

PFD REF: H-2-140641

PROCESS CONDITIONS OF SERVICE

OPERATING CONDITIONS: 1" Hg ABSOLUTE, 60°F

DESIGN CONDITIONS: 15 PSIG/FULL VACUUM, 450°F

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

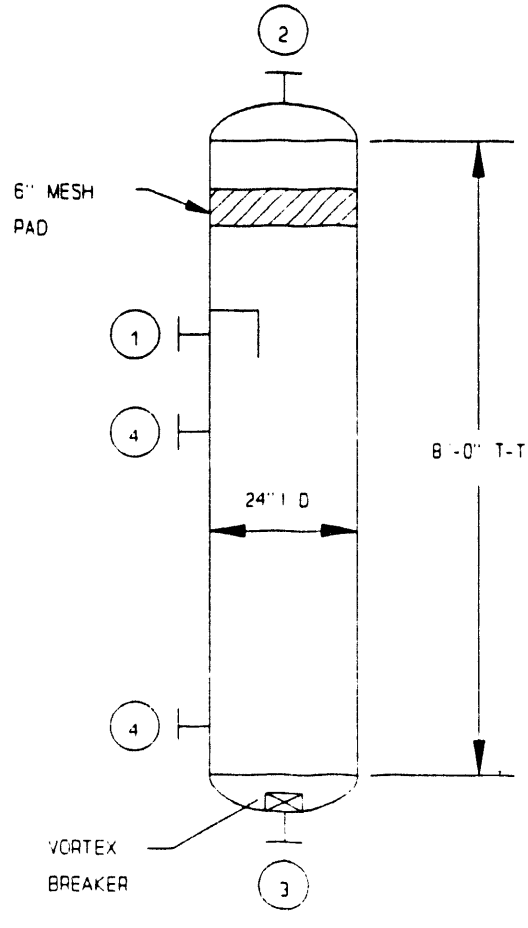
CORROSION ALLOWANCE: NONE

NOZZLES	QTY.	SIZE - RATING - FACE
1. GAS INLET	1	
2. GAS OUTLET	1	
3. LIQUID OUTLET	1	
4. LEVEL BRIDLE	2	
5.		
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1. VORTEX BREAKER
2. MIST ELIMINATOR
3. INLET DEFLECTOR
4.
5.
6.

NOTES:



MAT'L HANDLING & INTERNAL TRANSPORT
PFD H-2-140644 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER DL-08-100, 101, 102	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	G237.008	BY: AJZ

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWERED DRUM LIFT	3

PFD REF: H-2-140644

PROCESS CONDITIONS OF SERVICE

APPLICATION: VERTICAL TRANSFER OF INCOMING UNIT LOADS

UNIT LOAD DESCRIPTION: 55 AND 85 GALLON DRUMS

UNIT LOAD SIZE: 30" DIAMETER MAXIMUM X 40" HEIGHT MAXIMUM

UNIT LOAD WEIGHT: 2,000 LBS MAXIMUM

LOCATION: ZONE 2 PROCESS AREA AT DEBRIS SHRED SPECIAL WASTE AND PARTICULATE ENCLOSURE AREAS

RATED CAPACITY: 5,000 LBS

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

REPEATABILITY: ± 1/8 INCH

SPEED: 30 VFPM MINIMUM

NOTES:

1. DRIVE IS TO BE ELECTRICAL OR PNEUMATIC.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER FT-08-101	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/07/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: AJZ

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
ELECTRIC POWERED LIFT TRUCK	1

PFD REF: H-2-140644

PROCESS CONDITIONS OF SERVICE

APPLICATION: UNLOADING AND TRANSFER OF EMPTY PRODUCT CONTAINERS AND CONTAINERIZED BULK MATERIALS

UNIT LOAD DESCRIPTION: 55 GALLON DRUMS AND EMPTY PRODUCT CONTAINERS

UNIT LOAD SIZE: VARIOUS CONFIGURATIONS, MAXIMUM ENVELOPE 5' LONG X 5' WIDE X 4' HIGH

UNIT LOAD WEIGHT: 2,800 LBS MAXIMUM

LOCATION: MOBILE UNIT SERVES NEW CONTAINER RECEIPT AND STORAGE, TRANSFER CORRIDOR AND NEW CONTAINER INFEED AND STAGING TO PROCESS AND SAMPLING AREAS

RATED CAPACITY: 3,500 LBS

NOTES:

1. BATTERY CHANGER AND ASSOCIATED HANDLING EQUIPMENT IS REQUIRED.
2. TRUCK MANEUVERABILITY IS TO COMPLY WITH CLEARANCES PROVIDED ON CONTRACT GENERAL ARRANGEMENT DRAWINGS.
3. INCLUDES PALLET AND DRUM HANDLING ATTACHMENTS.
4. MINIMUM LIFT HEIGHT REQUIRED, 12'.
5. ATTACHMENTS FOR DRUM AND CONTAINER LIFTS REQUIRED.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER LT-08-100, 103, 104, 106, 108, 109, 110	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: AJZ

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
ELECTRICALLY OPERATED LIFT TABLE	7

PFD REF: H-2-140644

PROCESS CONDITIONS OF SERVICE

APPLICATION: FINAL VERTICAL POSITIONING OF CONTAINERS TO PROCESS ENCLOSURE LOAD IN/LOAD OUT PORTS

UNIT LOAD DESCRIPTION: PRODUCT CONTAINER

UNIT LOAD SIZE: L 4' X W 4' X H 4'

UNIT LOAD WEIGHT: 10,000 LBS

LOCATION: ENCLOSURE CONTAINER LOADING PORTS/SAMPLE AREA CONTAINER PORT

RATED CAPACITY: 15,000 LBS

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

LIFT TABLE TRAVEL REQMTS.: 36" EXTENSION FROM FULL CLOSE

VERTICAL POSITION STABILITY/REPEATABILITY: ± 1/8 INCH

HORIZONTAL POSITION STABILITY/REPEATABILITY: ± 1/8 INCH

NOTES:

1. A REVERSIBLE POWERED ROLLER CONVEYOR DECK IS TO BE PROVIDED WITH T' E LIFT TABLE FOR HORIZONTAL POSITIONING AND TO FACILITATE ON LOAD/OFFLOAD OF UNIT LOADS.

2. LIFT TABLE IS TO HAVE LOCAL MANUAL CONTROLS AND LOCAL PROGRAMMABLE LOGIC CONTROLLER (PLC) SLAVED TO PLANT MANAGEMENT SYSTEM.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER LT-08-101, 102, 111, 112	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/06/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: AJZ

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
ELECTRICALLY OPERATED LIFT TABLE	4

PFD REF: H-2-140644

PROCESS CONDITIONS OF SERVICE

APPLICATION: FINAL VERTICAL POSITIONING OF CONTAINERS TO PROCESS ENCLOSURE LOAD IN/LOAD OUT PORTS

UNIT LOAD DESCRIPTION: 55 AND 85 GALLON DRUMS

UNIT LOAD SIZE: USE 30" DIAMETER X 36" HEIGHT

UNIT LOAD WEIGHT: 2,000 LBS MAXIMUM

LOCATION: ENCLOSURE DRUM LOADING PORT

RATED CAPACITY: 3,000 LBS

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

LIFT TABLE TRAVEL REQMTS.: 36" EXTENSION FROM FULL CLOSE

VERTICAL POSITION STABILITY/REPEATABILITY: ± 1/8 INCH

HORIZONTAL POSITION STABILITY/REPEATABILITY: ± 1/8 INCH

NOTES:

1. A REVERSIBLE POWERED ROLLER CONVEYOR DECK IS TO BE PROVIDED WITH THE LIFT TABLE FOR HORIZONTAL POSITIONING AND TO FACILITATE ON LOAD/OFFLOAD OF UNIT LOADS.

2. LIFT TABLE IS TO HAVE LOCAL MANUAL CONTROLS AND LOCAL PROGRAMMABLE LOGIC CONTROLLER (PLC) SLAVED TO PLANT PC's MANAGEMENT SYSTEM.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER TC-08-100	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: AJZ

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWERED TRANSFER CART	1

PFD REF: H-2-140644

PROCESS CONDITIONS OF SERVICE

APPLICATION: TRANSFER WASTE DRUMS (FULL AND EMPTY) BETWEEN PROCESS ZONE 1 ENCLOSURES

UNIT LOAD DESCRIPTION: 55 AND 85 GALLON DRUMS

UNIT LOAD SIZE: 30" DIAMETER MAXIMUM X 40" HEIGHT MAXIMUM

UNIT LOAD WEIGHT: 2,000 LBS MAXIMUM

LOCATION: PROCESS AREA BETWEEN ENCLOSURES

RATED CAPACITY: 3,000 LBS

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

REPEATABILITY: ± 1/8 INCH

SPEED: 30 FPM

NOTES:

1. DRIVE IS TO BE ELECTRICAL OR PNEUMATIC.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER CL-08-100, 101	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/05/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: AJZ

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
POWERED CONTAINER LIFT	2

PFD REF: H-2-140644

PROCESS CONDITIONS OF SERVICE

APPLICATION: VERTICAL TRANSFER COMPACTED DRUM AND SPECIAL WASTE BOTTLES LOADOUT CONTAINER

UNIT LOAD DESCRIPTION: NEW PRODUCT CONTAINER

UNIT LOAD SIZE: L 4" X W 4" X H 4"

UNIT LOAD WEIGHT: 5,000 LBS (ESTIMATED MAXIMUM)

LOCATION: ZONE 2 PROCESS AREA AT DRUM COMPACTOR AND AT SPECIAL WASTE EXIT PORT

RATED CAPACITY: 7,500 LBS

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

REPEATABILITY: ± 1/8 INCH

SPEED: 30 VFPM MINIMUM

TRAVEL REQUIREMENTS: GRADE TO +35'

NOTES:

1. DRIVE IS TO BE ELECTRICAL OR PNEUMATIC.

SPECIAL WASTE TREATMENT
PFD H-2-140649 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER EM-06-101	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/24/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A	11/16/93 TWN	B	12/27/93 TWN	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SORTING MANIPULATOR	1

PFD REF: H-2-140649

PROCESS CONDITIONS OF SERVICE

APPLICATION: REMOVAL OF ITEMS FROM DRUMS, REMOTE WASTE SORTING, TRANSFER OF ITEMS WITHIN ENCLOSURE

UNIT LOAD DESCRIPTION: PACKETED WASTE (BOTTLES, FLASKS, BRICKS, ETC.)

UNIT LOAD SIZE: 10" X 6" X 28" MAXIMUM

UNIT LOAD WEIGHT: 60 LBS MAXIMUM

LOCATION: INSIDE SPECIAL WASTE ENCLOSURE

RATED CAPACITY: 60 LBS AT FULL EXTENSION

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

END EFFECTOR: REPLACEABLE TOOLS (GRASPING DEVICES, RAKE, SCOOP, ELECTRIC KNIFE)

NOTES:

1. MUST BE ABLE TO GRASP CONTAINERS FROM 22 ML GLASS VIALS TO 1 LITER GLASS BOTTLES WITHOUT CAUSING BREAKAGE.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER ST-06-101	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/26/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A	11/17/93 TWN	B	12/27/93 TWN	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SORTING TABLE	1

PFD REF: H-2-140649

PROCESS CONDITIONS OF SERVICE

APPLICATION: WORK TABLE FOR WASTE SORTING AND MECHANISM TO ALLOW DIRECT FEEDING OF SHREDDER

UNIT LOAD DESCRIPTION: RADIOACTIVE MIXED WASTE FROM 55 GALLON DRUMS

UNIT LOAD SIZE: 7.4 CU.FT. MAXIMUM

UNIT LOAD WEIGHT: 2,000 LBS MAXIMUM

LOCATION: INSIDE SPECIAL WASTE ENCLOSURE

THROUGHPUT: 2 DRUMS/SHIFT

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

CONSTRUCTION: 304 SS

SPECIAL FEATURES:

1. THE TABLE IS TO BE CONSTRUCTED WITH A LIP TO CONTAIN LIQUIDS AND LOOSE SOLIDS.
2. A MECHANISM IS TO BE PROVIDED TO TRANSFER WASTE FROM THE TABLE TO THE SHREDDER FEED HOPPER.

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER H-06-201	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/26/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A	11/17/93 TWN	B	12/27/93 TWN	C	2/23/94 TWN	D	
	E		F		G		H	

SERVICE	NO. REQ'D.
MERCURY EVAPORATOR	1

PFD REF: H-2-140649

PROCESS CONDITIONS OF SERVICE

TYPE OF EQUIPMENT: DOUBLE-CONE, ROTATING VACUUM DRYER

MATERIAL TO BE TREATED: SHREDDED HETEROGENEOUS SOLIDS CONTAINING ELEMENTAL MERCURY AND MERCURY COMPOUNDS ALSO MAY INCLUDE PAPER, GLASS, METAL, WATER AND INERT MATERIAL. MAXIMUM PARTICLE SIZE IS 1/2". WATER CONTENT IS APPROXIMATELY 10% BY WEIGHT. ELEMENTAL MERCURY CONTENT IS LESS THAN 1% BY WEIGHT.

OPERATING PHILOSOPHY: OPERATION WILL BE ONE BATCH PER DAY. OPERATION WILL INCLUDE HEATING, EVAPORATION AND COOL-DOWN CYCLES. DURING THE HEATING CYCLE (APPROXIMATELY 2 HOURS), THE PRESSURE WILL BE REDUCED TO 1" HG ABS. AND THE TEMPERATURE INCREASED TO 450°F. DURING THE EVAPORATION CYCLE (APPROXIMATELY 4 HOURS), THE TEMPERATURE WILL BE HELD AT 450°F. DURING THE COOL-DOWN CYCLE (APPROXIMATELY 16 HOURS), THE PRESSURE WILL BE INCREASED TO ATMOSPHERIC AND THE TEMPERATURE WILL BE REDUCED TO 120°F. NITROGEN PURGE GAS WILL BE USED TO PREVENT A FLAMMABLE GAS MIXTURE, REMOVE WATER AND MERCURY VAPORS, AND PROVIDE COOLING.

CONTROLS: A PROGRAMMABLE LOGIC CONTROLLER TO BE PROVIDED TO CONTROL TEMPERATURE, PRESSURE AND NITROGEN PURGE GAS FLOWRATE DURING COMPLETE CYCLE OF OPERATION.

HEAT INPUT: HEAT INPUT TO BE PROVIDED BY ELECTRIC HEATING ELEMENTS ON THE SHELL OF THE EVAPORATOR. MAXIMUM SHELL TEMPERATURE NOT TO EXCEED 550°F.

DESIGN DUTY: 65,000 BTU/HR

DESIGN CONDITIONS: FULL VACUUM/15 PSIG, 600°F.

DESIGN CAPACITY: 460 LB, 13 CU. FT. PER BATCH

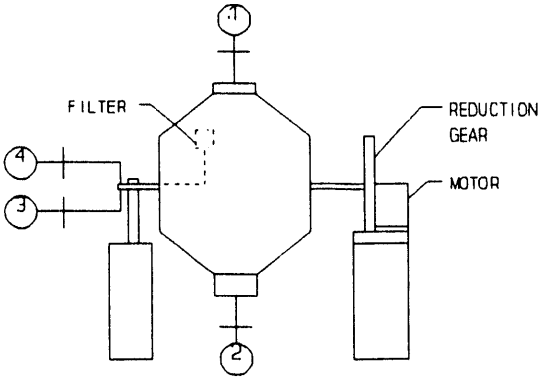
MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

NOZZLES	QTY.	SIZE - RATING - FACE
1. SOLIDS INLET	1	
2. SOLIDS DISCHARGE	1	
3. NITROGEN INLET	1	1" - 150 - RF
4. GAS OUTLET	1	2" - 150 - RF
5. PRESSURE RELIEF	1	150 - RF
6.		
7.		

INTERNALS & ACCESSORIES:

1. OFF-GAS FILTER
2.
3.

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER SH-06-101	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/26/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)								
	A	11/17/93 TWN	B	12/27/93 TWN	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
SHREDDER	1

PFD REF: H-2-140649

PROCESS CONDITIONS OF SERVICE

APPLICATION: SIZE REDUCTION OF RADIOACTIVE MIXED WASTE HETEROGENEOUS OVERSIZED SOLIDS

UNIT LOAD DESCRIPTION: RADIOACTIVE MIXED WASTE FROM 55 GALLON DRUMS

UNIT LOAD SIZE: 7.4 CU.FT. MAXIMUM

UNIT LOAD WEIGHT: 2,000 LBS MAXIMUM

LOCATION: INSIDE SPECIAL WASTE ENCLOSURE

FEED HOPPER CAPACITY: 15 CU.FT.

THROUGHPUT: 11.2 CU.FT./SHIFT

FEED WASTE DESCRIPTION: 0.5" THICK METAL, WOOD, PAPER, PLASTIC

FEED WASTE DENSITY: 30 TO 130 LBS./CU.FT.

SHREDDED PRODUCT SIZE: 1/2" NOMINAL

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL, HARDENED STEEL SHREDDER TEETH

NOTES:

1. SHREDDER AND FEED HOPPER WILL HAVE PROVISIONS (E.G., CONNECTIONS FOR INERT GAS) FOR PURGING TO PREVENT ANY COMBUSTIBLES PRESENT FROM BURNING. HOPPER WILL HAVE AN INLET DOOR TO MINIMIZE INERT GAS REQUIREMENTS. DOOR WILL BE CLOSED AND SHREDDER AND HOPPER PURGED ONLY IF COMBUSTIBLES ARE PRESENT.

SPECIAL WASTE TREATMENT
PFD H-2-140650 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER XX-06-205	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/27/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A	11/17/93 TWN	B	12/27/93 TWN	C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
AUTOTITRATOR PACKAGE	5

PFD REF: H-2-140650

PROCESS CONDITIONS OF SERVICE

APPLICATION: PROVIDE AUTOTITRATORS AND NECESSARY ASSOCIATED LABORATORY EQUIPMENT TO REMOTELY CONTROL DEACTIVATION REACTIONS (ACID/BASE NEUTRALIZATION, OXIDATION/REDUCTION REACTIONS).

INCLUDES (BUT NOT LIMITED TO):

a. AUTOTITRATOR CONTROLLERS
b. ELECTRODES FOR pH, OXIDATION/REDUCTION POTENTIAL (ORP), AND TEMPERATURE
c. PISTON BURETTES OR OTHER DEVICES FOR PUMPING AND CONTROLLING FLOW OF LIQUIDS FROM BOTTLES
d. MIXERS

LOCATION: OUTSIDE SPECIAL WASTE ENCLOSURE

DUTY: 1 SHIFT/DAY, 175 DAYS/YEAR, 30 YEAR LIFE

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER V-06-202	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/26/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A	11/16/93 TWN	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
MERCURY DECANT VESSEL	1

PFD REF: H-2-140650

PROCESS CONDITIONS OF SERVICE

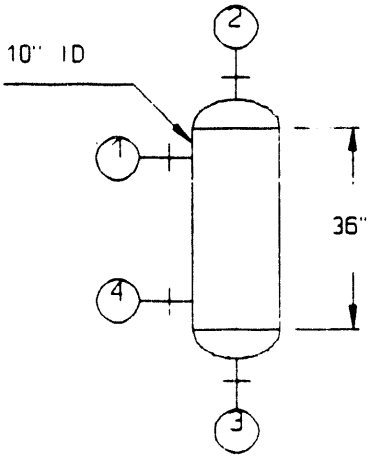
OPERATING CONDITIONS: 1" HG ABS. TO +5" W.C., 42°F TO 120°F

DESIGN CONDITIONS: FULL VACUUM TO 15 PSIG, 500°F

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

CORROSION ALLOWANCE: NONE

NOZZLES	QTY.	SIZE - RATING - FACE
1. GAS INLET	1	2" - 150 - RF
2. GAS OUTLET	1	2" - 150 - RF
3. MERCURY OUTL	1	1" - 150 - RF
4. WATER OUTLET	1	1" - 150 - RF
5.		
6.		
7.		
8.		
9.		
10.		



INTERNALS & ACCESSORIES:

1.
2.
3.
4.
5.
6.

NOTES:

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER XX-06-206	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/27/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
ION EXCHANGE COLUMN	1

PFD REF: H-2-140650

PROCESS CONDITIONS OF SERVICE

APPLICATION: TO REMOVE DISSOLVED ELEMENTAL MERCURY AND MERCURY COMPOUNDS FROM WATER RECOVERED FROM MERCURY EVAPORATOR OPERATION.

DESIGN FLOWRATE: 1.0 GPM

LOCATION: OUTSIDE SPECIAL WASTE ENCLOSURE

SPECIAL WASTE OFF-GAS DIAGRAM
PFD H-2-140651 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER V-06-301	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 09/26/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: TWN

REVISIONS (DATE & BY)	A	11/16/93 TWN	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
CHEMICAL SCRUBBER	1

PFD REF: H-2-140651

PROCESS CONDITIONS OF SERVICE

OPERATING CONDITIONS: 1" W.C. VACUUM, 70°F

DESIGN CONDITIONS: 15 PSIG, 200°F

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

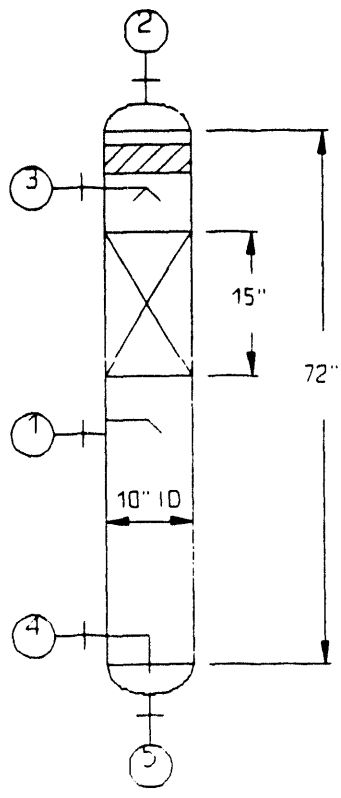
CORROSION ALLOWANCE: NONE

NOZZLES	QTY.	SIZE - RATING - FACE
1. GAS INLET	1	6" - 150 - RF
2. GAS OUTLET	1	6" - 150 - RF
3. LIQUID INLET	1	1.5" - 150 - RF
4. LIQUID OUTLET	1	1.5" - 150 - RF
5. MERCURY OUTL	1	1" - 150 - RF
6.		
7.		
8.		
9.		
10.		

INTERNALS & ACCESSORIES:

1. MIST ELIMINATOR
2. PACKING: 15" STRUCTURED 304 SS
3. LIQUID DISTRIBUTER
4. INLET DEFLECTOR
5. LIQUID DRAWOFF
6.

NOTES:



OVERALL PLANT WATER BALANCE
BFD H-2-140657 SHT. 1

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-07-101A,B	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
NON-ACTIVE WASTE COLLECTION TANKS	2

PFD REF: H-2-140657

PROCESS CONDITIONS OF SERVICE

WORKING CAPACITY: 3000 GALLONS EACH

OPERATING CONDITIONS: 1" W.C. VACUUM, 70°F

DESIGN CONDITIONS: 15 PSIG/5" WC Vac., 150°F

MATERIALS OF CONSTRUCTION: CARBON STEEL

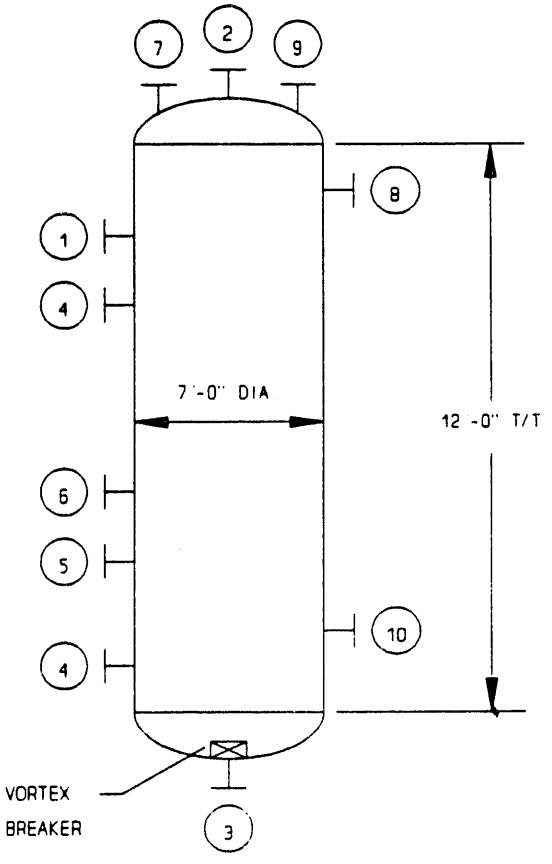
CORROSION ALLOWANCE: 1/4"

NOZZLES	QTY.	SIZE - RATING - FACE
1. WATER INLET	1	
2. MIXER	1	
3. WATER OUTLET	1	
4. LEVEL BRIDLE	2	
5. SAMPLE	1	
6. PH PROBE	1	
7. VENT	1	
8. CHEM INLET	1	
9. PROC. WATER	1	
10. RECYCLE	1	

INTERNALS & ACCESSORIES:

1. VORTEX BREAKER
2.
3.
4.
5.
6.

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-07-201 A&B	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A	2/18/94 DWC	B		C		D	
	E		F		G		H	

SERVICE: ACTIVE WASTE COLLECTION TANK

NO. REQ'D.: 2

PFD REF: H-2-140657

PROCESS CONDITIONS OF SERVICE

WORKING CAPACITY: 7,500 GALLONS

OPERATING CONDITIONS: 1" W.C. VACUUM, 70°F

DESIGN CONDITIONS: 15 PSIG/5" WC Vac., 150°F

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

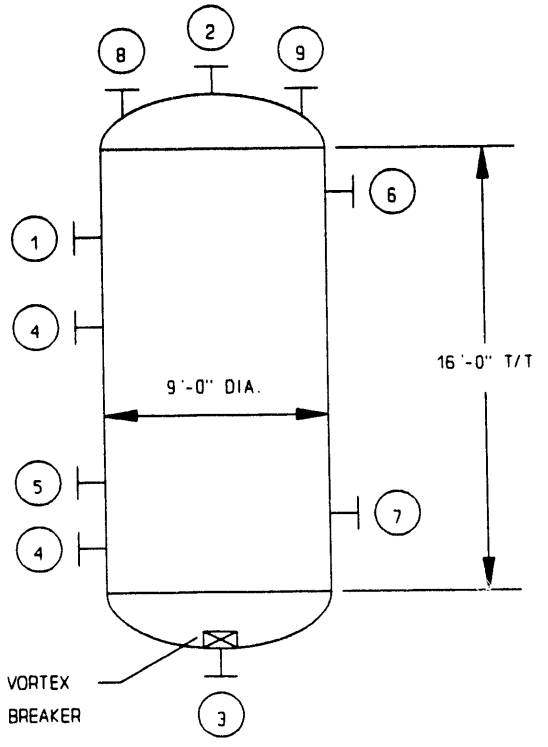
CORROSION ALLOWANCE: NONE

NOZZLES	QTY.	SIZE - RATING - FACE
1. WATER INLET	1	
2. MIXER	1	
3. WATER OUTLET	1	
4. LEVEL BRIDLE	2	
5. SAMPLE	1	
6. PROC. WATER	1	
7. RECYCLE	1	
8. AIR INLET	1	
9. VENT OUTLET	1	
10.		

INTERNALS & ACCESSORIES:

1. VORTEX BREAKER
2.
3.
4.
5.
6.

NOTES:



UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company Western Operations	EQUIPMENT DATA SHEET PROCESS CONDITIONS OF SERVICE	ITEM NUMBER T-07-202	PAGE 1 OF 1

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE: 12/30/93
DOE-RL HANFORD, WA	WRAP FACILITY MODULE 2A	6237.008	BY: DWC

REVISIONS (DATE & BY)	A	2/28/94 DWC	B		C		D	
	E		F		G		H	

SERVICE	NO. REQ'D.
TREATED ACTIVE WASTE TANK	1

PFD REF: H-2-140657

PROCESS CONDITIONS OF SERVICE

WORKING CAPACITY: 7,500 GALLONS

OPERATING CONDITIONS: 1" W.C. VACUUM, 70°F

DESIGN CONDITIONS: 15 PSIG/5" WC Vac., 150°F

MATERIALS OF CONSTRUCTION: 304 STAINLESS STEEL

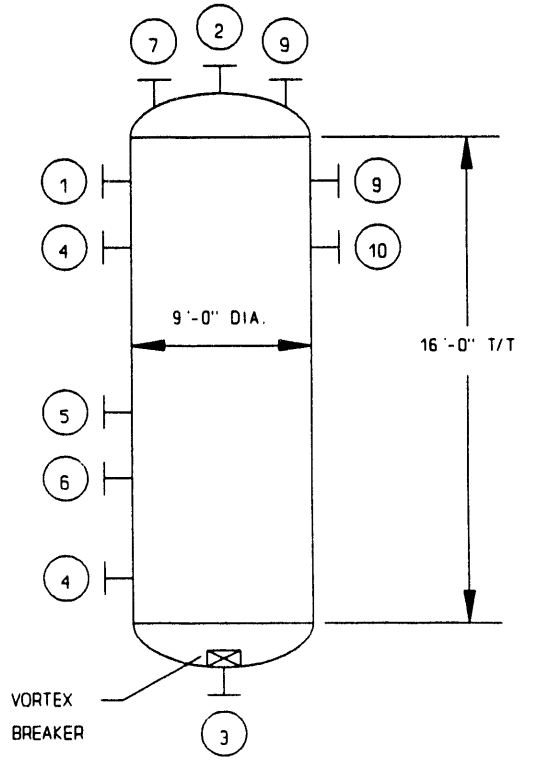
CORROSION ALLOWANCE: NONE

NOZZLES	QTY.	SIZE - RATING - FACE
1. WATER INLET	1	
2. MIXER	1	
3. WATER OUTLET	1	
4. LEVEL BRIDLE	2	
5. SAMPLE	1	
6. PH PROBE	1	
7. AIR INLET	1	
8. VENT OUTLET	1	
9. CHEM INLET	1	
10. PROC. WATER	1	

INTERNALS & ACCESSORIES:

1. VORTEX BREAKER
2.
3.
4.
5.
6.

NOTES:



WASTE RECEIVING AND PROCESSING FACILITY

TITLE: **WRAP 2A ADVANCED CONCEPTUAL DESIGN REPORT STUDY 1604-5: OPEN/SORT/SIZE REDUCTION EVALUATION**

Rev. 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company
Western Operations

Prepared by: for Andrew Sharpe Date: 5/20/93

Reviewed by: Date: 5/20/93

Approved by: Date: 5/20/93

Approved by: Date: 5/20/93
Project Manager

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Appendix A Engineering Sketches
Appendix B Vendor Data

1.0 OBJECTIVE

1. The objective of this study is to evaluate the Open, Sort and Size Reduction facilities within WRAP 2A such that the optimum processes and equipment can be established on which Title I design can proceed. **(Reference 1)**.

1.1 Scope

1. The scope of this study is to evaluate those areas of the Open, Sort and Size Reduction processes and equipment for which potential risk or uncertainty exists within the Conceptual Design Report (CDR) baseline design **(Reference 2)**. Specific areas of study **(Reference 1)** are listed as follows:

   a. Shredded waste size control

   b. Shredder power requirements

   c. Dust control and hazards

   d. Shredder installation

   e. Single route for shredded and non-shredded wastes

   f. Process routes for empty drums

   g. Process routes for 85 gallon drums containing absorbent

   h. Process routes for immobilized waste and supercompacted drums

   j. Waste entry into enclosures

   k. Impact of anti-floatation devices

   l. Drum entry enclosure arrangement

2. The study will identify the possible alternatives for the above areas of uncertainty, and systematically evaluate these taking into account cost/benefit, maintenance/replacement, airborne particulate abatement, confinement enclosure design and waste form size reduction requirements/size grading.

3. The open and sorting equipment proposed for WRAP 2A is based on similar equipment used in WRAP I. This equipment is currently at Title II design and sufficient confidence exists such that re-evaluation is not considered necessary as part of the WRAP 2A ACDR.

4. This study will not evaluate processes or equipment within the Box Breakdown area, or the Special Waste Process Enclosure.

1.2 Background

1. In June 1992 UE&C prepared the CDR for WRAP 2A (**Reference 2**). The CDR identified the requirement for processes and equipment to Open, Sort and Size Reduce/Process drums and boxes of waste entering the facility and repack this waste into new drums for immobilization in either a grout or polymer matrix. The CDR baseline design defined a Size Reduction Repacking area within WRAP 2A in which these operations were to be carried out.

2. The CDR baseline design identifies the requirement for two separate enclosures within the Size Reduction and Repacking area:

   a. Size Reduction and Repack enclosure

   b. Sludge Repack enclosure

   The Size Reduction and Repack enclosure is intended to deal with the bulk of the dry active wastes entering the facility via one of two processing lines within the enclosure. Large items of dry active waste will be shredded in the Shredding Line to a size which is suitable for immobilization using vibro encapsulation techniques. Materials such as soils and ash will be directly repacked into new drums in the Direct Repack line. The two lines utilize a common vibrating table and weigh hopper system to load waste into new drums. An illustration of the CDR baseline design Size Reduction and Repack enclosure is shown in **Appendix A** Sheet 1.1.

   Waste forms which are sludge like in nature will be dealt with in the Sludge Repack enclosure in order to homogenize, pretreat and meter the sludge into new drums. Uncertainties identified in the CDR, relating to the Sludge Repack equipment are addressed in the Sludge Repack Study (**Reference 3**).

   The feedstreams that are to be routed through the shredder of the Size Reduction and Repack line are discussed in Section 5.1.2.

3. The CDR review identified uncertainties in some of the open, sort and size reduction processes and equipment, associated with the Size Reduction and Repack enclosure, for which further investigation is required to confirm their suitability or establish alternative methods. The ACDR will address these issues and establish an optimum baseline design on which Title I design can proceed.

4. The following CDR design review comments will be addressed in this study (**Reference 1**):

Comment #	Comment
3	Identify method of checking the size of shredded material.
10	Investigate methods of segregating empty containers that do not require shredding/treatment before disposal.

66	Investigate deletion of the sorting operation to segregate shredder/non-shredder waste and therefore eliminate a sort table and manipulator.
67	Investigate relocation of the Pug Mill to the deleted sort table position and therefore use the drum entry/transfer equipment as a combined function.
96	Define procedure for handling 85 gallon drums containing absorbent.
102	Evaluate the method of fitting anti-floatation devices to ensure that waste processing is not impaired. Review the requirement for anti-floatation devices.
122	Identify the method of sampling/disposal of absorbent in 85 gallon overpack drums.
200	Define methods of shredding drums containing immobilized waste and drums that have been supercompacted.
294	Consider methods for reducing airborne particulates during the shredding processes -containment should be incorporated into the shredder specification as a functional requirement.

5. The following CDR uncertainties will be addressed by this study **(Reference 2)**:

   a. The ability to produce a targeted waste form size of 2" x 2" x 2" for such a wide variety of wastes.

   b. Capacity (HP) of the shredding equipment required to shred incoming waste.

   c. The general safe operation of shredders in an active environment (i.e. dust generation, fire explosion, requirement for inerting etc.).

   d. Integration of shredders into an active process enclosure (engineering, maintenance, decontaminating etc.).

1.3 Purpose and Need

1. The purpose is to define a system which resolves uncertainties identified in the CDR and CDR review comments to ensure that the processes and equipment specified will achieve the required FDC in a cost effective way.

2. The study is needed to determine the optimum processes and equipment for the Open, Sort and Size Reduction area, on which Title I design can proceed.

2.0 SUMMARY

1. This study evaluates those areas of the Open, Sort and Size Reduction processes and equipment for which potential risk or uncertainty exists within the CDR baseline design. The study identifies the possible alternative processes and equipment for the Open, Sort and Size Reduction area and systematically evaluates these taking into account safety, plant throughput, operations & maintenance, demonstrated technology/development requirements, flexibility, equipment cost, equipment procurement schedule, waste minimization & secondary waste generation.

2. Specific areas of study are listed as follows:

   a. Shredded waste size control

   b. Shredder power requirements

   c. Dust control and hazards

   d. Shredder installation

   e. Single route for shredded and non-shredded wastes

   f. Process routes for empty drums

   g. Process routes for 85 gallon drums containing absorbent

   h. Process routes for immobilized waste and supercompacted drums

   j. Waste entry into enclosures

   k. Impact of anti-floatation devices

   l. Drum entry enclosure arrangement

3. Results of the study confirm the existing baseline CDR design with some minor design and process modifications. A summary of the study recommended design solutions to the individual areas of study is given in **Table 2.1**. Specific conclusions and recommendations of the individual assessments listed above are given in section 3.0.

TABLE 2.1
SUMMARY OF STUDY FINDINGS

Area of Study	Recommended Design Solution
Shredded Waste Size Control	Two Shredders in Series. No Sorting of Shredded Waste. No Screening of Shredded Waste.
Shredder Power Requirements	Hydraulic: 200 HP Coarse Shredder 150 HP Fine Shredder Electric : 80 HP Coarse Shredder 40 HP Fine Shredder
Dust Control and Hazards	Sliding Hatch Over Shredders. Local Ventilation at Shredders. Inert Shredders.
Shredder Installation	Shredder Housing to be glovebox containment. Shredders Positioned Vertically in Line with Each Other.
Single Route for Shredded and Non Shredded Waste	Direct Repack Waste which does Not require Shredding. Shred Waste which requires Shredding.
Process Routes for Empty Drums	Compact Empty Drums.
Process Routes for 85 gallon Drums Containing Absorbent	Open, Size Reduce and Repack in the Box Breakdown Cell.
Process Routes for Immobilized Waste and Supercompacted Drums	Size Reduce and Repack in the Box Breakdown Cell.
Waste Entry into Enclosures	Transfer Full Drums of Waste into Containment using Simple Double Lidding Systems.
Impact of Anti-Floatation Devices	Fit Anti-Floatation Device to Drum Before Dispatch to Size Reduction Enclosure.
Enclosure Entry Systems	Each of the Size Reduction, Sludge Repack and Special Waste Lines has its own Separate Entry Enclosure.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Shredded Waste Size Control

1. Conclusions

   a. Two shredders in series with visual inspection of waste after shredding to confirm the shredded waste is within an acceptable size for vibro encapsulation represents the most suitable equipment arrangement to size reduce WRAP 2A wastes. Prior to shredding an initial screening of the waste will be carried out on the sorting table to remove any items which are unsuitable for shredding, no mechanical screening or sorting of the waste should be carried out after shredding. Discussions with shredder vendors indicates that this type of shredder arrangement will size reduce the majority of WRAP 2A wastes. Unshreddable items which are not identified and removed while the waste is on the sorting table, will stall but not damage the shredders. It is not possible to guarantee that all wastes will be size reduced to less than 2"x2"x2" maximum, however discussion with vendors indicate that a two stage shredding operation will size reduce the majority of waste into individual pieces which are in the order of 2"x2"x2". Soft materials such as plastic sheeting, suits etc will stretch and tear during the shredding operation and will be the least likely material to shred to the target size of 2"x2"x2".

   b. Shredded waste from the Open, Sort and Size Reduction enclosure is encapsulated in WRAP 2A using vibro-mixing techniques. BNFL experience in the UK suggests that when encapsulating solid materials in a free flowing grout, the maximum size of the waste that can be satisfactorily encapsulated is bounded by the physical size of the container in which the waste and grout is to be mixed.

2. Recommendations

   a. The WRAP 2A Title I design should incorporate two shredders in series to size reduce WRAP 2A wastes. This shredder arrangement will size reduce waste into individual pieces in the order of 2"x2"x2". Screening or sorting of the size reduced waste will not be necessary unless the shredded waste size of 2"x2"x2" maximum is a mandatory requirement.

   b. The shredded waste size is not constrained to an upper size of 2"x2"x2" maximum. Any physical constraints on the shredded waste should be specified by the grout or polymer vibro-mixing processes.

3.2 Shredder Power Requirements

1. Conclusions

   a. Several companies manufacture shredders for size reduction of waste material. Shredder selection is based on the characteristics of the waste to be shredded and the degree of size reduction required.

b. A Shredding system similar to that proposed for WRAP 2A has been designed and built by the Stock Equipment Company to process waste at the Perry Nuclear Power Plant in Ohio, this system uses Shred Pax 40 HP electrically driven shredders. Shredding tests carried out by INEL indicate Shred Pax 80 HP electrically driven shredders to be most suitably for processing specific INEL wastes. Discussions with Shred Pax indicate that their 80 HP electrically driven machine would be more suitable than the 40 HP machine to size reduce WRAP 2A wastes.

c. INEL shredding tests also recognize Saturn equipment as being suitable to shred INEL specific wastes, these tests were carried out using a Saturn 617 HP hydraulically driven shredder. Initial discussions with Saturn indicate two shredders in series, a 200 HP coarse shredder and a 150 HP fine shredder, would be the most suitable system to shred WRAP 2A wastes. Both shredders would be hydraulically driven.

d. Williams Shredders suggest two 150 HP hydraulically driven shredders to be most suitable to process WRAP 2A wastes.

e. All shredder manufacturers stated it would not be possible to guarantee that the shredded waste would not exceed a 2"x2"x2" maximum envelope.

f. Unshreddable items which are not identified and removed while the waste is on the sorting table, will stall but not damage the shredders.

g. Electrical power is the preferred type of drive for the shredders, because it is cleaner and simpler than hydraulic drives and does not generate active hydraulic fluid or hydraulic oil contaminated secondary wastes.

2. Recommendations

a. Discussions with shredder manufacturers indicate the most suitable power requirements for the WRAP 2A shredders are:

Hydraulically Driven Shredders

Coarse Shredder	200 HP
Fine Shredder	100 HP

Electrically Driven Shredders

Coarse Shredder	80 HP
Fine Shredder	40 HP

3.3 Dust Control and Hazards

1. Conclusions

a. A sliding hatch over the shredder feed hopper combined with a local ventilation exhaust from the shredding enclosure represents the most suitable equipment arrangement to achieve dust control during shredding operations.

b. The likelihood of fire and/or explosion occurring during shredding operations cannot at present be discounted. Inerting the shredding system will eliminate the possibility of fire and/or explosion.

2. Recommendations

a. The WRAP 2A Title I design incorporate a sliding hatch over the shredder feed hopper and local ventilation exhaust from the shredding enclosure.

b. The WRAP 2A shredders should be inerted to eliminate the possibility of fire and/or explosion.

3.4 Shredder Installation

1. Conclusions

a. The shredder housing should be an extension of the glovebox enclosure with the drive system external and accessible for maintenance/replacement. The shredder housing should be connected to adjacent enclosures by bolted flanges. It is more suitable for the shredders to be positioned vertically in line with each other rather than vertically in line and oriented at 90° to each other. The shredder and shredder enclosure should be supported by steelwork external to the enclosure with loadings transmitted to the building floor.

2. Recommendations

a. The WRAP 2A Title I design should progress on the basis that the shredder housing forms an integral part of the glovebox enclosure with drive systems external and accessible for maintenance and replacement. The shredder housing should be connected to adjacent enclosures by bolted flanges. It is more suitable for the shredders to be positioned vertically in line with each other rather than vertically in line and oriented at 90° to each other. The shredder and shredder enclosure should be supported by steelwork external to the enclosure with loadings transmitted to the building floor.

3.5 Single Route for Shredded/Non-Shredded Waste

1. Conclusions

a. Waste which does not require size reduction should be directly repacked and not shredded. A shredding line and a direct repack line are required for processing dry wastes within the size reduction area of WRAP 2A as currently identified in the CDR baseline design.

2. Recommendations

a. The WRAP 2A Title I design should progress on the basis that both a shredding line and a direct repack line are required to process dry wastes.

3.6 Process Routes for Empty Drums

1. Conclusions

   a. Empty drums arising from the size reduction area of WRAP 2A should be compacted, loaded into 85 gallon overpacks and disposed of as LLW. However, in order for this to be possible the FDC must be revised to allow compacted empty drums to be packaged into 85 gallon drums for disposal as LLW.

2. Recommendations

   a. The WRAP 2A Title I design should included an empty drum compactor and an empty drum compact load out facility. The FDC must also be revised to allow empty drums to be re-classified as LLW and output from WRAP 2A in 85 gallon drums.

3.7 Process Routes for 85 Gallon Drums Containing Absorbent

1. Conclusions

   a. 85 gallon drums containing absorbent should be opened, sampled, size reduced as necessary and repacked in the box breakdown area of WRAP 2A prior to shredding in the size reduction enclosure.

   b. The proposal to route 85 gallon drums containing absorbent through box breakdown area is in line with the CDR philosophy.

2. Recommendations

   a. The WRAP 2A Title I design should progress on the basis that 85 gallon drums containing absorbent are opened, size reduced as necessary and repacked in the box breakdown area prior to shredding.

3.8 Process Routes for Immobilized Waste and Supercompacted Drums

1. Conclusions

   a. Both drums of immobilized waste and supercompacted drums should be size reduced into shreddable pieces and repacked in the box breakdown area of WRAP 2A prior to shredding in the size reduction enclosure.

   b. The proposal to route immobilized waste and supercompacted drums through the box breakdown area is in line with the CDR philosophy.

2. Recommendations

   a. The WRAP 2A Title I design should progress on the basis that both drums of immobilized waste and supercompacted drums are size reduced into shreddable pieces and repacked in the box breakdown area prior to shredding.

3.9 Waste Entry into Containment

1. Conclusions

   a. The most suitable method of transferring waste into containment is to transfer full drums of waste into containment using simple double lidding systems.

2. Recommendations

   a. The WRAP 2A Title I design should include simple double lidding systems and drum handling equipment for transferring full drums of waste into containment.

3.10 Impact of Anti-Floatation Devices

1. Conclusions

   a. At present it is not known whether Anti-floatation devices will be required to prevent waste floating in the grout or polymer matrix. However, some wastes are known to have relatively low densities and the likelihood that these wastes will float cannot currently be eliminated. For the purpose of the assessment it has been assumed that anti-floatation devices will be required.

   b. Waste anti-floatation devices should be fitted to the new drum before dispatch to the size reduction enclosure. At the size reduction enclosure the anti-floatation device is removed remotely in order to allow the drum to be filled with waste, after which the anti-floatation device will be replaced. The same rationale applies to baskets to prevent waste sinking to the bottom of the drum, disposable paddles for in-drum mixing and anti-vortex devices if required. In some cases removal of the device may not be required to allow the drum to be filled with waste.

2. Recommendations

   a. Further work should be carried out on waste characterization, in order that the grout and polymer processes can confirm that waste anti-floatation devices are required.

   b. When the necessity for anti-floatation devices is confirmed, anti-floatation devices are required, the WRAP 2A Title design should include anti-floatation handling facilities in the Size Reduction, Sludge Repack and Special Waste enclosures.

   c. When the necessity for anti-floatation devices is confirmed, anti-floatation devices are required, conceptual design of the new drum and anti-floatation device should be initiated. These should be coordinated with other internal drum devices such as anti-sinking baskets, in drum mixing paddles etc.

3.11 Enclosure Entry Systems

1. Conclusions

   a. Utilization of individual entry enclosure to each of the Size Reduction, Sludge Repack and Special Waste lines is the most suitable entry configuration for introducing drums of waste into containment. This represents the CDR baseline design.

2. Recommendations

   a. The WRAP 2A Title I design should progress on the basis that each of the Size Reduction, Sludge Repack and Special Waste lines has its own entry enclosure.

4.0 UNCERTAINTIES

1. Limited information exists at present on the physical and chemical characteristics of the wastes to be processed in WRAP 2A. In order for the Open, Sort and Size Reduction study to be carried out, assumptions have been made for the characteristics of the WRAP 2A wastes such that alternative processes and equipment could be evaluated and a preferred baseline design identified. Accurate information on the actual characteristics of the WRAP 2A wastes will hence give greater confidence in the preferred baseline design.

2. The size of waste after shredding has previously been targeted at 2"x2"x2" maximum. No evidence exists that this size is dictated by regulations, and in fact the upper size of waste after shredding only appears to be related to the maximum size of waste that can be satisfactorily encapsulated in the grouting and polymer processes. Shredded waste is encapsulated in WRAP 2A using vibro-mixing techniques, and BNFL experience suggests that when encapsulating solid materials in a free flowing grout the maximum size of waste that can be satisfactorily be encapsulated is bounded by the physical size of the container in which the waste and grout is mixed. If for some reason it is mandatory for the waste size after shredding to be 2"x2"x2" maximum, then screening or sorting equipment will be required to segregate and refeed oversize waste back into the shredder.

3. The potential impact of the Debris Rule on WRAP 2A has been ignored at this stage of the design, following WHC direction.

4. This study and the CDR is based on information that waste to be processed in WRAP 2A is packaged within plastic bags which are in turn contained within drums. Recent information suggests that a significant quantity of drums exist in which the waste has been packaged in 90 mil rigid liners, however little information exists on the 90 mil liners and it has been agreed with WHC that opening and processing of these liners should not be addressed as part of this study.

5. The requirements that are necessary to verify that a drum is empty and can be disposed of as LLW (i.e., visual inspection, measuring equipment etc.) are uncertain at this stage.

6. At present it is not known whether anti-floatation devices will be required to prevent waste floating in the grout or polymer matrix. However, some wastes are known to have relatively low densities and the likelihood that these wastes will float cannot currently be eliminated. For the purpose of the assessment it has been assumed that anti-floatation devices will be required.

7. The disposal costs for LLW and LLRMW have been assumed to be $44/cuft and $90/cuft, respectively.

8. The study estimates that approximately 700 x 85 gallon drums containing absorbent will require processing in WRAP 2A over the lifetime of the plant.

9. The study estimates that approximately 190 immobilized drums and minimal supercompacted drums will require processing in WRAP 2A each year. The 190 immobilized drums comprises of 100 drums per year produced by the grout or polymer processes which do not comply with WAC and 90 drums per year which require destructive examination.

10. It is assumed that the box breakdown cell is required to process approximately one box per month and that on average, each box required two weeks to be processed in the box breakdown cell leaving a spare two weeks per month capacity to carry out additional tasks.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC Requirements

1. The criteria for the equipment and process evaluations covered by this study within the open, sort and size reduction enclosure are subject to the following Functional Design Criteria (FDC) **(Reference 4)** requirements:

   a. Throughput shall be based on single shift operation 5 days per week with a 70% facility availability.

   b. The facility systems shall be designed to minimize the release of radioactive and hazardous materials.

   c. Equipment shall be designed to meet the criteria for special equipment identified in Section 2.1.5 of the FDC.

   d. Shredders shall be provided to size reduce feedstream waste to provide acceptable feed for subsequent waste treatment.

   e. The process enclosure and equipment shall be designed for operation decontamination and decommissioning.

5.1.2 Process Objectives and Functional Requirements

1. These objectives and requirements are the basis for selection of the most suitable processes and equipment in the Size Reduction and Repack facilities in WRAP 2A.

   a. Waste fed to the shredder will not exceed the size of an 85 gallon drum.

   b. The shredder must be sized to achieve a maximum throughput of approximately 25 drums per day.

   c. The physical size of the shredded waste must be suitable for vibro encapsulation techniques. This final shredded waste is currently targeted at 2" x 2" x 2".

   d. Materials of construction must be compatible with waste feeds.

   e. Dust generation during shredding must be minimized.

   f. The shredder must be capable of size reducing the following types of materials

      1) Hypalon liner strips
      2) Protective clothing and polythene sheets
      3) Cloth, paper wood
      4) Hand tools, buckets and shovel
      5) Absorbent
      6) Glass

7) Structural and sheet steels
8) Sorbonded (solid gelatinous grout material)
9) Empty drums
10) concrete

A detailed description of the wastes to be shredded are given in the Study Assumptions Section 5.2.

2. A summary of the WRAP 2A feedstreams which are to be size reduced in the shredder are given in **Table 5.2.**

3. The shredder evaluation will evaluate a number of design configurations to produce a waste size which conforms to the immobilization criteria, multiple shredders and screening equipment will be included in the evaluation. Dust and Hazard control, during shredding will be assessed by considering the use of a shredder inlet enclosure and by local ventilation exhausts. Shredder mounting alternatives will be evaluated to ensure that maintenance, containment and support criteria are achieved.

4. The process evaluation will consider alternative process routes for specific waste types. These were identified by the CDR and subsequent reviews as requiring further investigation to confirm waste routing, equipment suitability and impact on throughput. The study will identify a suitable method for processing:

   a. Empty drums by shredding or compaction.

   b. 85 gallon drums with absorbent by using the 55 gallon process route or through box breakdown.

   c. Immobilized waste/supercompacted drums by shredding or through box breakdown.

   d. Waste entry into enclosures by bagging or bagless transfer.

5. In the event that anti-floatation devices are required, the effect of such devices on drum filling operations (from the size reduction enclosures) will be evaluated. The impact on drum filling of having the devices fitted prior to arrival or at the enclosure will be assessed for the effect on throughput and to ensure feasibility.

6. Alternative methods of drum entry into the enclosures will be reviewed to assess any cost savings in equipment that could be made by using a common entry into two or more enclosures.

7. Comments and uncertainties identified in the CDR phase and listed in the Work Task Assignment for Study #5 are to be addressed.

8. Specific Areas of Study are as follows:

   a. Shredded waste size control:

      - Two shredders in series
      - Single shredder with sizing screen

TABLE 5-2
WRAP 2A FEEDSTREAM PHYSICAL CHARACTERISTICS SUMMARY

WRAP 2A Feedstream	Dry Particulate	Wet Particulate	Dry Size Reduced/ Oversized	Wet Size Reduced/ Oversized	Ion Exchange Resins	Lead Bricks[2]
1A 183 H Solidified Liquid				20,625 (2.8%)		
1B 183 H Crystalline Solid	32,500 (4.5%)					
1C 183 H Sludge		35,000 (4.8%)				
1D 183 H Miscellaneous Cleanup			4,813 (0.7%)	4,813 (0.7%)		
2A Ammonium Sulfate	261,500 (36.1%)					
2B Ion Exchange Resins					53,500 (7.4%)	
2C Metal Sludge		76,250 (10.5%)				
2D RO Filter Elements				8,750 (1.2%)		
3 Dry Active Waste			52,500 (7.2%)			
4 Construction Debris			28,875 (4.0%)			
5A Mercury/Mercury Contaminated Waste			12,900 (1.8%)			
5B Reactive Metals	440 (<0.1%)					
5C Lead/Lead Contaminated Waste			735 (0.1%)			11,764 (1.6%)
5D Miscellaneous Metals			3,035 (0.4%)			
6 Absorbed Chemicals	42,500 (5.9%)					
7 Incinerator Ash	57,500 (7.9%)					
8 Contaminated Soils	17,000 (2.3%)					
TOTAL[1]	411,440 (56.8%)	111,250 (15.3%)	102,858 (14.2%)	34,188 (4.7%)	53,500 (7.4%)	11,764 (1.6%)

Notes:

1 Values are FT^3 volume
Values in ( ) are volume %

2 _____ streams to be size reduced in the shredder

b. Shredder power requirements:

- Manufacturer recommendation from CDR
- Power Source
- Material to be shredded

c. Dust control and hazards:

- Local exhausts
- Shredder enclosures exhausts
- Use waste characteristics to determine hazard of dust generation

d. Shredder installation

- Shredder support attachments to enclosure
- Access for maintenance/removal

e. Single route for shredded/non-shredded waste:

- Compatibility with final waste form
- Dust generation
- Throughput capacity

f. Empty drums

- Shred
- Compact
- Store

g. 85 gallon drums with absorbent

- Shred
- Pre-treat in box breakdown

h. Immobilized waste and supercompacted drums

- Shred
- Pre-treat in box breakdown

i. Waste entry into enclosure

- Bagless transfer
- Bagging techniques

j. Impact of anti-floatation devices:

- Drum filling
- Method and location for installing anti-floatation devices

k. Enclosure Entry Systems:

- Drum entry enclosure arrangement
- Installation/maintenance/decontamination
- Operability

5.1.3 Screening Criteria

1. The purpose of the screening criteria is to eliminate alternatives which do not meet functional criteria, and there is no overriding reason to support further evaluation.

2. Screening criteria are as follows:

   a. Functional Criteria ("Shall")

   FDC and other mandatory requirements are to be listed in this section. Each alternative shall be compared to that criteria.

   b. No Justification for Further Evaluation

   Alternatives which do not merit further evaluation can be eliminated from further study at this stage providing a technical justification to support the elimination is given.

5.1.4 Evaluation Criteria

1. Alternatives which are not eliminated by the screening evaluation, are considered against a list of evaluation criteria. Each individual evaluation criteria is given :

   a. A weighting factor.

   b. A raw score in the range 1-5, reflecting the potential relative merits of the alternative. The raw score is determined by comparing the alternatives against each other rather than against absolute criteria.

2. The total scoring is calculated by multiplying the raw score selected and the weighting factor.

3. Evaluation Criteria, Weighting Factors and Raw Score

a. Criteria: Potential Hazards

1) Weighting Factor: 15%

2) Raw Score:

All processes must be safe. Factors to consider include operator dose exposure; human factors; potential for operator puncture wounds; potential for leaks, spills or uncontrolled releases; potential for dropping objects; potential for flammable gas generation. This category is judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

b. Criteria: Plant Throughput

1) Weighting Factor: 15%

2) Raw Score:

All processes must meet the required FDC throughput. Alternatives are compared against each other to determine which offers the greatest potential to exceed the FDC throughput. This category is judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

c. Criteria: Operability and Maintainability

1) Weighting Factor: 15%

2) Raw Score:

Factors to consider include ability of the operator to view and carry out all required routine operations and maintenance activities; labor requirements for operations and maintenance; potential for modularization of equipment; complexity of equipment and process configuration; and materials of

construction in relation to their conditions of service (corrosivity, temperature etc). Operability and maintainability also represents a direct reflection of how the equipment performs in carrying out the specified task. In order to be considered for evaluation each alternative must be judged as capable of achieving the required task with various degrees of effectiveness. This category is judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

d. Criteria: Demonstrated Technology/Development Requirements

1) Weighting Factor: 20%

2) Raw Score:

The ability to demonstrate that the equipment has been successfully operated within the nuclear industry over a reasonable period of time. Whether the equipment has operated successfully outside the nuclear industry over a reasonable period of time. Whether the equipment requires a development program. This category will be judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

e. Criteria: Flexibility

1) Weighting Factor: 15%

2) Raw Score:

The ability to meet potentially changing criteria. The capability to accommodate future expansion or change out requirements. This category will be judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

f. Criteria: Equipment Cost

1) Weighting Factor: 10%

2) Raw Score:

The equipment cost of each alternative will be calculated and scores awarded which reflect the comparative cost of each alternative. This category will be judged subjectively, and the scores will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

g. Criteria: Equipment Procurement Schedule

1) Weighting Factor: 5%

2) Raw Score:

An assessment will be made to determine how each alternative affects the equipment procurement schedule. Scores will then be awarded based on the following:

Improves to schedule	5
Meets schedule	3
Delays schedule	1

h. Criteria: Waste Minimization/Secondary Waste Generation

1) Weighting Factor: 5%

2) Raw Score:

The ability to reduce the overall waste volume. Generation of no significant secondary wastes. Generation of additional waste which can be dealt with in WRAP 2A. Generation of additional waste which has to be dealt with in another facility. This category will be judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

5.2 Assumptions

5.2.1 Study Prerequisites

1. CDR baseline design.

5.2.2 Study Assumptions

1. Waste material characteristics are as specified in the CDR.

2. Waste will not exceed the size of an 85 gallon drum.

3. The items listed below are assumed to be maximum waste sizes which will be fed through the shredder system. The purpose of this list is to provide shredder vendors with information on the physical characteristics of the waste to be processed.

   a. Material Types

      (i) Hypalon Liner Strips
      (ii) Protective Clothing - Boots, Gloves, Suits
      (iii) Cloth Material
      (iv) Shovels, 5 gal. Buckets
      (v) Polyethylene Sheets
      (vi) Hand Tools
      (vii) Paper, Wood
      (viii) Absorbent
      (ix) Glass
      (x) Sheet Metal (12g & 10g) Carbon Steel
      (xi) Structural Steel Sections (see below for maximum anticipated sizes)
      (xii) "Sorbond" (Solid/Gelatinous Grout Material)
      (xiii) 55 & 85 Gallon Drums (Some 55 gallon filled with concrete)
      (xiv) Supercompacted drums of waste

4. <u>Maximum Size of Waste</u>

   a. All waste materials will be delivered in 55 gallon drums and this, therefore, is a limitation on size. Plastic sheeting however can be compressed into the drums resulting in larger sheet sizes. Within the drums, waste items will be wrapped in pvc packets. Each drum will contain approximately 10 to 15 packets of waste. Any drum may contain a mixture of the types of waste listed in i to xiv.

   b. <u>Typical Maximum Anticipated Sizes</u>

      (i) 1 1/4" Diameter Steel Bar X 36" Long
      (ii) 4" Square Hollow Section X 1/4" Wall Thickness X 36" Long
      (iii) 4" X 3" Hardwood X 36" Long
      (iv) 85 Gallon Drum (Empty)
      (v) 55 Gallon Drum filled with Concrete

c. Material Feed Rate (Average)

Empty 55/85 gallon drums	=	5 drums/hour
Waste	=	25 drums/day

d. Material Size After Processing

Target size of 2" maximum in any direction

5. At present it is not known whether anti-floatation devices will be required to prevent waste floating in the grout or polymer matrix. However, some wastes are known to have relatively low densities and the likelihood that these wastes will float cannot currently be eliminated. For the purpose of the assessment it has been assumed that anti-floatation devices will be required.

6. The disposal costs for LLW and LLRMW have been assumed to be $45/cuft and $135/cuft, respectively. (These values were derived from information provided by WHC as order of magnitude estimates. The estimated cost (FY 93 dollars) of disposal of Hanford generated LLW and LLRMW are in the range of $40-50 and $130-140 respectively, and the mid-points of these ranges were assumed. It is recognized that disposal costs for waste generated by sites other than Hanford are higher than these costs, and also that these costs are susceptible to change with time including escalation; however, the relatively constant ratio between LLW and LLRMW disposal costs is of interest for this study and individual fluctuations have little consequence).

7. The study estimates that approximately 700 x 85 gallon drums containing absorbent will require processing in WRAP 2A over the lifetime of the plant (Section 6.7.5.d).

8. The study estimates that approximately 190 immobilized drums and minimal supercompacted drums will require processing in WRAP 2A each year. The 190 immobilized drums comprises of 100 drums per year produced by the grout or polymer processes which do not comply with WAC and 90 drums per year which require destructive examination (Section 6.8.4a).

9. It is assumed that the box breakdown cell is required to process approximately one box per month and that on average, each box required two weeks to be processed in the box breakdown cell leaving a spare two weeks per month capacity to carry out additional tasks.

6.0 DESCRIPTION OF ALTERNATIVE AND SOLUTIONS

6.1 Shredded Waste Size Control

1. Introduction

   a. The purpose of this assessment is to determine the most effective method of shredding WRAP 2A wastes. A shredded waste final size for immobilization has been targeted at a 2" x 2" x 2" maximum. The alternatives identified, indicate possible methods of achieving size control by using screening and sorting methods to remove any oversized materials such that they can be recycled through the shredding system for further size reduction.

2. List of Alternatives Considered

   a. ALT A1 = Single Shredder - Close Fitting Screen - No Sort

   b. ALT A2 = Single Shredder - Close Fitting Screen - Sort

   c. ALT A3 = Single Shredder - Vibrating Screen - No Sort

   d. ALT A4 = Single Shredder - Vibrating Screen - Sort

   e. ALT A5 = Single Shredder - No Screen - No Sort

   f. ALT A6 = Single Shredder - No Screen - Sort

   g. ALT A7 = Two Shredders - Close Fitting Screen - No Sort

   h. ALT A8 = Two Shredders - Close Fitting Screen - Sort

   i. ALT A9 = Two Shredders - Vibrating Screen - No Sort

   j. ALT A10 = Two Shredders - Vibrating Screen - Sort

   k. ALT A11 = Two Shredders - No Screen - No Sort

   l. ALT A12 = Two Shredders - No Screen - Sort

3. Description of Alternatives

   a. Waste enters the size reduction and repack enclosure in drums. Once inside the enclosure the drum lid is removed and the waste tipped onto an inspection/sorting table. While on this table the waste is visually inspected and any waste which is considered not suitable for shredding is segregated/screened using manipulators and removed from the enclosure using a bagless transfer system. Waste which is considered as suitable for shredding is shredded and the waste size controlled by the following methods:

1) Alt A1 Single Shredder - Close Fitting Screen - No Sort

a) This alternative uses a screen fitted close to the shredder cutters, the screen would be formed around the lower half of the cutters to recycle any "oversize" material through the shredder. The small gap between the cutters and the screen would ensure that any material too large to pass through the screen would be swept up and refed into the shredder for a second pass.

b) The combination of screen design and spacing between the cutter and screen would ensure that only material of the specified size passes through the screen.

2) Alt A2 Single Shredder - Close Fitting Screen - Sort

a) A single shredder is fitted with a close fitting screen to refeed any oversize waste through the shredder. The discharged waste is sorted by an operator to remove and recycle any lengthy items not filtered out by the two dimensional screen.

3) Alt A3 Single Shredder - Vibrating Screen - No Sort

a) The shredder discharges onto a vibrating screen which, as the material is fed forward, allows the correct size material to pass through to the next process stage and the oversize material to be collected for refeed through the shredder.

4) Alt A4 Single Shredder - Vibrating Screen - Sort

a) A single shredder is fitted with a vibrating screen to refeed any oversize waste through the shredder. The discharged waste is sorted by an operator to remove and recycle any lengthy items not filtered out by the two dimensional screen.

5) Alt A5 Single Shredder - No Screen - No Sort.

a) A single shredder discharges onto the vibrating conveyor for loading directly into new drums. After shredding the waste will be visually inspected using CCTV equipment to confirm that the shredded waste is in line with the target waste size. This alternative relies on the single stage shredder to consistently shred waste within the target size and that the visual inspection is to confirm the shredded waste size is acceptable.

6) Alt A6 Single Shredder - No Screen - Sort

a) Material discharged from the single shredder would be visually examined and oversize waste removed for refeed through the shredder.

7) Alt A7 Two Shredders - Close Fitting Screen - No Sort

a) A close fitting screen, fitted to the lower half of the of the second shredder, recycling oversize material through the second shredder to achieve the specified waste size.

8) Alt A8 Two Shredders - Close Fitting Screen - Sort

a) Two shredders mounted in series, use a close fitting screen to separate and refeed oversize material into the shredders. The discharged waste is sorted by an operator to remove and recycle any lengthy items which have not been filtered out by the two dimensional screen.

9) Alt A9 Shredders - Vibrating Screen - No Sort

a) The addition of a vibrating screen will separate any oversize material which passes through the second shredder and enable this to be refed through the process.

10) Alt A10 Two Shredders - Vibrating Screen - Sort

a) Two shredders mounted in series, use a close fitting screen to separate and refeed oversize material into the shredders. The discharged waste is sorted by an operator to remove and recycle any lengthy items which have not been filtered out by the two dimensional screen.

11) Alt A11 Two Shredders - No Screen - No Sort

a) Shredded material from the first shredder feeds directly into the second shredder, providing a second pass for material to be further reduced. After shredding the waste will be visually inspected using CCTV equipment to confirm that the shredded waste is in line with the target waste size. This alternative relies on the double shredding system to consistently shred waste within the target size and that the visual inspection is to confirm the shredded waste size is acceptable.

12) Alt A12 Two Shredders - No Screen - Sort.

a) Two shredders mounted in series discharge directly onto a conveyor where any oversize material is removed using manipulators for refeed through the shredders.

b. The FDC specifies that segregation/screening of waste is carried out to remove lumps and foreign objects. Each of the alternatives A1 to A2 is considered to meet this objective by carrying out an initial visual inspection and screening/removal of wastes which are not considered suitable for shredding, prior to the shredding operation being carried out. Alternatives A5 to A11 propose that a visual inspection is carried out to ensure shredded waste is within an acceptable size for vibro encapsulation. This visual inspection screening is considered as an alternative to mechanical screening or sorting and is considered to comply with FDC requirements.

4. <u>Alternatives Screened From Further Evaluation</u>

a. Alternatives - A2, A4, A8 & A10

1) These alternatives propose the use of both screening and sorting equipment to achieve shredded waste size control. This duplicates equipment which carry out the same function and hence these alternatives are not considered necessary or cost effective.

b. Alternatives - A3 & A6

1) These alternatives propose the use of a single shredder and either a vibrating table or sorting equipment to achieve shredded waste size control. In order to re-feed oversized waste back into the shredder it will be necessary to provide a basket and hoist for these alternatives. The use of a single shredder will provide less size reduction than two shredders and will therefore increase the quantity of waste which has to be re-fed into the shredder. This will subsequently require a significantly higher number of operations and increase operator involvement.

c. Alternative - A5

1) This alternative proposes the use of a single shredder with no screen or no sorting equipment to provide shredded waste size control. It is considered that a single shredder could not reliably produce waste of the correct size for the full range of waste forms. This alternative will provide less size control than the baseline design.

5. Description of Evaluation Matrix Scoring

a. An illustration of the alternatives evaluated is given in **Appendix A**, Sheet 6.1. The evaluation matrix is given in **Table 6.1**, located after the evaluation matrix description.

b. All alternatives use shredding equipment to size reduce the waste and either screening or sorting to achieve control of the waste size after size reduction.

c. Alternatives using the vibrating screen and sorting manipulators will require additional equipment to re-feed waste into the shredding equipment, this will also increase the glovebox envelope. The close fitting screen naturally re-feeds waste back into the shredder until the required size is achieved and hence does not require additional equipment.

d. Potential Hazards

1) The single shredder alternatives present less of a hazard due to there being less equipment to operate & maintain and potentially less dust generation. Similarly the double shredder with no screening or sorting represents less of a hazard due to there being less equipment to maintain than for the other double shredder alternatives.

2) Both close fitting and vibrating screening techniques are considered less hazardous than sorting because they can be carried out without direct operator involvement and hence reduce operator exposure.

e. Plant Throughput

1) There will be no significant difference in throughput when operating two shredders in series rather than operating a single shredder.

2) It is likely to take slightly longer for waste to pass through a shredding system with a close fitting screen rather than a shredding system without a close fitting screen due to recycling of waste through the shredder.

3) Re-feeding waste into the shredders for either the vibrating screen or sorting manipulators requires additional equipment operations. Although the extent of these operations depends on the ability of the shredding equipment to achieve the required size reduction, re-feeding waste into the shredder is carried out in parallel with the main shredding process. The time and motion study carried out as part of the CDR allowed 10 minutes between loading waste onto the sort table and shredding the waste, hence on average, 10 minutes exist to re-feed waste back into the shredder for each drum.

f. Operability and Maintainability

1) Operation of the shredding equipment will be automatic and hence there will be no significant difference between operating one or two shredders.

2) Although a single shredder alone will be easier to maintain than a double shredder, a single shredder is far less likely to achieve the desired waste product size on a single pass. Consequently a single shredder with a close fitting screen is more likely to experience jamming of waste against the screen and additional recovery operations or breakdown maintenance. Similarly double shredders with a close fitting screen may experience some operational and maintenance difficulties, these will however be far less than for a single shredder with close fitting screen.

3) Re-feeding waste into the shredding equipment after sorting or screening with a vibrating screen requires additional equipment to be operated and maintained. However, it is likely that the close fitting screens will be more difficult to maintain.

4) Sorting requires an operator to be constantly present at the glovebox face during the length of the plant operation, this will incur additional operator exposure and is considered the least favorable alternative with respect to operability and maintainability.

5) Although it will not be possible to guarantee that all waste can be sized reduced to less than a target size of 2"x2"x2" maximum without screening or sorting the shredded waste, discussions with shredder vendors indicate that a two stage shredding operation will size reduce the majority of waste into individual pieces which are in the order of 2"x2"x2". Soft materials such as plastic sheeting suits etc will stretch and tear during the shredding operation and will be the least likely material to shred to the target size of 2"x2"x2". Shredded waste from the Open, Sort and Size Reduction enclosure is encapsulated in WRAP 2A using vibro-mixing techniques. BNFL experience in the UK suggests that when encapsulating solid materials in a free flowing grout, the maximum size of the waste that can be satisfactorily encapsulated is bounded by the physical size of the container in which the waste and grout is to be mixed. In order to take advantage of the reduced amount of equipment to purchase, operate, maintain and decommission, associated with not screening or segregating the shredded waste, the current target size of 2"x2"x2" maximum could be re examined to determine if this could be increased in size.

6) Unshreddable items which are not identified and removed while on the sorting table, will stall but not damage the shredders.

g. Demonstrated Technology/Development Requirements

1) Although shredding equipment has been tested and operated in an active environment, it is recommended that testing and development work be performed specifically related to size reduction and size control of the wastes which are to be treated in the WRAP 2A facility.

2) The use of manipulators to carry out handling operations in an active environment is well established but labor intensive technology.

3) Although BNFL have carried out testing and development of the combined shredder/close fitting screen arrangement for soft wastes in waste treatment plants at Sellafield in the UK, it has yet to be established whether the close fitting screen is suitable to screen the wide variety of wastes which are to be size reduced in WRAP 2A. Information on close fitting screens has been requested from BNFL in the UK.

4) The use of vibrating screens to achieve physical separation of solid waste items is common practice outside the nuclear industry.

h. Flexibility

1) Alternatives which offer sorting as the means of waste size control are considered to be more flexible than dedicated screens, as they allow waste to be sorted on other criteria (waste type, hard/soft etc) after shredding.

i. Equipment Cost

1) The baseline CDR TEC cost of two shredders in series with a close fitting screen all located within a glovebox enclosure is:

	Equipment Cost $ K
Coarse Shredder	270
Fine Shredder	140
Close Fitting Screen (Included in Shredder Cost)	
Enclosure	128
Total	538

2) The following costs are used to build up the cost for each alternative :

	Equipment Cost $ K
One Shredder	270
Two Shredders	410
Vibrating Screen	3.0
Close Fitting Screen (Included in Shredder Cost Estimate)	
Pair of Sorting Manips	107
Hoist & Re-feed Basket	10.0
Enclosure (Cost estimate calculated on an individual basis)	

3) ALT A1: Single Shredder - Close Fitting Screen - No Sort

	Equipment Cost $ K
Single Shredder	270
Close Fitting Screen	128
Enclosure	
Total	398

4) ALT A7: Two Shredders - Close Fitting Screen - No Sort

	Equipment Cost $ K
Two Shredders	410
Close Fitting Screen	
Enclosure	128
Total	538

5) ALT A9: Two Shredders - Vibrating Screen - No Sort

	Equipment Cost $ K
Two Shredders	410
Vibrating Screen	3
Hoist and Re-feed Basket	10.0
Enclosure	275
Total	698

6) ALT A11: Two Shredders - No Screen - No Sort

	Equipment Cost $ K
Two Shredders	410
Enclosure	128
Total	538

7) ALT A12: Two Shredders - No Screen - Sort

	Equipment Cost $ K
Two Shredders	410
Sorting Manipulators	107
Hoist and Re-feed Basket	10.0
Enclosure	275
Total	802

j. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

k. Waste Minimization Including Secondary Waste Generation

1) Alternatives employing two shredders in series may provide some volume reduction in the size reduction area of WRAP 2A however as waste is to be loaded into drums for Grout/Polymer on a weight basis the overall size reduction within the plant is the same.

2) No Significant differences are considered to exist between each alternative in producing secondary operational wastes.

3) Alternatives proposing the most equipment will produce more maintenance and decommissioning wastes.

6. Conclusions

a. Two shredders in series with visual inspection of waste after shredding to confirm the shredded waste is within an acceptable size for vibro encapsulation represents the most suitable equipment arrangement to size reduce WRAP 2A wastes. Prior to shredding, an initial screening of the waste will be carried out on the sorting table to remove any items which are unsuitable for shredding, no mechanical screening or sorting of the waste should be carried out after shredding. Discussions with shredder vendors indicates that this type of shredder

arrangement will size reduce the majority of WRAP 2A wastes. Unshreddable items which are not identified and removed while the waste is on the sorting table, will stall but not damage the shredders. It is not possible to guarantee that all wastes will be size reduced to less than 2"x2"x2" maximum, however discussion with vendors indicate that a two stage shredding operation will size reduce the majority of waste into individual pieces which are in the order of 2"x2"x2". Soft materials such as plastic sheeting, suits etc will stretch and tear during the shredding operation and will be the least likely material to shred to the target size of 2"x2"x2".

b. Shredded waste from the Open, Sort and Size Reduction enclosure is encapsulated in WRAP 2A using vibro-mixing techniques. BNFL experience in the UK suggests that when encapsulating solid materials in a free flowing grout, the maximum size of the waste that can be satisfactorily encapsulated is bounded by the physical size of the container in which the waste and grout is to be mixed.

7. Recommendations

a. The WRAP 2A Title I design should incorporate two shredders in series to size reduce WRAP 2A wastes. This shredder arrangement will size reduce waste into individual pieces in the order of 2"x2"x2". Screening or sorting of the size reduced waste will not be necessary unless the shredded waste size of 2"x2"x2" maximum is a mandatory requirement.

b. The shredded waste size is not constrained to an upper size of 2"x2"x2" maximum. Any physical constraints on the shredded waste should be specified by the grout or polymer vibro-mixing processes.

TABLE 6.1
SHREDDED WASTE SIZE CONTROL - EVALUATION MATRIX

ALT A1 = Single Shredder - Close Fitting Screen - No Sort
ALT A7 = Two Shredders - Close Fitting Screen - No Sort
ALT A9 = Two Shredders - Vibrating Screen - No Sort
ALT A11 = Two Shredders - No Screen - No Sort
ALT A12 = Two Shredders - No Screen - Sort

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT A1		ALT A7		ALT A9		ALT A11		ALT A12	
			RS	WS	RS	WS	RS	WS	RS	WS	RS	WS
Potential Hazards	15%	1-5	3.5	0.53	3.0	0.45	3.0	0.45	3.5	0.53	2.5	0.38
Throughput	15%	1-5	2.5	0.38	2.5	0.38	3.0	0.45	3.0	0.45	2.0	0.30
Cps & Main	15%	1-5	2.0	0.30	3.0	0.45	3.5	0.53	4.0	0.60	2.5	0.38
Dem Tech/Dev	20%	1-5	2.0	0.40	2.0	0.40	3.0	0.60	3.5	0.70	3.0	0.60
Flexibility	15%	1-5	2.0	0.30	2.0	0.30	3.0	0.45	3.0	0.45	3.5	0.53
Equipment Cost	10%	1-5	3.5	0.35	3.0	0.30	2.5	0.25	3.0	0.30	2.0	0.20
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15	2.5	0.13
Waste Min	5%	1-5	3.0	0.15	3.0	0.15	2.0	0.10	3.0	0.15	2.0	0.10
Total	100%			2.55		2.58		2.98		3.33		2.60

6.2 Shredder Power Requirements

1. Introduction

   a. Shredders achieve size reduction by way of 2 slow rotating shafts fitted with intermeshing cutters which crush and shear the material drawn into the cutters by the cutter rotation. High torque is required to perform this function at the slow operating speeds necessary to allow feed back to stop rotation when non-compliant material is present. This feature prevents the machine jamming and prolongs the life of cutter and drive components. This study will assess the power requirements for the shredders and investigate the use of:

      1) Electric Power

         a) An electric motor drives the two shredder shafts through gearboxes which provide the speed reduction and torque output required for the shredding operation. The gearboxes drive the shaft through couplings and are mounted directly in line with the shredder shafts.

      2) Hydraulic Power

         a) The hydraulic motor is directly attached to the two shredder shafts and incorporates a speed control to obtain the required shredder speed, an electric motor driven power pack is required to generate hydraulic pressure through hoses to the shredder motor.

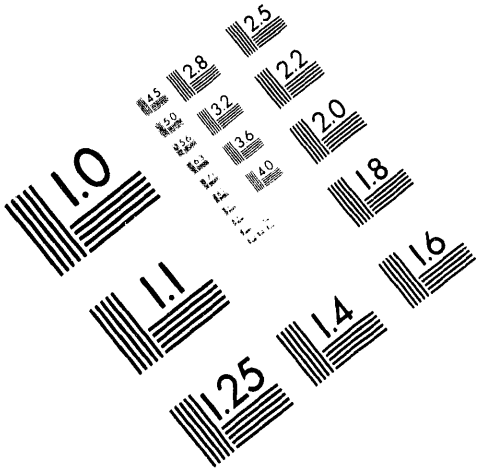
   b. Electric power is the preferred type of drive for the shredders, because it does not generate active hydraulic fluid and is cleaner and simpler than hydraulic drives. Electrically driven shredders have an additional advantage in that they require less facility space than hydraulically driven shredders which have substantially more bulky drive mechanisms.

2. Discussion

   a. In order to develop an estimate of the power requirements for the WRAP 2A shredding systems, shredder vendors have been consulted and information on shredding systems acquired. As a basis for discussion shredder manufacturers were given information on the assumed characteristics of the waste to be shredded and the targeted final waste size if 2"x2"x2" as indicated in section 5.2.2.3 and 5.2.2.4

   b. Saturn Shredders **(References 5 & 6)**

      1) Telephone discussions with Saturn Shredder indicate that a two shredder system would be required to achieve a target shredded waste size in the order of 2" x 2" x 2". The coarse shredder was likely to be in the power range of 200 HP and the fine shredder in the range of 150 HP, both shredders would be hydraulic drive vendor data on Saturn Shredders is provided in **Appendix B**. Saturn would be prepared to carry out shredding tests on surrogate waste at their works in Texas.



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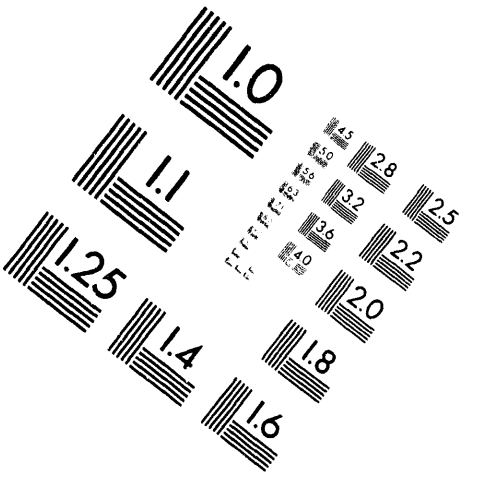

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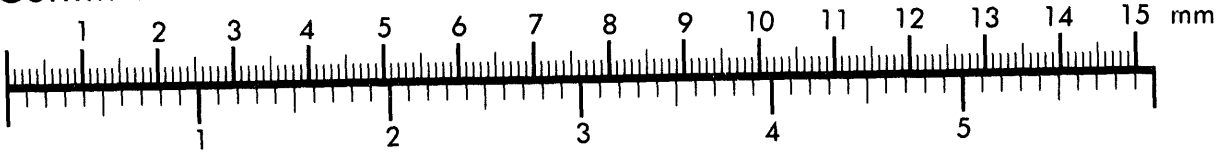

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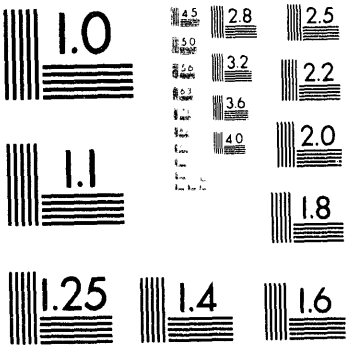

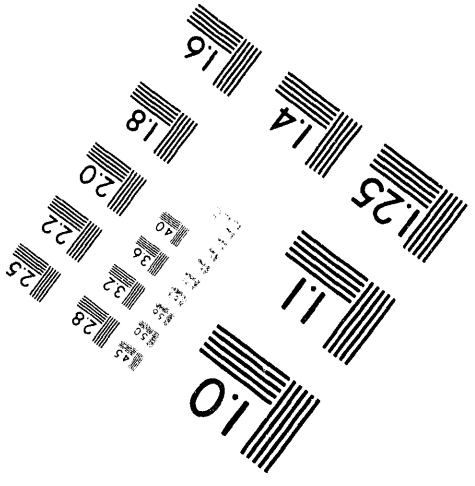

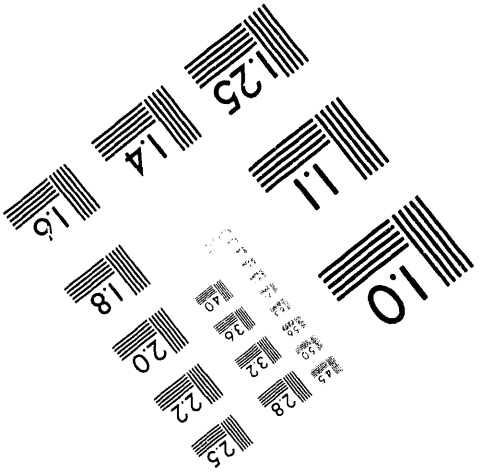

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c. Stock Equipment Company **(Reference 7)**

1) The Stock Equipment Company have designed and built a shredding and compaction facility for processing LLW generated at the Perry Nuclear Power plant. The Stock design incorporates the use of two shred Pax 40 HP shredders in series to size reduce materials such as steel and wood filter frames, empty 55 gallon drums, protective clothing, plastic sheeting, sheet steel and 3/4", conduit down to a size of approximately 1" wide x 3"-8" long. UE&C/BNFL visited Stock to witness a demonstration of the shredding and compaction unit, features of the Stock shredder design relevant to the WRAP 2A shredder design are listed as follows:

a. The two shredders are positioned vertically in line with a horizontal offset of 2" between the centerline of the two shredders.

b. The shredder housing is an integral part of the enclosure.

c. Screening or sorting of the shredded waste is not carried out, as shredded waste size control is not critical.

d. The Shred Pax shredders used by Stock are electrically driven.

e. Processing of liquids or chemicals is not part of the design basis for the shredding and compaction unit and hence excess corrosion, fire and explosion is not considered a problem.

f. The shredder feed hopper is covered over by a sliding door, to prevent projectiles being thrown from the shredder during shredding operations.

g. In order to establish that Shred Pax shredders were the most suitable for shredding waste generated by the Perry Nuclear Power plant, Stock identified three shredder vendors and carried out shredding trials on surrogate waste at each vendors site. A prime factor in selection of Shred Pax as the preferred supplier of the shredding equipment, was that they were willing to carry out trials using three types of shredder cutter design (cutter spacing, number of hooks on the cutter etc.) such that an acceptable shredded waste size could be achieved.

2) There are close similarities between the Stock shredding unit and he WRAP 2A shredding system. The approach of identifying typical wastes to be shredded followed by shredding trials at vendors sites, as carried out by Stock Equipment Company, would assist in selection of the specific shredder model for WRAP 2A.

d. Idaho National Engineering Laboratory (INEL) Waste Shreddability Tests **(Reference 8)**

1) In 1983 INEL published a report documenting tests on low speed shredders and waste shreddability (Reference). In summary, INEL carried out shredding trials using four manufacturers low speed shredders:

a. Blower Application Company

b. Saturn Manufacturing Company

c. Shred Pax Corporation

d. Triple/S Dynamics

2) Identical sets of test waste were assembled and packaged in 55 gallon drums and 4'x4'x4' wooden boxes. Materials fed into the shredders included paper, plastic sheeting,wooden pallets, steel plate, steel tube and pipe, steel section etc. Some waste fed to the shredders was unshreddable, however it was determined that unshreddable materials did not damage the shredders, although recovery of the unshreddable items was required from the shredders. INEL tests conclude that shredders can size reduce 1" steel rods, heavy steel cable, concrete, 1/4" carbon and stainless steel plate and all lesser waste.

3) INEL findings indicate that the Shred Pax 80 HP shredder and the Saturn 617 HP shredder were more than adequate to shred the specific INEL waste to an acceptable particle size. However of the two, the Shred Pax was considered to be the best suited to INEL's specific requirements being compact, electrically driven, least expensive, low anticipated maintenance requirements, most energy efficient and produced acceptable waste particle size. INEL however recognize that each of the four shredders tested are all excellent machines and that each have advantages in different shredding applications.

e. Shred Pax **(Reference 9)**

1) Shred Pax offered to carry out shredder trials on surrogate wastes at their works in Illinois. Shred Pax indicated that the 80 HP shredder, tested in the INEL Report, was likely to be the most suitable to size reducing WRAP 2A wastes, rather than the 40 HP machine demonstrated at Stock Equipment Company. Vendor data on Shred Pax Shredders is provided in **Appendix B**.

f. SSI Shredding Systems Inc. **(Reference 10)**

1) SSI were hesitant to provide an immediate estimate of the shredder power requirements although they are prepared to carry out shredder tests on surrogate waste at their works in Oregon. SSI supply both hydraulic and electric shredders. Vendor data on SSI Shredders is provided in **Appendix B.**

g. Williams Shredders **(Reference 11)**

1) Williams suggest consideration of a two shredder system to size reduce WRAP 2A waste to a target size of 2"x2"x2". Williams suggest the coarse shredder be a 150 HP machine equipped with nominal 1-1/2" thickness, 2 tooth cutters above a fine shredder of 150 HP equipped with nominal 1-1/2", 6 or 8 tooth cutters. Vendor data on Williams Shredders is provided in **Appendix B.**

h. All shredder manufacturers stated it would not be possible to guarantee that the shredded waste would not exceed a 2"x2"x2" maximum envelope

3. Conclusions

a. Several companies manufacture shredders for size reduction of waste material. Shredder selection is based on the characteristics of the waste to be shredded and the degree of size reduction required.

b. A Shredding system similar to that proposed for WRAP 2A has been designed and built by the Stock Equipment Company to process waste at the Perry Nuclear Power Plant in Ohio, this system uses Shred Pax 40 HP electrically driven shredders. Shredding tests carried out by INEL indicate Shred Pax 80 HP electrically driven shredders to be most suitably for processing specific INEL wastes. Discussions with Shred Pax indicate that their 80 HP electrically driven machine would be more suitable than the 40 HP machine to size reduce WRAP 2A wastes.

c. INEL shredding tests also recognize Saturn equipment as being suitable to shred INEL specific wastes, these tests were carried out using a Saturn 617 HP hydraulically driven shredder. Initial discussions with Saturn indicate two shredders in series, a 200 HP coarse shredder and a 150 HP fine shredder, would be the most suitable system to shred WRAP 2A wastes. Both shredders would be hydraulically driven.

d. Williams Shredders suggest two 150 HP hydraulically driven shredders to be most suitable to process WRAP 2A wastes.

e. All shredder manufacturers stated it would not be possible to guarantee that the shredded waste would not exceed a 2"x2"x2" maximum envelope.

f. Unshreddable items which are not identified and removed while the waste is on the sorting table, will stall but not damage the shredders.

g. Electrical power is the preferred type of drive for the shredders, because it is cleaner and simpler than hydraulic drives and does not generate active hydraulic fluid or hydraulic oil contaminated secondary wastes.

4. Recommendations

a. Discussions with shredder manufacturers indicate the most suitable power requirements for the WRAP 2A shredders are:

Hydraulicly Driven Shredders

Coarse Shredder	200 HP
Fine Shredder	100 HP

Electrically Driven Shredders

Coarse Shredder	80 HP
Fine Shredder	40 HP

6.3 Dust Control and Hazards

1. Introduction

   a. The purpose of this assessment is to determine the most effective method of dust control during shredding. The alternatives identified, indicate possible methods of achieving dust control using seals and ventilation airflows. The number of shredders required to achieve the targeted shredded waste size will be determined by the shredded waste size control evaluation. Each alternative considered as part of the dust control and hazards evaluation applies to both a single and double shredding system.

2. List of Alternatives

   a. ALT C1 = Local Exhaust - Brush Seal

   b. ALT C2 = Local Exhaust - Sliding Hatch Cover

   c. ALT C3 = Local Exhaust - No Seal

   d. ALT C4 = Enclosure Exhaust Only - Brush Seal

   e. ALT C5 = Enclosure Exhaust Only - Sliding Hatch Cover

   f. ALT C6 = Enclosure Exhaust Only - No Seal

3. Description of Alternatives

   a. ALT C1 Local Exhaust - Brush Seal

      1) A brush type seal fitted across the shredder inlet allows waste items to pass through and provides a restriction on the outflow of particulate during the shredding operation. Local ventilation exhaust connections are fitted at the inlet and discharge of the shredder exhaust from the local ventilation will be routed into the glovebox ventilation exhaust and filtered in bag and HEPA filters. Local exhaust is in addition to the enclosure ventilation system. Inert gas purge connections will be provided.

   b. ALT C2 Local Exhaust - Sliding Hatch Cover

      1) A sliding hatch cover is fitted across the shredder inlet to provide containment of dust during the shredding operation. Local ventilation exhausts are provided at the inlet and discharge of the shredder. Local exhaust is in addition to the enclosure ventilation system. Inert gas purge connections will be provided.

c. ALT C3 Local Exhaust - No Seal

1) Local ventilation exhausts are fitted to the inlet and discharge of the shredder to remove airborne particulate generated by the shredding operation. Local exhaust is in addition to the enclosure ventilation system. Inert gas purge connections will be provided.

d. ALT C4 Enclosure Exhaust Only - Brush Seal

1) A brush seal fitted at the shredder inlet to contain airborne particulate generated by the shredding operation. Inert gas purge connections will be provided.

e. ALT C5 Enclosure Exhaust Only - Sliding Hatch Cover

1) A sliding hatch cover is fitted at the shredder inlet. Inert gas purge connections will be provided.

f. ALT C6 Enclosure exhaust only - No seal.

1) Waste is loaded into an open top shredder, airborne particulate released into the enclosure is removed by the enclosure ventilation exhaust. Inert gas purge connections will be provided.

4. Description of Evaluation Matrix Scoring

a. An illustration of the alternatives evaluated is given in **Appendix A**, Sheet 6.3. The evaluation matrix is given in **Table 6.3**, located after the evaluation matrix description.

b. The Waste Treatment Complex at BNFLs Sellafield Site in the UK was originally built to sort and shred waste for disposal. As part of the detail design of this project the possibility of a dust explosion occurring during shredding operation was considered and could not be eliminated. A prime factor in recognizing the amount of dust generated during shredding operations and the potential for dust explosion was established by knowledge gained from shredding operations carried out at UKAEAs Harwell Site in the UK. As a result the shredders in Waste Treatment Complex were inerted to eliminate the possibility of fire and/or explosion.

c. Dust will be generated during the shredding operations carried out in WRAP 2A. Based on experience gained by BNFL in the UK, the risk of fire and/or explosion occurring during shredding operations cannot at present be discounted for WRAP 2A. The inerting system will be required for each of the alternatives evaluated.

d. Potential Hazards

1) Local exhausts will provide additional airflow out of the shredder without drawing contamination through the entire enclosure, thus allowing airborne particulate to be removed at the point of shredding.

2) Both the sliding hatch cover and brush seals will provide additional containment over the shredder enclosure during shredding operations thus minimizing spread of contamination.

3) The sliding hatch cover is likely to provide better contamination control than brush seals as any residual contamination trapped between the brushes will become released when waste is dropped through the seal.

4) The sliding hatch cover will provide a cover to prevent projectiles being thrown from the shredder during the shredding operation.

5) As a result, the sliding hatch cover is considered safer than the brush seal.

e. Plant Throughput

1) The use of local exhausts, a sliding hatch cover and brush seals to control dust are off line activities and will have no effect on plant throughput. The sliding hatch cover can be opened while waste is inspected on the sorting table and hence will not affect throughput.

f. Operability and Maintainability

1) The enclosure exhaust will run continuously and not require direct operator input. The local exhaust can either operate continuously or be interlocked to operate only when the shredder is activated, this will not require direct operator input. Neither brush seals or the sliding hatch cover will require direct manual input from the operator.

2) There will be minimal difference between maintenance of a local exhaust in addition to the enclosure exhaust. Both brush seals and the sliding hatch will require some maintenance.

3) Local exhausts, a sliding hatch cover and brush seals will provide contamination control and hence reduce clean up operations.

4) Brush seals have the potential to become weak over a period of time and become drawn into the shredder cutters.

5) Although brush seals have no moving parts the brushes will wear and become damaged as waste is dropped through, from the sorting table into the shredder.

6) Recovery of non shreddable waste will be more difficult through a brush seal system.

7) Airflows will have to be balanced/compensated when the local exhaust is started and stopped.

8) It is intended that the operator will use CCTV equipment to view the waste when in the shredding hopper after loading from the sorting table and prior to closing the sliding hatch/starting the shredders. It is not intended that viewing of the waste shredding operation will be a routine activity. It is likely that windows will be required in the shredder enclosure for maintenance requirements, if necessary these could be used for non routine operational viewing.

g. Demonstrated Technology/Development Requirements

1) There will be a requirement to operate and test the shredding equipment as part of the shredded waste size control work, this will provide valuable information on dust generation from the various waste streams which are shredded.

2) Operation of enclosure and local exhaust is standard practice within the nuclear industry. Sliding doors are also common features to facilitate contamination control.

3) Although brush seals may be used for contamination control, it is likely some testing will be required to demonstrate the effectiveness of a brush seal over a shredder aperture sized to take a 55 or 85 gallon drum.

h. Flexibility

1) Although dust control is a service to the main process, the greater the capability to control dust and minimize spread of contamination, the greater is the potential for WRAP 2A to process wastes in addition to the current CDR baseline design. Brush seals may reduce the ability to process additional waste, i.e., the waste may stick to the brushes or may cut the brushes etc.

j. Equipment Cost

1) The baseline CDR design proposed that dust control was achieved by the enclosure ventilation airflow through the shredders. The cost of equipment additional to that included in the CDR TEC are estimated as follows:

	Equipment Cost
	$ K
Local exhaust system	10.0
Brush Seal	2.0
Sliding Hatch Cover	26.3

2) ALT C1: Local Exhaust - Brush Seal

	Equipment Cost $ K
Local exhaust system	10.0
Brush Seal	2.0
Total	12.0

3) ALT C2: Local Exhaust - Sliding Hatch Cover

	Equipment Cost $ K
Local exhaust system	10.0
Sliding Hatch Cover	26.3
Total	36.3

4) ALT C3: Local Exhaust - No Seal

	Equipment Cost $ K
Local exhaust system	10.0
Total	10.0

5) ALT C4: Enclosure Exhaust - Brush Seal

	Equipment Cost $ K
Enclosure Exhaust (Included in CDR TEC)	
Brush Seal	2.0
Total	2.0

6) ALT C5: Enclosure Exhaust - Sliding Hatch Cover

	Equipment Cost $ K
Enclosure Exhaust (Included in CDR TEC)	
Sliding Hatch Cover	26.3
Total	26.3

7) ALT C6: Enclosure Exhaust - No Seal

8) Enclosure exhaust with no seal is the CDR baseline design against which ALT C1 to C5 are being compared.

k. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

j. Waste Minimization Including Secondary Waste Generation

1) Alternatives which provide the greatest dust control will minimize the quantity of secondary wastes produced by reducing the amount of clean up required.

5. Conclusions

a. A sliding hatch over the shredder feed hopper combined with a local ventilation exhaust from the shredding enclosure represents the most suitable equipment arrangement to achieve dust control during shredding operations.

b. The likelihood of fire and/or explosion occurring during shredding operations cannot at present be discounted. Inerting the shredding system will eliminate the possibility of fire and/or explosion.

6. Recommendations

a. The WRAP 2A Title I design incorporate a sliding hatch over the shredder feed hopper and local ventilation exhaust from the shredding enclosure.

b. The WRAP 2A shredders should be inerted to eliminate the possibility of fire and explosion.

TABLE 6.3
DUST CONTROL AND HAZARDS - EVALUATION MATRIX

ALT C1 = Local Exhaust - Brush Seal
ALT C2 = Local Exhaust - Sliding Hatch Cover
ALT C3 = Local Exhaust - No Seal
ALT C4 = Enclosure Exhaust Only - Brush Seal
ALT C5 = Enclosure Exhaust Only - Sliding Hatch Cover
ALT C6 = Enclosure Exhaust Only - No Seal

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT C1		ALT C2		ALT C3		ALT C4		ALT C5		ALT C6	
			RS	WS	RS	WS	RS	WS	RS	WS	RS	WS	RS	WS
Potential Hazards	15%	1-5	2.5	0.38	3.5	0.53	2.5	0.38	2.5	0.38	3.5	0.53	2.5	0.38
Throughput	15%	1-5	3.0	0.45	3.0	0.45	3.0	0.45	3.0	0.45	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	1.5	0.23	4.0	0.60	3.0	0.45	1.5	0.23	3.5	0.53	2.5	0.38
Dem Tech/Dev	20%	1-5	3.0	0.60	4.0	0.80	4.0	0.80	3.0	0.60	4.0	0.80	4.0	0.80
Flexibility	15%	1-5	1.5	0.23	3.0	0.45	2.0	0.30	1.5	0.23	3.0	0.45	2.0	0.30
Equipment Cost	10%	1-5	3.0	0.30	2.5	0.25	3.0	0.30	3.0	0.30	2.5	0.25	3.0	0.30
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.5	0.18	4.0	0.20	2.5	0.13	3.5	0.18	4.0	0.20	2.5	0.13
Total	100%			2.52		3.43		2.95		2.52		3.35		2.88

6.4 Shredder Installation

1. Introduction

   a. The purpose of this assessment is to determine the most suitable method of installing a shredding system into the enclosure. The number of shredders required to achieve the targeted shredded waste size will be determined by the shredded waste size control evaluation and shredder testing. However, for the purpose of the shredder installation evaluation, two shredders are assumed to be required.

2. List of Alternatives

   a. ALT D1 = Inside Enclosure - Shredders in Line

   b. ALT D2 = Inside Enclosure - Shredders at 90 Degree Orientation

   c. ALT D3 = Outside Enclosure - Shredders in Line

   d. ALT D4 = Outside Enclosure - Shredders at 90 Degree Orientation

3. Description Of Alternatives

   a. ALT D1 Inside Enclosure - Shredders In-line

      1) Two shredders are mounted within the enclosure and supported by internal enclosure steelwork which is directly supported from ground level. Drive components where possible will be located external to the enclosure to allow easy access for maintenance. Anti vibration mounting will be used to limit transmission of the shredder forces into the supporting structure. Shredders are mounted in-line with the discharge flange of the first shredder bolted directly to the inlet flange of the second.

   b. ALT D2 Inside Enclosure - Shredders 90° Orientation

      1) Two shredders are mounted within the enclosure and positioned at 90° to each other. A transition section is fitted between the discharge flange of the first shredder and the inlet flange of the second shredder, this is necessary to compensate for rectangular flanges being at 90°. Anti vibration mounts will be fitted at the shredder support locations.

   c. ALT D3 Outside Enclosure - Shredders In-line

      1) The shredders will be connected to the enclosure by the top and bottom flanges. The shredder housing is an extension of the enclosure and the only maintainable components inside the enclosure are the cutter blades. The drive system is external and accessible for maintenance/replacement.

2) The shredders and shredder enclosure are supported by steelwork external to the enclosure with loadings transmitted to the building floor.

3) Flexible connections are used between the shredder and enclosure flange to prevent transmission of vibrations generated by the shredding operation.

4) The two shredders are mounted in line with the first shredder discharge and the second shredder inlet flanges being bolted together.

d. ALT D4 Outside Enclosure - Shredders 90° Orientation

1) The shredders are flanged to the enclosure with all drive components accessible for maintenance. Flexible connections fitted between the shredder and enclosure isolate shredder vibrations. A transition section is fitted between the two shredders to compensate for the rectangular flanges being at 90°.

4. Description of Evaluation Matrix Scoring

a. An illustration of the alternatives evaluated is given in **Appendix A**, sheet 6.4. The evaluation matrix is given in **Table 6.4**, located after the evaluation matrix description.

b. Potential Hazards

1) Locating shredding equipment totally inside the glovebox enclosure slightly increases the size of the enclosure and hence reduces the available reach to operate and maintain the shredders. This leads to a higher risk of puncture wounds and dropping objects, and also has a lower human factors rating.

2) It is probable that the time to maintain shredders totally inside containment will be longer than if the shredders form part of the enclosure thus increasing operation exposure. Major maintenance outside the enclosures will probably require tenting operations with the associated risk of breaching containment.

3) Locating shredders totally within an enclosure means that the outside of the shredder housing becomes contaminated thus increasing clean up requirements. A proportion of the shredder drive will also be within the enclosure and require cleaning.

4) Shredding equipment which forms part of the glovebox enclosure (i.e., Outside Enclosure Alternatives) has a slightly higher potential of breaching containment due to the seals between the main enclosure and the shredder housing enclosure. However this is the same means of construction as bolting and sealing together gloveboxes and is not considered a problem. It is likely that flexible couplings between the shredder housing/enclosure adjacent enclosures, these will be more prone to failure and slightly increase the risk of breaching containment.

5) It will be much simpler to support the shredders and any loads produced by the shredders during operation, if the shredder housing forms part of the enclosure rather than if the shredders are totally located within the enclosure.

6) Little difference is considered to exist between positioning the shredders in line rather than at 90 degrees to each other.

7) BNFL in the UK have built the Waste Treatment Complex in which the shredder cutting shafts and blades can be removed as a cartridge from the shredder enclosure, this eases major maintenance of these items thus reducing the risk of puncture wounds and also reduces maintenance exposure.

c. Plant Throughput

1) No significant difference is considered to exist between each alternative in meeting plant throughput.

d. Operability and Maintainability

1) As with safety, locating the shredders totally within containment reduces the ability to reach the shredders and will increase the time required to maintain the shredders.

2) Major maintenance of the shredders within the enclosure (eg changing shredder shafts or cutters) will also be more difficult as this will require large heavy items to be handled and transferred in and out of containment.

3) Although, testing is required to validate any efficiency in size reduction, little difference is considered to exist between operating and maintaining shredders in line rather than at 90 degrees to each other.

4) Discussions with other companies working with shredding equipment **(Reference 12)** indicates that when shredders are located at 90 degrees to each other, then this causes excess wear on the central cutters of the lower shredder.

e. Demonstrated Technology/Development Requirements

1) Shredding equipment has been used within the nuclear industry to size reduce waste. Shredders are widely used outside the nuclear industry to process waste.

2) BNFL has designed and constructed a shredding system within a waste processing facility at their Sellafield plant in the UK. This design is based on using the housing of a single shredder to form part of the glovebox enclosure.

f. Flexibility

1) Considering that it will probably be easier to remove the cutting shaft on a shredding system in which the shredder housing forms part of the enclosure, it follows that it will be slightly easier to change the cutters and hence process additional wastes. The difference in alternatives is however considered marginal.

g. Equipment Cost

1) Although each alternative is shown as having two shredders, one shredder may be found to give adequate size reduction and size control of the waste. This will be determined by the Shredded Waste Size Control Evaluation. Although making the shredder housing the actual enclosure reduces the overall volume of the enclosure it also increases the fabrication complexity. For the purpose of this assessment the cost of placing the shredders inside an enclosure is considered to be similar to integrating the shredder housing and the enclosure. All alternatives are assumed to require two shredders and a similar size enclosure.

a) All Alternatives

	Equipment Cost $ K
Two Shredders	410
Enclosure	128
Total	538

h. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

i. Waste Minimization Including Secondary Waste Generation

1) Locating shredders totally within the glovebox enclosure means the outside of the shredder housing becomes contaminated thus increasing the difficulty of clean up operations and the magnitude of secondary wastes.

5. Conclusions

a. The shredder housing should be an extension of the glovebox enclosure with the drive system external and accessible for maintenance/replacement. The shredder housing should be connected to adjacent enclosures by bolted flanges. It is more suitable for the shredders to be positioned vertically in line with each other rather than vertically in line and oriented at 90° to each other. The shredders and shredder enclosure should be supported by steelwork external to the enclosure with loadings transmitted to the building floor.

6. Recommendations

a. The WRAP 2A Title I design should progress on the basis that the shredder housing is an extension of the glovebox enclosure with drive systems external and accessible for maintenance/replacement. The shredder housing should be connected to adjacent enclosures by bolted flanges. It is more suitable for the shredders to be positioned vertically in line with each other rather than vertically in line and oriented at 90° to each other. The shredders and shredder enclosure should be supported by steelwork external to the enclosure with loadings transmitted to the building floor.

TABLE 6.4
SHREDDER INSTALLATION - EVALUATION MATRIX

ALT D1 = Inside Enclosure - Shredders in Line
ALT D2 = Inside Enclosure - Shredders at 90 Degree Orientation
ALT D3 = Outside Enclosure - Shredders in Line
ALT D4 = Outside Enclosure - Shredders at 90 Degree Orientation

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT D1		ALT D2		ALT D3		ALT D4	
			RS	WS	RS	WS	RS	WS	RS	WS
Potential Hazards	15%	1-5	3.0	0.45	3.0	0.45	3.5	0.53	3.5	0.53
Throughput	15%	1-5	3.0	0.45	3.0	0.45	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	3.0	0.45	2.5	0.38	4.0	0.60	3.5	0.53
Dem Tech/Dev	20%	1-5	3.0	0.60	3.0	0.60	3.5	0.70	3.5	0.70
Flexibility	15%	1-5	3.0	0.45	3.0	0.45	3.5	0.53	3.5	0.53
Equipment Cost	10%	1-5	3.0	0.30	3.0	0.30	3.0	0.30	3.0	0.30
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.0	0.15	3.0	0.15	3.5	0.18	3.5	0.18
Total	100%			3.00		2.93		3.44		3.37

6.5 Single Route for Shredded/Non-Shredded Waste

1. Introduction

   a. The baseline design for the Open, Sort and Size Reduction enclosure includes a separate sort table for direct repack waste and shredded waste. This study will evaluate the feasibility of processing all waste directly through the shredder system.

2. List of Alternatives

   a. ALT E1 = Direct Repack Line and Shredding Line

   b. ALT E2 = Shredding Line Only

3. Description of Alternatives

   a. ALT E1 Direct Repack Line and Shredding Line

      1) This alternative proposes that waste such as ash, soil and other materials which do not require size reduction, are not shredded. Only material requiring size reduction will be shredded. This alternative represents the CDR baseline design.

   b. ALT E2 Shredding Line Only

      1) This alternative proposes that all material will be routed through the shredders.

4. Description of Evaluation Matrix

   a. An illustration of the alternatives evaluated is given in **Appendix A**, sheet 6.5. The evaluation matrix is given in **Table 6.5**, located after the evaluation matrix description.

   b. Potential Hazards

      1) Shredding material such as ash and dry soils will cause large amounts of dust to be generated blocking filters, contaminating equipment and resulting in greater clean up requirements and hence increased radiation exposure to plant personnel. It will also give a slightly higher potential for dust explosion.

   c. Plant Throughput

      1) The CDR time and motion assessment concludes that the size reduction and repack area achieves the required plant throughput with both a shredding line and a direct repack line. Each line is intended to operate independently and hence minimal difference in throughput is considered to exist when operating each line separately.

d. Operability and Maintainability

1) The use of both a direct repack and a shredding line involves more equipment and hence will increase maintenance requirements. However processing all waste through the shredder will result in increased maintenance requirements.

e. Demonstrated Technology/Development Requirements

1) Each alternative proposes use of the same type of equipment. No difference is considered to exist between the two alternatives with respect to demonstrated technology and development requirements.

f. Flexibility

1) Alternative E1 proposes the use of a direct repack route for items not suitable for shredding and a shredding line for shreddable waste. This provides more flexibility than the use of a shredder line only.

g. Equipment Cost

1) Alternative E1 represents the baseline CDR TEC cost.

2) Alternative E2 will be cheaper by the cost of a sorting enclosure and its associated sorting equipment. This is estimated as follows:

	Equipment Cost $ K
Sorting/Tipping Table	16.5
Manipulator Assembly	107.0
Purged Port	10.0
Repack Enclosure	123.5
Total	257.0

h. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

i. Waste Minimization Including Secondary Waste Generation

1) Processing ash and dry soil through a shredder will cause high levels of dust to be generated and will produce additional secondary clean up wastes.

2) The additional plant and equipment associated with alternative E1 will result in additional maintenance and decommissioning wastes.

5. Conclusions

   a. Waste which does not require size reduction should be directly repacked and not shredded. A shredding line and a direct repack line are required for processing dry wastes within the size reduction area of WRAP 2A as currently identified in the CDR baseline design.

6. Recommendations

   a. The WRAP 2A Title I design should progress on the basis that both a shredding line and a direct repack line are required to process dry wastes.

TABLE 6.5
SINGLE ROUTE FOR SHREDDED/NON SHREDDED/NON SHREDDED WASTE - EVALUATION MATRIX

ALT E1 = Direct Repack for Waste Which Does Not Require Shredding
Shredding of Waste Which Requires Shredding
ALT E2 = All Waste Routed Through the Shredders.

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT E1		ALT E2	
			RS	WS	RS	WS
Potential Hazards	15%	1-5	3.5	0.53	2.0	0.30
Throughput	15%	1-5	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	2.5	0.38	3.5	0.53
Dem Tech/Dev	20%	1-5	3.0	0.60	3.0	0.60
Flexibility	15%	1-5	4.0	0.60	3.0	0.45
Equipment Cost	10%	1-5	3.0	0.30	4.0	0.40
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.5	0.18	2.5	0.13
Total	100%		3.18		3.00	

6.6 Process Routes for Empty Drums

1. Introduction

   a. The purpose of this assessment is to determine the most effective method of processing empty drums within WRAP 2A. Removal of the empty drums from the enclosure for decontamination and reuse is not considered practical due to it being labor intensive and generating large quantities of secondary wastes and effluents. Some doubt also exists as to the physical integrity of the drum after opening using a saw to cut the clamp band.

2. List of Alternatives

   a. ALT F1 = Shred Empty Drums In Existing Shredder and Dispose as LLRMW

   b. ALT F2 = Compact Empty Drums and Dispose as LLW

   c. ALT F3 = Fill Drum With Inert Material For Disposal as LLW

   d. ALT F4 = Decontaminate Drums and Reuse

   e. ALT F5 = Place Empty Drum in Box for Disposal as LLW

   f. ALT F6 = Shred Empty Drums to Separate Shredder and Dispose as LLW

3. Description of Alternatives

   a. ALT F1 Shred empty drums in existing shredder and dispose as LLRMW.

      1) Empty waste drums used in the Size Reduction enclosure are shredded as part of the waste process. Empty drums from the Pug Mill and Special Waste enclosures are routed to the Size Reduction enclosure for shredding.

   b. ALT F2 Compact empty drums and dispose as LLW.

      1) Empty drums from the Size Reduction, Pug Mill and Special Waste enclosures can be classified as LLW (**Reference 13**). These empty drums are transported through the interconnecting transfer tunnel to a drum compactor housed in a small enclosure adjacent to the Special Waste Facility. At the compactor station the drums will be compacted and loaded into 85 gallon overpacks. Discussions with WHC (**Reference 13**) indicate that when compacted empty drums are loaded into a new drum, then this drum can be disposed of as LLW. It will however be necessary to verify that each drum is empty and hence can be disposed of as LLW, it is anticipated that this verification can be carried out by visual inspection using CCTV equipment. Although WRAP 1 have encountered some design difficulties in engineering an empty drum compactor and empty drum load out facilities, it is anticipated these will not be insurmountable and that WRAP 2A can take advantage of the title design work on WRAP 1 for the processing of empty drums.

2) Drums which are suspected as being above the LLW acceptance criteria are routed to the Size Reduction enclosure for shredding. these drums will then be treated as LLRMW and handled in full compliance with the requirements of LLRMW.

c. ALT F3 Drum fill with inert material for disposal as LLW.

1) Empty waste drums are removed from the enclosure, decontaminated and filled with an inert (non-reactive void filling material) material and disposed as whole drums.

d. ALT F4 Decontaminate Drum and Reuse

1) Empty waste drums are removed from the enclosure, decontaminated and reused to store waste.

e. ALT F5 Place empty drums in box for direct disposal as LLW.

1) Empty waste drums are removed from the enclosure and directly placed in a box within WRAP 2A. Once full, the box will be transferred from WRAP 2A for disposal as LLW.

f. ALT F6 Shred empty drums in separate shredder and dispose as LLW.

1) Empty waste drums will be transferred to a separate LLW shredder and shredded into new 55 gallon drums for disposal as LLW.

g. The FDC specifies that WRAP 2A should have the capability to dispose of waste containers by size reduction and treating for disposal as waste. Size reduction of empty drums by shredding or compaction are considered to comply with this FDC requirement.

4. <u>Alternatives Screened From Further Evaluation</u>

a. Alternative - F3

1) Alternative F3 proposes removal of the empty drums from the enclosure followed by filling with an inert material prior to disposal as whole drums. This alternative is screened from further evaluation on the basis that it will be costly and wasteful to fill all empty drums which arise over the lifetime of the plant (approximately 100,000) with an inert material. In addition if no volume reduction is carried out on these drums, then a much larger site will be required to dispose of a relatively clean waste arising from WRAP 2A. When removing the lid from the drum the clamp band is sawn off using a sawzall. This operation also cuts into the drum thus damaging the drum and leaving sharp edges on the drum. This will increase the risk of puncture wounds when decontaminating the drum.

b. Alternative - F4

1) As for alternative F3, when the lid is removed from the drum the clamp is sawn off using a sawzall. This operation also cuts into the top sides of the drum thus rendering it of little use for further containment purposes. In addition, decontamination of the large number of drums involved will be labor intensive, generate large quantities of secondary wastes and increase the risk of puncture wounds during decontamination operations.

c. Alternative - F5

1) In order for this alternative to be effective the box must be sufficiently large to contain a number of empty drums. The material handling equipment within the main processing areas of WRAP 2A are sized to handle 55 and 85 gallon drums and hence placement of empty drums into boxes would have a major impact on the material handling equipment in WRAP 2A. In addition, direct placement of empty drums into boxes without taking advantage of any volume reduction will result in a large volume of waste for disposal thus increasing the size of the disposal site and the cost of disposal. The boxes containing the empty drums will largely be voidage and would either have to have a degree of mechanical strength to prevent slumping in the disposal site or have to be filled with an inert (non-reactive void filling) material.

d. Alternative - F6

1) Alternative F6 is similar to alternative F2 in that both propose empty drums are reclassified as LLW, size reduced and loaded into new drums for disposal. Alternative F6 proposes that empty drums are shredded and loaded into new 55 gallon drums, this alternative complies with the FDC in that all output from WRAP 2A should be in 55 gallon drums. However, Alternative F2 provides a much greater volume reduction of empty drums by compacting rather than shredding and will hence offer a greater saving in terms of disposal site size, disposal cost and material movement within WRAP 2A. Although Alternative F2 proposes compacted drums are loaded into 85 gallon overpacks which is a variation on the FDC, the material handling equipment outlined in the baseline CDR design is sized to handle 55 and 85 gallon drums. In addition, WRAP 1 Change Request 55 proposes that empty drums are compacted and loaded into 85 gallon drums for disposal as LLW. Alternative F2 also has the advantage that the process of compacting empty drums and loading into 85 gallon drum overpacks for disposal is directly consistent with the WRAP 1 design philosophy.

5. Description Evaluation Matrix Scoring

a. An illustration of the alternatives evaluated is given in **Appendix A**, sheet 6.6. The evaluation matrix is given in **Table 6.6**, located after the evaluation matrix description.

b. Potential Hazards

1) Both shredding and compaction of empty drums will be carried out remotely and hence will incur minimal occupational radiation exposure levels. Similarly both shredding and compacting empty drums will generate dust.

2) Shredding can be carried out using equipment which exist in the baseline CDR design. Compaction requires additional equipment to the baseline design and as a result of this will require additional maintenance and clean up including the associated exposure and risk.

c. Plant Throughput

1) The potential to achieve higher plant throughput will be recognized by compacting rather than shredding empty drums. This is made possible because compaction can be carried out off line from the shredding process. The main bottleneck in the shred and repack enclosure is the drum handler and in particular holding empty drums whilst waste is being inspected on the sorting table prior to shredding. This sequence of operations is briefly described as follows:

a) Drum handler grabs drum.

b) Drum lid is removed from drum.

c) Drum is lifted to the shredding line sort table.

d) Waste is tipped from drum onto sort table.

e) Waste is inspected on sort table.

f) After inspection waste is tipped from sort table into shredder.

g) Empty drum is placed on sort table and then deposited into shredder.

h) Drum handler returns to handle next drum.

2) Items a to d are on line operations which require use of the drum handler. Items e to g require the drum handler to hold the empty drum while the waste is sorted and shredded, prior to the empty drum being shredded. If this stage can be eliminated, it releases the handler to receive and assist in lid removal of the next drum. If empty drums are compacted the drum handler can lower the empty drum after tipping in order for removal from the shredding and repack enclosure and transfer for compaction.

d. Operability and Maintainability

1) Both shredding and compaction of empty drums will be carried out remotely and will hence require minimal operator involvement. Similarly both shredding and compacting empty drums will generate dust.

2) Compaction will require additional equipment and hence additional maintenance.

e. Demonstrated Technology/Development Requirements

1) The use of shredding equipment to process empty 55 gallon drums is demonstrated technology.

2) Supercompactors are in limited use to process full 55 gallon drums of waste within the nuclear industry .Empty drum compactors are widely used outside the nuclear industry. No knowledge exists of the integration of an empty drum compactor into an active environment however this technology is to be developed as part of WRAP 1 Change Request 55, and WRAP 2A will be able to take advantage of this work.

f. Flexibility

1) Compaction provides additional processing capabilities to the baseline CDR design and hence potentially increases flexibility of the facility. However, it is intended that the compacted empty drums can be classified and disposed of as LLW. This may reduce the flexibility if mixed wastes cannot be processed in the compactor.

g. Equipment Cost and Operational Cost

1) Equipment Cost

a) Compaction is an additional process to the baseline CDR design and will require the following equipment:

	Equipment Cost $ K
Empty drum compactor	10.0
Compactor enclosure	40.0
Compact exit enclosure	95.0
Drum exit port	36.0
Lift table	14.0
Compact lifter	30.0
Monorail & Hoist	3.5
Total	228.5

2) Operational Cost

a) As part of the baseline CDR design it is assumed that 24 empty drums can be shredded into 3 new drums giving a volume reduction ratio of 8:1. If empty drums are shredded, they are processed with the same equipment as the mixed waste.

b) In order to estimate what volume reduction factors might be achievable for empty drum compaction, consider the following assumptions:

- Empty drums can be compacted to 2" in height
- Empty drums when compacted and reloaded into a disposal container can be classified as LLW.
- Compacted empty drums are loaded into an 85 gallon drum which has an available internal height of 32 inches for waste containment.

c) Using the above assumptions it will be possible to achieve a volume reduction ratio of 16:1 by compacting empty drums. In general it is assumed that compaction will give a better volume reduction than shredding by a factor of approximately two (2).

d) Within WRAP 2A approximately 25 empty used drums require processing each day. Over a 25 year plant life, 175 operational days per year, the following disposal benefits can be calculated:

A number of empty drums will arise from processing operations in the sludge repack enclosure. These drums will contain sludge either within a drum liner or a plastic bag. The drums in which sludge has only been contained within a plastic bag, will likely be contaminated as the plastic bag has degraded or torn, and could not be disposed of as LLW. However, initial estimates indicate that the number of drums which contain sludge in plastic bags is expected to be small and should not have a major impact on the total number of drums that can be re-classified as LLW and compacted.

	Used Drum Feed	Product Drums	Total Disposal Cost if LLW $45/CuFt	Total Disposal Cost if LLRMW $135/CuFt
Shredding	110,000	13,750		$13.74M
Compaction	110,000	6,875	$3.53M	

h. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

k. Waste Minimization Including Secondary Waste Generation

1) As demonstrated above there is a big reduction in process waste by adopting compaction.

2) Compaction requires additional equipment to the baseline design and will hence produce additional clean up wastes.

3) Again additional equipment will produce additional maintenance and decommissioning wastes.

6. Conclusions

a. Empty drums arising from the size reduction area of WRAP 2A should be compacted, loaded into 85 gallon overpacks and disposed of as LLW. However, in order for this to be possible the FDC must be revised to allow compacted empty drums to be packaged in 85 gallon drums for disposal as LLW.

7. Recommendations

a. The WRAP 2A Title I design should included an empty drum compactor and an empty drum compact load out facility. The FDC must also be revised to allow empty drums to be reclassified as LLW and output from WRAP 2A in 85 gallon drums.

TABLE 6.6
ASSESSMENT OF PROCESS ROUTES FOR EMPTY DRUMS - EVALUATION MATRIX

ALT F1 = Shred Empty Drums
ALT F2 = Compact Empty Drums

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT F1		ALT F2	
			RS	WS	RS	WS
Potential Hazards	15%	1-5	4.0	0.60	3.5	0.53
Throughput	15%	1-5	3.0	0.45	4.5	0.68
Ops & Main	15%	1-5	4.0	0.60	3.5	0.53
Dem Tech/Dev	20%	1-5	3.0	0.60	2.5	0.50
Flexibility	15%	1-5	3.0	0.45	3.5	0.53
Equipment Cost	10%	1-5	3.0	0.30	4.5	0.45
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.0	0.15	4.5	0.23
Total	100%		3.30		3.58	

6.7 Process Routes for 85 Gallon Drums Containing Absorbent

1. Introduction

   a. The purpose of this assessment is to determine the most effective method of processing 85 gallon drums containing absorbent within WRAP 2A. It is anticipated that the 85 gallon drums have been used to overpack 55 gallon drums which have been damaged, corroded or leaked and that the interspace between the 55 gallon drum and the 85 gallon overpack has been fitted with absorbent.

2. List of Alternatives:

   a. ALT G1 = Pre Treat 85 Gallon Drum in Box Breakdown

   b. ALT G2 = Open Both Drums and Shred as to the Baseline Design

   c. ALT G3 = Open 85 Gallon Drum, and Shred 55 Gallon Drum Without Opening

   d. ALT G4 = Shred 85 Gallon Drum Without Opening

3. Description of Alternatives

   a. ALT G1 Route through box breakdown

      1) Drums are opened in the box breakdown area, the contents are examined/ sampled, coarse size reduced and repacked into 55 gallon drums and transferred to the size reduction enclosure where the waste is shredded.

   b. ALT G2 Open Both drums and Shred as to the Baseline Design

      1) The drum handling equipment in the Size Reduction process is capable of handling 85 and 55 gallon drums. Once inside the enclosure the 85 gallon drum will be opened and the 55 gallon drum removed. The 55 gallon drum is processed normally with the waste being tipped from the drum onto the sort table and then loaded onto the conveyor for weighing and drum filling. The empty 85 gallon drum will be raised to the higher level and size reduced in the shredder.

   c. ALT G3 Open 85 gallon drum and shred 55 gallon drum without opening.

      1) The 55 gallon drum is removed from the 85 gallon overpack drum and routed for shredding without removing the waste for sorting.

   d. ALT G4 Shred 85 gallon drum directly without opening.

      1) The 85 gallon drums is routed for shredding without removing the 55 gallon drum and waste for sorting.

4. Alternatives Screened From Further Evaluation

a. Alternatives - G3 & G4

1) These alternatives have been screened from further evaluation because they propose unopened drums of waste being processed through the shredding equipment, this potentially may result in incompatible waste being processed through the shredder.

5. Description of Evaluation Matrix Scoring

a. In order to meaningfully evaluate the most suitable method of processing 85 gallon drums containing absorbent, the number of 85 gallon drums expected to be processed must be estimated. In order to do this consider the following assumptions:

1) Approximately 200 x 85 gallon overpacks currently exist. **(Reference 14)**

2) Most waste to be processed by WRAP 2A have yet to be generated and are less likely to require overpacks than existing stored wastes. Assume the number of future 85 gallon overpacks will arise in half the proportion as the number of backlog 85 gallon drums. Hence if 200 backlog drums were generated from waste which represent 4800 Cu Ft/year (feedstreams 1A to 1D) throughput in the plant and the total waste to be processed is 29,000 CuFt/year, then:

0.5 x 24,200 x (1/4800) x 200 = Approximately 500

500 x 85 gallon overpacks will arise from future operations.

b. An illustration of the alternatives evaluated is given in **Appendix A**, Sheet 6.7. The evaluation matrix is given in **Table 6.7**, located after the evaluation matrix description.

c. Potential Hazards

1) Within the box breakdown cell, 85 gallon drums could be opened remotely and the 55 gallon drum removed using the box breakdown manipulator. Once the 55 gallon drum becomes exposed it may be visually inspected to determine the extent of damage or leakage, from which a decision can be made whether it should be cleaned and/or repacked either remotely or manually. The 85 gallon overpack will then be size reduced using the box breakdown manipulator. It is likely that some manual operation will be required to assist in processing 85 gallon drums containing absorbent. This will give rise to occupational exposure and some additional risk of puncture wounds.

2) The WRAP 2A drum entry system is based on that of WRAP 1. With this system it is possible for an 85 gallon drum to gain entry into the enclosure, however this requires modifications to be made to the entry bagless transfer port which will give rise to occupational exposure and a some risk of puncture wounds.

d. Plant Throughput

1) The box breakdown cell is required to process approximately one box per month. On an average, it will take much less than one month to process a box in the box breakdown cell. If two weeks are allowed to process a box, then a total of 600 weeks (12 boxes/year x 2 weeks/box x 25 year work-off) would be required over the lifetime of the plant to carry out this task in the box breakdown cell. Assuming a 30 year operating life, the available time is 1050 weeks (35 weeks/year x 30 years), which leaves another 450 weeks (1050-600) in the box breakdown cell to perform other operations. If approximately 700 overpack drums are to be processed (Reference 6.7.5.a) over the lifetime of the plant, and if each drum takes 1 day to process, then 140 weeks will be required to process overpacks in the box breakdown cell. The available 450 weeks to carry out additional operations thus far exceeds the 140 weeks required to process overpacks containing absorbent.

2) The CDR indicates that the size reduction and repack enclosure can at maximum process 11,500 output drums per year and that this exceeds the FDC required output of 7,500 drums per year.

3) Based on these figures it is reasonable to assume that the size reduction and repack enclosure can process an additional 28 (700/25 year plant life) input overpacks per year, assume this to be equivalent to 60 output drums per year.

Operability and Maintainability

1) Routing drums through the box breakdown cell will require additional maintenance of equipment and hence additional exposure and risk of puncture wounds.

2) In order for 85 gallon drums to enter the glovebox enclosure modification is required to the drum entry facilities. Also when the 55 gallon drum is removed from the overpack the absorbent material will be lifted out of the overpack with the 55 gallon drum. This will be much more difficult to clean up than in the box break down cell where a smooth flat floor can be provided on which to carry out this operation.

Demonstrated Technology/Development Requirements

1) It is unlikely that there will be additional development requirements to those for the baseline CDR box breakdown cell.

2) The WRAP 1 design will have to demonstrate that the enclosure can handle 85 gallon drums. The WRAP 2A plant must however process drums up to 3000 lb in weight and some consideration must be given to up-rating the WRAP 1 systems from 1000 lb.

f. Flexibility

1) The box breakdown cell provides additional processing flexibility and hence can receive more complex waste types.

g. Equipment Cost

1) It is estimated that 85 gallon drums containing absorbent could be processed in either the box breakdown cell or the size reduction enclosure with no major additional increases to the CDR TEC.

h. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

i. Waste Minimization Including Secondary Waste Generation

1) No significant differences are considered to exist between each option in volume reduction of process waste or in the generation of secondary wastes.

6. Conclusions

a. 85 gallon drums containing absorbent should be opened, sampled, size reduced as necessary and repacked in the box breakdown area of WRAP 2A prior to shredding in the size reduction enclosure.

b. The proposal to route 85 gallon drums containing absorbent through the box breakdown areas is in line with the CDR philosophy.

7. Recommendations

a. The WRAP 2A Title I design should progress on the basis that 85 gallon drums containing absorbent are opened, size reduced as necessary and repacked in the box breakdown area prior to shredding.

TABLE 6.7
ASSESSMENT OF PROCESS ROUTES FOR 83 GALLON DRUMS WITH ABSORBENT - EVALUATION MATRIX

ALT G1 = Pre Treat 83 Gallon Drum in Box Breakdown
ALT G2 = Open 83 and 55 Gallon Drum and Process Waste in Shred and Repack Enclosure

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT G1		ALT G2	
			RS	WS	RS	WS
Potential Hazards	15%	1-5	3.0	0.45	3.0	0.45
Throughput	15%	1-5	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	4.0	0.60	2.0	0.30
Dem Tech/Dev	20%	1-5	3.0	0.60	3.5	0.70
Flexibility	15%	1-5	3.5	0.53	3.0	0.45
Equipment Cost	10%	1-5	3.0	0.30	3.0	0.30
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.0	0.15	3.0	0.15
Total	100%		3.23		2.95	

6.8 Process Routes for Immobilized Waste and Supercompacted Drums

1. Introduction

   a. The purpose of this assessment is to determine the most effective method of processing immobilized waste and supercompacted drums.

2. List of Alternatives

   a. ALT H1 = Route through Box Breakdown

   b. ALT H2 = Route Directly to Shredders

3. Description of Alternatives

   a. ALT H1 Route through box breakdown.

      1) Drums are coarse size reduced and repacked into 55 gallon drums in the box breakdown cell then transferred to Size Reduction where the waste is shredded.

      2) The FDC specifies that WRAP 2A has the capability to shred and process drums that have already been immobilized and drums that have been supercompacted. Preliminary size reduction in the box breakdown cell prior to shredding in the size reduction and repack enclosure is considered to comply with this FDC requirement.

   b. ALT H2 Route directly to shredder.

      1) Drums are processed in the size reduction enclosure through the shredder route. A ram is likely to have to be fitted at the shredder inlet to force drums into the cutters.

4. Description of Evaluation Matrix Scoring

   a. Assume WRAP 2A produces a total 2 days of product drums per year (approximately 100 drums /year) which do not comply with WAC and have to be reprocessed in WRAP 2A. In addition, the FDC specifies that WRAP 2A will destructively examine 1% of the immobilized produce drums (approximately 90 drums per year). It is assumed that most of supercompacted drums arise from WRAP 1 and that the numbers will be minimal in comparison to the immobilized drums.

   b. An illustration of the alternatives evaluated is given in **Appendix A**, Sheet 6.8. The evaluation matrix is given in **Table 6.8**, located after the evaluation matrix description.

c. Potential Hazards

1) The WRAP 2A CDR proposes to use cutting equipment in the box breakdown cell to size reduce the immobilized waste into smaller pieces, which can more easily be shredded. This operation will however cause dust generation which will have to be controlled and will result in additional clean up operations and hence dose uptake. In addition heat and possibly sparks will be generated during cutting operations which give rise to potential fire and explosion problems.

2) Attempting to shred immobilized drums in the shredders will cause wear and damage to the shredder cutters and may ultimately result in complete failure of the shredders. In order to shred immobilized drums of waste, Shredder vendors have recommended the use of a feed ram to push the drum into the shredder cutters. The feed ram is a large piece of equipment which will require additional maintenance. As with carrying out pre treatment in the box breakdown cell, shredding immobilized drums will generate dust and require clean up operations.

d. Plant Throughput

1) The main size reduction operations for cutting up the immobilized drums can be carried out in parallel with box breakdown operations, only limited use of the manipulator will be required to load the size reduced waste into a new drum for transportation to the shred and repack enclosure.

2) If approximately 190 drums are to be processed over the lifetime of the plant and each takes 1 day to process, then 38 weeks will be required to process immobilized drums and supercompacted drums in the box breakdown cell. It has already been established in Section 6.7.5d that 450 weeks exist (over the lifetime of the plant) in which the box breakdown area is available to process items other than boxes, and of this 450 weeks, 140 weeks are required to process 85 gallon drums containing absorbent. Hence sufficient space capacity exists in the box breakdown area for 38 weeks of processing immobilized drums and supercompacted drums.

3) The WRAP 2A CDR indicates that the size reduction and repack enclosure can at maximum process 11,500 output drums per year and that this exceeds the FDC output of 7,500 output drums per year. As for the study assessing process routes for 85 gallon drums containing absorbent it is reasonable to assume that the size reduction and repack enclosure can process an additional 190 input immobilized drums per year, assume this to be equivalent to 380 output drums per year.

e. Operability and Maintainability

1) Routing drums through the box breakdown cell will require maintenance of equipment and hence additional exposure and risk of puncture wounds.

2) The feed ram required to push the drum into the shredder cutters will result in additional maintenance operations.

3) Both alternatives will produce dust during processing operations which will require clean up operations. However as both options propose the use of shredding to reduce the waste size down to 2" x 2" x 2" and alternative H1 proposes additional coarse size reduction techniques in the box breakdown cell this will produce the higher of the two dust problems and require the greatest clean up operations.

4) When assessing the ability of each alternative to carry out the required task, pre treatment of the immobilized drum in the box breakdown cell gives the greatest confidance. Discussions with shredder vendors have indicated that coarse size reduction of immobilized waste prior to shredding would be the preferred alternative.

f. Demonstrated Technology /Development Requirements

1) Sawing techniques exist in industry to cut concrete items eg. abrasive wheels, diamond ropes.

2) Large shredders exist in industry, and initial discussions with vendors indicate that shredding 55 gallon drums filled with concrete will be possible, but require the use of a ram to push the drums into the shredder cutters. However it is likely that a single/double shredder unit will require more testing and development if required to process immobilized drums in addition to the wide variety of wastes that are to be treated in WRAP 2A.

g. Flexibility

1) The box breakdown cell provides additional processing flexibility and hence will have additional probability in being able to treat a wider variety of "out of specification" immobilized drums.

h. Equipment Cost

1) Pre treatment of the immobilized drums in the box breakdown cell represents the baseline CDR TEC.

2) Size reduction of immobilized drums will require an feed ram to push the drum into the shredder cutters, the additional cost is estimated as follows:

	Equipment Cost $ K
Feed Ram	20.0
Feed Ram Enclosure	80.0
Total	100.0

i. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

j. Waste Minimization Including Secondary Waste Generation

1) Size reducing the immobilized drums in both the box breakdown cell and in the shredder will result in more dust and hence secondary clean up wastes.

2) Shredding of whole immobilized drums will probably give rise to additional shredder maintenance and breakdown wastes.

5. Conclusions

a. Both drums of immobilized waste and supercompacted drums should be size reduced into shreddable pieces and repacked in the box breakdown area of WRAP 2A prior to shredding in the size reduction enclosure.

b. The proposal to route immobilized waste, supercompacted drums and 85 gallon drums containing absorbent through the box breakdown area is in line with the CDR philosophy. The implication of routing these wastes through the box breakdown area has been addressed in sections 6.7 and 6.8 and no impact on throughput is anticipated.

6. Recommendations

a. The WRAP 2A Title design should progress on the basis that both drums of immobilized waste and supercompacted drums are size reduced into shreddable pieces and repacked in the box breakdown area prior to shredding.

TABLE 6.8
ASSESSMENT OF PROCESS ROUTES FOR IMMOBILIZED WASTE AND SUPERCOMPACTED DRUMS - EVALUATION MATRIX

ALT H1 = Pre Treat Immobilized Waste and Supercompacted Drums in Box Breakdown
ALT H2 = Route Directly to Shredder

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT H1		ALT H2	
			RS	WS	RS	WS
Potential Hazards	15%	1-5	2.5	0.38	2.0	0.30
Throughput	15%	1-5	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	3.5	0.53	2.5	0.38
Dem Tech/Dev	20%	1-5	3.0	0.60	2.0	0.40
Flexibility	15%	1-5	3.0	0.45	2.0	0.30
Equipment Cost	10%	1-5	3.0	0.30	2.5	0.25
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	2.5	0.13	3.0	0.15
Total	100%		2.98		2.38	

6.9 Waste Entry into Containment

1. Introduction

   a. The purpose of this assessment is to determine the most effective method of transferring waste or drums of waste into the shredder and direct repack enclosure.

2. List of Alternatives

   a. ALT J1 = Transfer Drums of Waste into Containment using Simple Double Lidding Systems

   b. ALT J2 = Transfer of Waste into Containment using Simple Double Lidding Systems

   c. ALT J3 = Bag Drums of Waste into Containment

   d. ALT J4 = Bag Waste into Containment

3. Description of Alternatives

   a. ALT J1 Transfer drums of waste into containment using simple double lid systems.

      1) A bagless transfer system is used to allow full drums of waste to be transferred into containment in a similar manner to that used in WRAP 1. Once inside containment the drum would be opened, waste removed and the empty drum disposed of as waste.

   b. ALT J2 Transfer of waste into containment using simple double lid systems.

      1) A bagless transfer system will be used to remove the lid from a drum while maintaining containment, thus allowing waste items to be removed from the drum. After waste has been removed from the drum, the drum lid is replaced using the bagless transfer system and the empty drum removed for reuse, storage or treatment.

   c. ALT J3 Bagging drums of waste into containment.

      1) A large bagging port will be used to bag full drums of waste into containment. This alternative is a reversal of the standard bagging operation used to remove active waste from containment. Once inside containment the drum would be opened, waste removed and the empty drum shell classed as waste.

d. ALT J4 Bagging of waste into containment.

1) A large bagging port would be used to bag waste into containment from a drum. The sequence of operations would be as follows:

a) Initial state - bagging port with bag and a drum with lid.

b) Connect bagging port and outside of drum with a second bag.

c) Remove initial bag on bagging port thus exposing drum lid.

d) Remove lid from drum.

e) Remove waste from inside drum.

f) Replace drum lid onto drum.

g) Seal weld and cut bag connecting bagging port and outside of drum.

4. <u>Alternatives Screened From Further Evaluation</u>

a. Alternatives - J3 & J4

1) These alternatives are not to be evaluated because of the difficulties associated with performing bagging operations through large diameter bagging ports, these are described as follows:

a) The gloveboxes are maintained below atmospheric pressure and, therefore, the forces exerted on the bag/seal between bag and containment, due to the pressure differential acting on the projected area of the bagging port, will make the operation very difficult and increase the risk of breaking containment.

b) The flexibility/dexterity required to carry out bagging results in it being a manual operation. Hence if bagging operations were carried out as a production process to introduce drums/waste into containment, it would be labor intensive and result in increased personnel radiation exposure and increased risk of accidents.

c) Bagging techniques generate secondary waste.

d) The high risk of ripping bags when passing pieces of waste through the bagging port into the bag.

5. Description of Evaluation Matrix Scoring

a. An illustration of the alternatives evaluated is given in **Appendix A**, Sheet 6.9. The evaluation matrix is given in **Table 6.9**, located after the evaluation matrix description.

b. Potential Hazards

1) Removal of waste from drums at the entry enclosure (ALT J2) will be unacceptable by manual operations. The use of a remote tool to lift waste from the drum will probably result in some of the waste being dropped by the remote tool, this consequently will have to be recovered either by the tool or by manual methods.

2) Removing waste from drums using a remote tool will require operator involvement to control the tool, if the operator has to observe the waste removal at the glovebox face then additional radiation exposure will be incurred.

3) The baseline design proposes the full drum to be transferred into containment (ALT J1). In this case the drum clamp band is removed remotely. If the drum lid is to be removed using a bagless transfer system (ALT J2) then prior to offering the drum up to the bagless transfer port the drum clamp band will have to be removed. This is an additional operational stage which if carried out manually will incur additional radiation exposure.

c. Plant Throughput

1) The WRAP 2A plant is required to process approximately 25 drums of waste per day. The WRAP 2A baseline design proposes the use of bagless transfer techniques to allow full drums of waste to enter containment, this method allows the required plant throughput to be achieved.

2) It will be difficult to achieve the required throughput when removing waste from drums using a single remote tool and bagless transfer port.

d. Operability and Maintainability

1) As discussed in the safety evaluation for alternative J2, the drum clamp band will have to be removed prior to the lid being removed using a bagless transfer system. Removal of the drum clamp band is an additional operational stage which if carried out manually will incur additional dose.

2) Removal of waste using a remote tool will be labor intensive. In addition, it is improbable that the tool will be able to remove all waste from the drum, particularly for the wide variety of waste WRAP 2A will have to process. The removal of waste using a remote tool is likely to require additional clean up from dust generation and spillage of waste.

3) Some drums processed by WRAP 2A have been generated from retrieval operations and may have their lids damaged. It will be difficult to remove the lid from a drum using bagless transfer techniques if the lid has been damaged or if the lid is tightly pressed into the drum.

4) On removal of waste from the drum (ALT J2), the empty drum shell must then also be processed. If carried out within WRAP 2A this will also have to be carried out within an enclosure.

e. Demonstrated Technology/Development Requirements

1) Bagless transfer of drums into containment will be demonstrated as part of the WRAP 1 project. BNFL in the UK have carried out extensive testing of bagless transfer systems both actively and inactively.

2) BNFL in the UK are investigating the use of petal grabs to retrieve waste from storage silos, this work is on a much larger scale (3 feet diameter petal grab) and would probably have to be repeated at the drum size for WRAP 2A.

f. Flexibility

1) No significant differences are considered to exist between the two alternatives.

g. Equipment Cost

1) Drums of waste can be transferred with relative ease within an enclosure. If waste was to be lifted out of a drum it would have to be placed into a secondary container to be transferred to the process. The cost of this container would, however, be small.

2) Removal of waste from the drum at the bagless transfer port (ALT J2) would not require any drum delidding equipment and hence reduce the cost by approximately:

	Equipment Cost $ K
Band Saw	3.0
Lid Remover	10.0
Total	13.0

h. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

i. Waste Minimization Including Secondary Waste Generation

1) The transfer of waste into containment using a remote tool will lead to more clean up operation as a result of dust generation and spillage of waste and consequently produce additional secondary wastes.

6. Conclusions

a. The most suitable method of transferring waste into containment is to transfer full drums of waste into containment using simple double lidding systems.

7. Recommendations

a. The WRAP 2A Title I design should include simple double lidding systems and drum handling equipment for transferring full drums of waste into containment.

TABLE 6.9
ASSESSMENT OF PROCESS ROUTES FOR WASTE ENTRY INTO CONTAINMENT - EVALUATION MATRIX

ALT J1 = Bagless Transfer Drums of Waste Into Containment
ALT J2 = Bagless Transfer of Waste Into Containment

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT J1		ALT J2	
			RS	WS	RS	WS
Potential Hazards	15%	1-5	4.0	0.60	3.0	0.45
Throughput	15%	1-5	4.0	0.60	1.0	0.15
Ops & Main	15%	1-5	4.0	0.60	1.0	0.15
Dem Tech/Dev	20%	1-5	3.0	0.60	2.0	0.40
Flexibility	15%	1-5	3.0	0.45	3.0	0.45
Equipment Cost	10%	1-5	3.0	0.30	3.5	0.35
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.0	0.15	2.0	0.10
Total	100%		3.45		2.20	

6.10 Impact of Anti-Floatation Devices

1. Introduction

   a. The purpose of this assessment is to determine the most suitable method of introducing anti-floatation devices into the process.

   b. At present it is not known whether anti-floatation devices will be required to prevent waste floating in the grout or polymer matrix. However, some wastes are known to have relatively low densities (plastics etc.) and the likelihood that these wastes will float cannot currently be eliminated. For the purpose of the assessment it will be assumed that anti-floatation devices are required.

2. List of Alternatives

   a. ALT K1 = Anti-Floatation Device Fitted Before Dispatch to the Size Reduction and Repack Enclosure.

   b. ALT K2 = Anti-Floatation Device Fitted at the Size Reduction and Repack Enclosure After Filling With Waste

   c. ALT K3 = Anti-Floatation Device Fitted at the Polymer/Grout Processes Prior to Filling

3. Description of Alternatives

   a. ALT K1 Anti-floatation device fitted before dispatch to size reduction and repack enclosure.

      1) Anti-floatation devices are fitted to the empty drums prior to delivery for filling at the enclosures. The devices are removed before the drum is filled with waste and replaced when full.

   b. ALT K2 Anti-floatation device fitted at size reduction and repack enclosure after filling with waste.

      1) A supply of anti-floatation devices are held at the drum filling station of the enclosures, when the drums have been filled with treated waste the devices are fitted prior to the drum lid being installed.

   c. ALT K3 Anti-floatation device fitted at polymer/grout prior to filling.

      1) No provision is made for anti-floatation devices at the Size Reduction, Pug Mill or Special Waste enclosures, these will be fitted at the polymer/grout facilities. Fitting of anti-floatation devices would then be assessed by polymer/grout studies.

4. Description of Evaluation Matrix Scoring

a. An illustration of the alternatives evaluated is given in **Appendix A**, Sheet 6.10. The evaluation matrix is given in **Table 6.10**, located after the evaluation matrix description.

b. Potential Hazards

1) If anti-floatation devices are fitted at the size reduction, Grout or Polymer enclosures, then either bagging or bagless transfer equipment will have to be provided to allow the anti-floatation device to be introduced into the enclosure. Any operations which allow transfer items into/out of an enclosure have some associated risk of breaching containment, this is however considered to be small. If bagging techniques are employed then this will be labor intensive and will incur additional operator radiation exposure. If bagless transfer is used this will require additional maintenance.

2) Bagless transfer is being proposed to allow waste to be loaded into new drums at the size reduction and repack enclosure and to allow drums to immobilized at the grout and polymer enclosures.

c. Plant Throughput

1) Fitting the drum with an anti-floatation device before dispatch to open, sort and size reduction will probably mean that the device will have to be removed at the shred and repack enclosure while waste is loaded into the drum. However it is anticipated that the time to carry out this operation would only be in the order of 2-3 minutes and could be carried out in parallel with drum handling, opening and sorting operations within the enclosure.

2) Similarly if the anti-floatation device was introduced at either the size reduction, grouting or polymer enclosures, this could be carried out in parallel with drum filling operations.

3) No significant differences in throughput are considered to exist between the location at which the anti-floatation device is fitted to the drum.

d. Operability and maintainability

1) Introducing the anti-floatation device before dispatch to the shred and repack enclosure will allow removal, for waste filling, to be carried out in conjunction with lid removal and drum filling. This operation will be carried out remotely.

2) Introducing the anti-floatation device at either the shred and repack enclosure or the grout/polymer enclosures will require additional handling operations to transfer the device to and into the enclosures. If bagging techniques are employed then this will be labor intensive and will incur additional operator radiation exposure. If bagless transfer is used this will require additional maintenance.

e. Demonstrated Technology/Development Requirements

1) BNFL make use of anti-floatation devices in encapsulation plants at Sellafield in the UK. Anti-floatation devices are fitted to new drums entering the plant prior to entering the process. The anti-floatation device is remotely removed from the drum prior to loading waste into the drum, then remotely replaced once the drum is filled with waste. BNFL do not introduce anti-floatation devices after drums are filled with waste or grout.

f. Flexibility

1) No considerable differences in flexibility are considered to exist between each alternative.

g. Equipment Cost

1) Additional bagging/bagless transfer facilities will be required if anti-floatation devices are fitted at either the shred and repack, grout or polymer enclosures. This will increase the design and construction costs of alternative K2 and K3 by approximately $25K.

h. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

j. Waste Minimization including Secondary Waste Generation

1) Additional bagging/bagless transfer techniques required to introduce anti-floatation devices into the shred and repack, grout or polymer enclosures will produce some additional clean up and maintenance wastes. If bagging techniques are adopted this will generate additional secondary wastes.

5. Conclusions

a. At present it is not known whether anti-floatation devices will be required to prevent waste floating in the grout or polymer matrix. However, some wastes are known to have relatively low densities and the likelihood that these wastes will float cannot currently be eliminated. For the purpose of the assessment it has been assumed that anti-floatation devices will be required.

b. Waste anti-floatation devices should be fitted to the drum before dispatch to the size reduction enclosure. At the size reduction enclosure the anti-floatation device is removed remotely in order to allow the drum to be filled with waste, after which the anti-floatation device will be replaced. The same rationale applies to baskets to prevent waste sinking to the bottom of the drum, disposable paddles for in drum mixing and anti-vortex devices, if required. In some cases removal of the device may not be required to allow the drum to be filled with waste.

6. Recommendations

a. Further work should be carried out on waste characterization, in order that the grout and polymer processes can confirm that waste anti-floatation devices are required.

b. When the necessity for anti-floatation devices is confirmed, the WRAP 2A title design should include anti-floatation handling facilities in the Size Reduction, Sludge Repack and Special Waste enclosures. Also, design of the new drum and anti-floatation device should be initiated. This should be coordinated with other internal drum devices such as anti-sinking baskets, in-drum mixing paddles, etc.

TABLE 6.10
IMPACT OF ANTI-FLOATATION DEVICES - EVALUATION MATRIX

ALT K1 = Anti-Floatation Device Fitted Before Dispatch to Open/Sort/Size Reduction
ALT K2 = Anti-Floatation Device Fitted at Open/Sort/Size Reduction After Filling with Waste
ALT K3 = Anti-Floatation Device Fitted at Polymer/Grout After Filling With Waste

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT K1		ALT K2		ALT K3	
			RS	WS	RS	WS	RS	WS
Potential Hazards	15%	1-5	3.5	0.53	3.0	0.45	3.0	0.45
Throughput	15%	1-5	3.0	0.45	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	3.5	0.53	3.0	0.45	3.5	0.53
Dem Tech/Dev	20%	1-5	3.5	0.70	3.0	0.60	3.0	0.60
Flexibility	15%	1-5	3.0	0.45	3.0	0.45	3.0	0.45
Equipment Cost	10%	1-5	4.0	0.40	3.5	0.35	3.5	0.35
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.5	0.18	3.0	0.15	3.0	0.15
Total	100%			3.38		3.05		3.13

6.11 Enclosure Entry Systems

1. Introduction

   a. The purpose of this assessment is to determine the most effective enclosure entry configuration to introduce drums into the size reduction and repack, pug mill and special waste processes.

2. List of Alternatives

   a. ALT L1 = Individual Entry to Each Process Line

   b. ALT L2 = Single Common Entry to the Process Lines

   c. ALT L3 = Double Common Entry to the Process Lines

3. Description of Alternatives

   a. ALT L1 Individual entry to each process line.

      1) An entry box is included for each of the Size Reduction, Pug Mill and Special Waste enclosures which contains all the facilities for drum receipt, lid removal, drum hoisting/travel and enclosure entry hatch. This provides a controlled and segregated entry into the individual enclosures.

   b. ALT L2 Single common entry to all process lines.

      1) A single entry box is provided to supply waste drums to the Size Reduction, Pug Mill and Special Waste enclosures. A transfer mechanism relocates the drum from the entry enclosure to the entry point of the appropriate process line.

   c. ALT L3 Combination entry systems.

      1) Two entry enclosures serve the three process lines. This can be achieved by the following arrangements.

         a) Double common entry to Pug Mill and Size Reduction Enclosures.

            A dedicated entry box is provided for the Special Waste and Common entry for the Pug Mill and Size Reduction.

         b) Double common entry to Special Waste and Pug Mill Enclosures.

            A dedicated entry box is provided for the Size Reduction and common entry for the Pug Mill and Special Waste.

c) Double common entry to Special Waste, Pug Mill and Size Reduction Enclosures.

Two entry boxes are provided to serve the Size Reduction, Pug Mill and Special Waste enclosures, a transfer mechanism positions the drum at the appropriate enclosure.

5. Description of Evaluation Matrix Scoring

a. An illustration of each alternative evaluated is given in **Appendix A**, Sheet 6.11. The evaluation matrix is given in **Table 6.11**, located after the evaluation matrix description.

b. Potential Hazards

1) The purpose of the entry system is to allow drums of waste to enter containment with minimal risk of breaching containment. Each alternative meets this requirement and minimal difference is considered to exist between each alternative with respect to safety.

c. Plant Throughput

1) WRAP 2A is required to process approximately 25 drums per day based on single shift working. The WRAP 2A CDR proposes the use of individual entry enclosures to each process line, with this arrangement the CDR time and motion assessment concludes that plant throughput can be achieved. The CDR time and motion assessment allows seven (7) minutes for a drum to enter containment through the entry enclosure and an additional five (5) minutes for the drum lid to be removed. It will, however, not be possible for each line to process 25 drums per day in each process line using a single entry enclosure to allow drums to be introduced into containment (i.e 75 drums per day).

2) Breakdown of a single entry enclosure will stop all size reduction and repack operations. With the individual entry or double entry alternatives, if one entry facility breaks down then it will still be possible for operations to continue in another enclosure.

d. Operability and Maintainability

1) Drum entry and lid removal are non manual operations and hence no difference exists between operating one or more entry facilities.

2) The greater the number of entry facilities the higher the maintenance requirements.

e. Demonstrated Technology/Development Requirements

1) The method of drum entry into containment and drum lid removal is based on WRAP 1 technology and will require to be demonstrated as part of the WRAP 1 project. Each alternative utilizes similar drum entry and drum opening equipment and minimal difference is considered to exist between each alternative.

f. Flexibility

1) Individual or double entry facilities will allow each line to operate independently. Breakdown/repair of one entry facility will not prevent the plant from operating. A single combined entry facility does not give this flexibility.

g. Equipment Cost

1) The cost of an entry facility and lid removal equipment is estimated as follows:

	Equipment Cost $ K
Lift Table	8.9
Enclosure	61.7
Simple Double Lid	25.5
Drum Hoist	5.8
Drum Lifter	2.0
Sliding Hatch	12.5
Drum Pusher	3.5
Band Saw	3.0
Lid Remover	10.0
Total	132.9

h. Based on these figures the cost of each alternative is estimated as follows

Alternative	Number of entry and lid removal Facilities	Cost $K
L1	3	396
L2	1	132
L3	2	264

i. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

j. Waste Minimization Including Secondary Waste Generation

1) Individual entry facilities will produce the greatest maintenance and decommissioning wastes.

5. Conclusions

a. Utilization of individual entry enclosure to each of the Size Reduction, Sludge Repack and Special Waste lines is the most suitable entry configuration for introducing drums of waste into containment. This represents the CDR baseline design.

6. Recommendations

a. The WRAP 2A Title I design should progress, as specified in the CDR, on the basis that each of the Size Reduction, Sludge Repack and Special Waste lines has its own entry enclosure.

TABLE L
ENCLOSURE ENTRY SYSTEMS - EVALUATION MATRIX

ALT L1 = Individual Entry to Each Process Line
ALT L2 = Single Common Entry to All Process Lines
ALT L3 = Double Common Entry to Process Lines

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT L1		ALT L2		ALT L3	
			RS	WS	RS	WS	RS	WS
Potential Hazards	15%	1-5	3.0	0.45	3.0	0.45	3.0	0.45
Throughput	15%	1-5	4.0	0.60	2.0	0.30	3.0	0.45
Ops & Main	15%	1-5	2.5	0.38	3.5	0.53	3.0	0.45
Dem Tech/Dev	20%	1-5	3.0	0.60	3.0	0.60	3.0	0.60
Flexibility	15%	1-5	4.0	0.60	2.0	0.30	3.0	0.45
Equipment Cost	10%	1-5	2.0	0.20	4.0	0.40	3.0	0.30
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	2.5	0.13	3.5	0.18	3.0	0.15
Total	100%			3.10		2.90		3.00

7.0 DISCUSSION OF PREFERRED ALTERNATIVES

7.1 Shredded Waste Size Control

1. The preferred alternative for achieving shredded waste size control is to demonstrate that two shredders when operating in series can repeatedly produce waste of an acceptable size within a given tolerance. Prior to shredding an initial screening of the waste is carried out on the sorting table to remove any items which are unsuitable for shredding. After shredding the waste will be visually inspected to confirm the final waste size is acceptable for immobilization using vibro encapsulation techniques. Currently, all waste is targeted to fall within 2"x2"x2" after size reduction. This size is however a target size and not a specified by regulations. Discussions with shredder manufacturers indicate that it is not possible to guarantee that two shredders when operating in series will produce shredded waste within the targeted size of 2"x2"x2". If the 2"x2"x2" becomes an absolute requirement then either screening or sorting the waste will almost certainly be required thus increasing the complexity and cost of the process.

2. BNFL experience in the UK suggests that when encapsulating solid materials in a free flowing grout, the maximum size of the waste that can be satisfactorily encapsulated is bounded by the physical size of the container in which the waste and grout is to be mixed. WHC intends to carry out vibro encapsulation tests, the results of which will provide a clearer indication of the most suitable waste sizes that can be best immobilized using vibro encapsulation techniques.

3. In order to determine the most suitable make and model of the selected shredder, further work will be required to fully define the characteristics of the waste to be shredded. Shredding trials on surrogate wastes would assist in determining the average final shredded waste size that can be consistently produced by the shredding equipment.

7.2 Shredder Power Requirements

1. Shredders achieve size reduction by way of 2 slow rotating shafts fitted with intermeshing cutters which crush and shear the material drawn into the cutters by the cutter rotation. High torque is required to perform this function at the slow operating speeds necessary to allow feed back to stop rotation when non-compliant material is present. This feature minimizes machine jamming and prolongs the life of cutter and drive components. Shredders can be driven either hydraulically or electrically. Electrical power is the preferred type of drive because it is cleaner and simpler than hydraulic drives and does not generate active hydraulic fluid or hydraulic oil contaminated secondary wastes.

2. Several companies manufacture shredders for size reduction of waste material. Shredder selection is based on the characteristics of the waste to be shredded and the degree of size reduction required. A Shredding system similar to that proposed for WRAP 2A has been designed and built by the Stock Equipment Company, this system uses Shred Pax 40 HP electrically driven shredders. However, the wastes processed by the Stock shredding system are not as varied or as heavy in nature as the WRAP 2A wastes and hence it is likely a higher power shredder will be required for WRAP 2A.

3. In order to establish the most suitable shredding equipment to process the WRAP 2A wastes further work is required to fully characterize the waste which requires shredding. Discussions should continue with shredder vendors to establish the most suitable shredder design (i.e. shredder cutter spacing, number of hooks on cutter etc). These discussions may lead to shredding trials being carried out at vendors sites or at WHC.

7.3 Dust Control and Hazards

1. The preferred alternative for dust and hazard control during shredding operations is to provide a sliding hatch over the shredder feed hopper combined with a local exhaust from the shredder enclosure.

2. The proposed sequence of operations to achieve dust and hazard control during shredding operations is as follows:

   a. Initial conditions - Waste on the sorting table after sorting.
      Shredder off
      Sliding Hatch covering shredder feed hopper

   b. Sliding hatch opened and waste loaded into the shredder from the sorting table.

   c. Waste is observed in the shredder feed hopper via CCTV to ensure problems will not be encountered during shredding.

   d. Sliding hatch closed over shredder feed hopper.

   e. Shredders turned on and waste shredded.

3. During this sequence of operations the local ventilation can be operated continuously or interlocked to operate during the shredding operation only.

4. Dust will be generated during the shredding operation carried out in WRAP 2A. Based on experience gained by BNFL in the UK, the risk of fire and/or explosion occurring during shredding operations cannot at present be discounted for WRAP 2A.

7.4 Shredder Installation

1. The preferred alternative for installation of the shredders in the glovebox suite is to make the shredder housing an integral part of the glovebox enclosure. It will be more suitable for the shredders to be in line rather than at 90% to each other, drive systems to the shredders should be external to the glovebox enclosure and accessible to simplify maintenance/replacement. The shredder housing/glovebox enclosure will be fabricated from stainless steel and bolted to adjacent enclosures using flanges, seals and anti-vibration mountings. The load of the shredder should be taken through structural steelwork external to the shredder enclosure. Viewing windows and gloveports will be required for maintenance operations.

7.5 Single Route for Shredded and Non-Shredded Wastes

1. The preferred alternative for processing dry wastes in the open, sort and size reduction enclosure is to:

   a. Shred wastes which require size reduction.

   b. Directly repack wastes which do not require size reduction, without shredding the waste.

   This principal is primarily driven by the fact that it is unnecessary to shred waste which does not require size reduction and that shredding material such as dry powder, ash and soil will give rise to unnecessary dust generation, increased contamination & clean up requirements and increase the load on the filtration system. Increasing the amount of airborne dust may increase the potential of dust explosion.

2. The drum entry, opening, tipping and sorting facilities for the open, sort and size reduction enclosure are based on similar equipment used in WRAP 1. This equipment is currently at Title II design and sufficient confidence exists that re-evaluation as part of the WRAP 2A ACDR is not considered cost effective or necessary. However specific differences in design requirements between the two facilities will have to be addressed during Title I and Title II design, i.e., increase in drum weight, positioning of viewing windows and gloveports etc. The open, sort and size reduction glovebox will be fabricated from individual stainless steel enclosures (drum entry, sorting etc) which are bolted together by flanges and seals. As a result of the size of the open, sort and size reduction glovebox, it will be necessary to have supporting steelwork external to the shredder enclosure.

7.6 Process Routes for Empty Drums

1. The preferred process route for empty drums arising from the size reduction area of WRAP 2A is compaction and loading into 85 gallon overpacks for disposal as LLW. At present the proposed design solution is to have a dedicated empty drum compactor and load out facility in WRAP 2A and that this will be connected to the size reduction, sludge repack and special waste enclosures. This allows empty drums to be processed at the source of generation thus minimizing the movement of empty drums around the facility. An alternative solution would be to transfer the empty drums in overpacks to the LLW supercompactor in WRAP 1 for compaction and loading into disposal overpacks. Although this alternative reduces the capital cost of WRAP 2A it does significantly increase material handling requirements between WRAP 2A and WRAP 1 and also makes operation of WRAP 2A reliant on operation of WRAP 1.

2. The current proposal to demonstrate the drum is empty and hence suitable for disposal as LLW is by visual inspection using CCTV equipment. If after inspection a drum is not considered to be empty then the drum can be shredded and treated as LLRMW along with the main WRAP 2A feed. As an alternative to shredding , the option exist to clean up the drum which is not considered to be empty (i.e. classified as LLW), the decision of whether to clean or shred a drum can be made on an individual drum basis.

3. In addition, WRAP 1 Change Request 55 proposes that empty drums are compacted and loaded into 85 gallon drums for disposal as LLW. Compaction and loading of empty drums into 85 gallon overpacks is thus consistent with the WRAP 1 design philosophy.

4. In order for empty drums to be compacted and loaded into 85 gallon overpacks the FDC must be revised to allow output from WRAP 2A to be in 85 gallon drums as well as 55 gallon drums.

7.7 Process Routes for 85 Gallon Drums Containing Absorbent

1. The preferred alternative process for 85 gallon drums containing absorbent is to pretreat the drum in the box breakdown area of WRAP 2A prior to shredding in the size reduction enclosure. This solution is dependent on the number of 85 gallon drums which are expected to contain absorbent. This study assumes a total of approximately 700 x 85 gallon drums containing absorbent will be processed in WRAP 2A, if this number increases then re-evaluation of throughput in the box breakdown area will be necessary.

2. The box breakdown area will require the flexibility to deal with treatment of a number of uncertain waste forms which may arise in boxes. This flexibility can be used to overcome the problems associated with treating 85 gallon drums containing absorbent. The 85 gallon drum will firstly be removed by the box breakdown equipment and the extent of damage to the 55 gallon drum inside assessed. If damage to the 55 gallon drum is minimal it may be possible for it to be cleaned and loaded directly into a new overpack for transfer to the open, sort and size reduction enclosure. If the 55 gallon drum is damaged it will be opened and the contents repacked into a new 55 gallon drum for transfer to the open, sort and size reduction enclosure, inside an overpack. The 85 gallon drum shell will be size reduced and loaded into a new 55 gallon drum, together with any absorbent released during processing, and transferred to the open, sort and size reduction enclosure in a new overpack.

7.8 Process Routes for Immobilized Waste and Supercompacted Drums

1. The preferred alternative process for immobilized waste and supercompacted drums is to pretreat the drum in the box breakdown area of WRAP 2A prior to shredding in the size reduction enclosure. As for 85 gallon drums containing absorbent this solution is dependent on the number of immobilized drums and supercompacted drums which are expected require processing. This study assumes approximately 190 immobilized drums and minimal supercompacted drums will be processed in WRAP 2A each year. It is assumed that the 190 immobilized drums per year comprise of 100 drums which are produced by either the grout or polymer processes which do not comply with WAC and 90 drums which require destructive examination (i.e 1% of the immobilized drums produced by WRAP 2A). If this number increases then re-evaluation of throughput in the box breakdown area will be necessary.

2. The WRAP 2A CDR proposes to use cutting equipment in the box breakdown cell to slice the immobilized drums into disks which can then be broken down into smaller pieces and loaded into a 55 gallon drum for transfer to the open, sort and size reduction enclosure for shredding. Supercompacted drums can be size reduced in the box breakdown cell using remote tooling. Pretreatment of these wastes in the box breakdown cell will reduce the wear and potential damage to the shredding equipment.

7.9 Waste Entry into Enclosures

1. The preferred method of transferring waste into containment is to transfer full drums of waste into containment using simple double lid systems. The drum entry facilities for the open, sort and size reduction enclosure are based on similar equipment used in WRAP 1.

2. The use of simple double lidding systems reduces the risk of operator wounds, exposure and breaching containment associated with bagging techniques. Simple double lidding systems also minimize secondary waste generation.

7.10 Impact of Anti-Floatation Devices

1. The preferred method of introducing anti-floatation devices into the processes is to pre-fit the anti-floatation device in the drum before dispatch to the size reduction, sludge repack and special waste enclosures. The anti-floatation devices could be pre-fitted in the drum before delivery to WRAP 2A, or could be procured separately and fitted in the drum in the WRAP 2A new drum receipt area. The same rationale applies to baskets to prevent waste sinking to the bottom of the drum, disposable paddles for in drum mixing and anti-vortex devices if required. In some cases removal of the device may not be required to allow the drum to be filled with waste.

2. The proposed sequence of operations for loading waste into the drum which has previously been fitted with an anti-floatation device is as follows:

   a. Anti-floatation device is fitted to drum prior to dispatch to enclosures.

   b. Drum is transferred to enclosure and offered to waste load out bagless transfer port.

   c. Lid of drum is removed at bagless transfer port.

   d. Anti-floatation device is removed from drum using remote tool.

   e. Waste is loaded into drum.

   f. Anti-floatation device is replaced in drum using remote tool.

   g. Lid of drum is replaced at bagless transfer port.

h. Drum is lowered from bagless transfer port and transferred to storage prior to polymer or grout processing.

3. As for the in drum mixing paddles, the anti-floatation devices will most likely be made of carbon steel.

4. The anti-floatation device works on the principle that the weight of the device is always sufficient to overcome the buoyancy force exerted by the waste being immersed in the polymer or grout medium while the encapsulation material is still fluid.

7.11 Drum Entry Enclosure Arrangement

1. The preferred entry configuration for introducing drums into containment is to utilize an individual entry enclosure to each of the size reduction, sludge repack and special waste process lines. The main reasons for this is to provide independent operation for each process line ie. if only one entry facility was provided then breakdown of this single entry facility would stop all operations in the size reduction area. Individual entry systems also provides some flexibility by allowing drums to enter at one enclosure entry facility and be transferred to an alternative processing line using the transfer tunnel, should one of the entry enclosures be blocked.

2. The drum entry facilities for the open, sort and size reduction enclosure are based on similar equipment used in WRAP 1. However specific differences in design requirements between the two facilities will have to be addressed during Title I and Title II design, i.e. increase in drum weight, positioning of viewing windows and gloveports etc. The entry facilities will be from stainless steel fabricated enclosures which are bolted to adjacent enclosures by flanges and seals.

8.0 REFERENCES

1. WRAP 2A ACDR Work Plan, 26 January 1993.

2. WRAP 2A Conceptual Design Report, Prepared by UE&C for US-DOE, July 1992.

3. WRAP 2A Advanced Conceptual Design Report Study 1604-5: Sludge Repack Evaluation, Prepared by UE&C for U.S.-DOE, June 1993.

4. WRAP 2A Functional Design Criteria Revision 1, J Westcott WHC, 14 December 1992.

5. Telecon Note TC92014.008: S A Sharpe - J Crowley, 18 December 1992.

6. Telecon Note TC93001.008: S A Sharpe - J Crowley, 29 December 1993.

7. Trip Report TR93002.008: Shredder and Compactor Demonstration, S A Sharpe & D Veronica, 27 January 1993.

8. EGG-2226, INEL Low Speed Shredder and Waste Shreddability Tests, G. Ross Darnell & W C Aldrich, April 1983.

9. Telecon Note TC930012.008: S A Sharpe - J Myres, 26 February 1993.

10. Telecon Note TC93002.008: S A Sharpe - J Beasley, 29 December 1992.

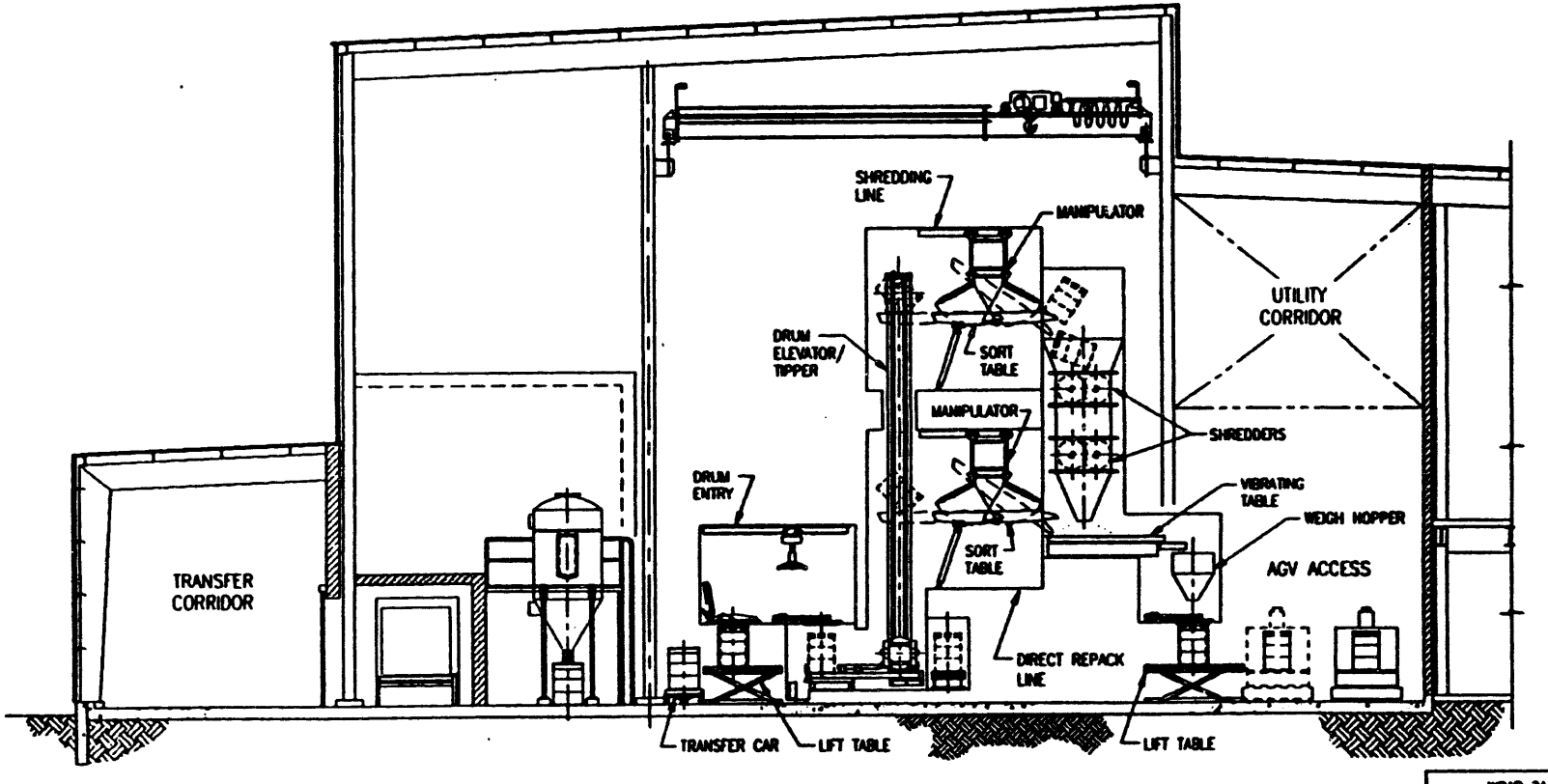
11. Fax From: H Groves to S A Sharpe, 15 October 1992.

12. Telecon Note TC92011.008: S A Sharpe - W Phillips, 16 December 1992.

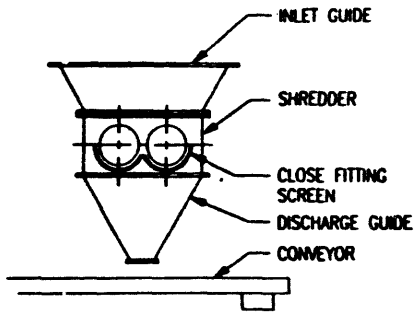
13. Telecon Note TC92015.008: S A Sharpe - T Pauly, 22 December 1992.

14. Telecon Note TC92006.006: S A Sharpe - S Kooiker, 17 March 1992.

APPENDIX A
ENGINEERING SKETCHES

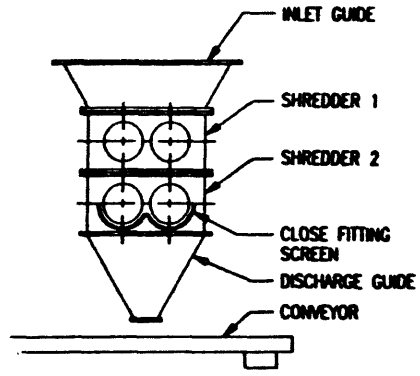


WRAP 2A
CONCEPTUAL DESIGN
CDR BASELINE DESIGN
SIZE REDUCTION AND
REPACK ENCLOSURE
SHEET 1.1



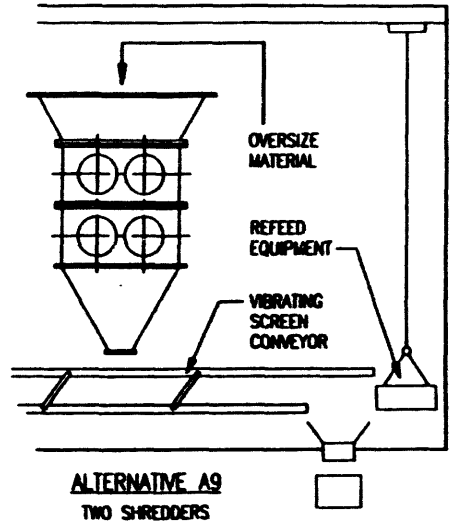
ALTERNATIVE A1

SINGLE SHREDDER
CLOSE FITTING SCREEN - NO SORT



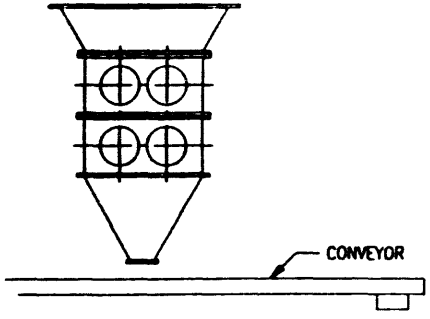
ALTERNATIVE A7

TWO SHREDDERS
CLOSE FITTING SCREEN - NO SORT



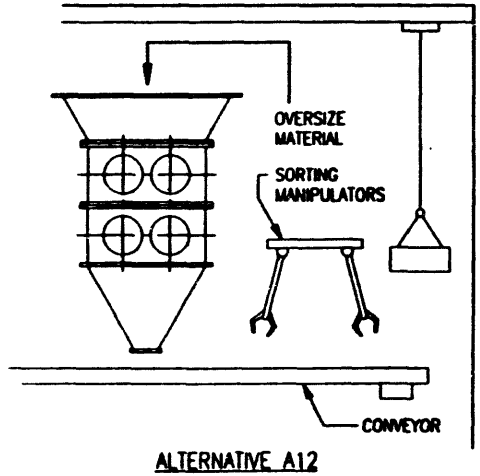
ALTERNATIVE A9

TWO SHREDDERS
VIBRATING SCREEN - NO SORT



ALTERNATIVE A11

TWO SHREDDERS
NO SCREEN - NO SORT



ALTERNATIVE A12

TWO SHREDDERS
NO SCREEN - SORT

NOTES

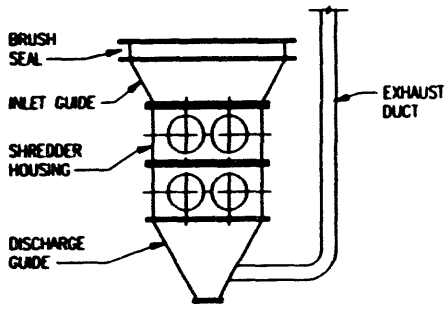
1. INTIAL LIST OF ALTERNATIVES

ALT A1 = SINGLE SHREDDER
CLOSE FITTING SCREEN - NO SORT
ALT A2 = SINGLE SHREDDER
CLOSE FITTING SCREEN - SORT
ALT A3 = SINGLE SHREDDER
VIBRATING SCREEN - NO SORT
ALT A4 = SINGLE SHREDDER
VIBRATING SCREEN - SORT
ALT A5 = SINGLE SHREDDER
NO SCREEN - NO SORT
ALT A6 = SINGLE SHREDDER
NO SCREEN - SORT
ALT A7 = TWO SHREDDERS
CLOSE FITTING SCREEN - NO SORT
ALT A8 = TWO SHREDDERS
CLOSE FITTING SCREEN - SORT
ALT A9 = TWO SHREDDERS
VIBRATING SCREEN - NO SORT
ALT A10= TWO SHREDDERS
VIBRATING SCREEN - SORT
ALT A11= TWO SHREDDERS
NO SCREEN - NO SORT
ALT A12= TWO SHREDDERS
NO SCREEN - SORT

2. ALTERNATIVE A2, A3, A4, A5, A6, A8, A10 SCREENED FROM FURTHER EVALUATION.

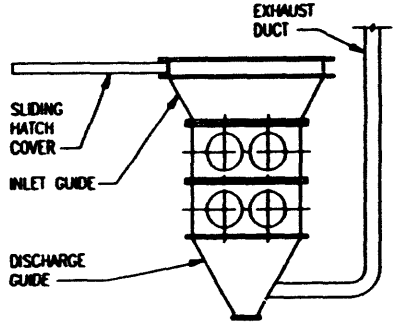
WRAP 2A CONCEPTUAL DESIGN
SHREDDER EVALUATION
SHREDDED WASTE SIZE CONTROL

SHEET 6.1



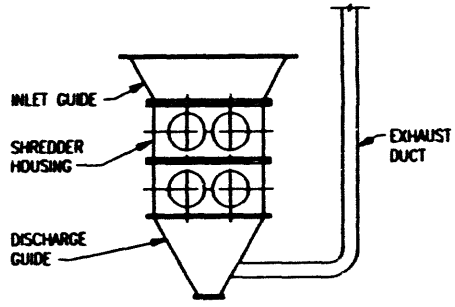
ALTERNATE C1

LOCAL EXHAUST
BRUSH SEAL



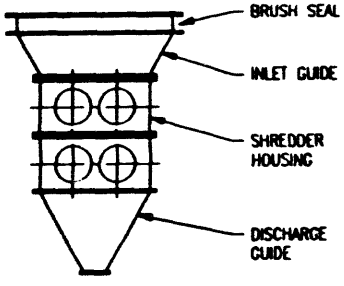
ALTERNATE C2

LOCAL EXHAUST
SLIDING HATCH COVER



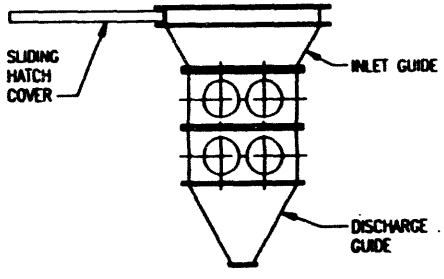
ALTERNATE C3

LOCAL EXHAUST
NO SEAL



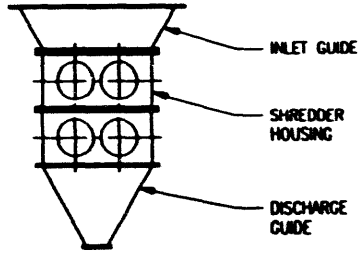
ALTERNATE C4

ENCLOSURE EXHAUST ONLY
BRUSH SEAL



ALTERNATE C5

ENCLOSURE EXHAUST ONLY
SLIDING HATCH COVER



ALTERNATE C6

ENCLOSURE EXHAUST ONLY
NO CONTAINMENT

NOTES

1. INITIAL LIST OF ALTERNATES

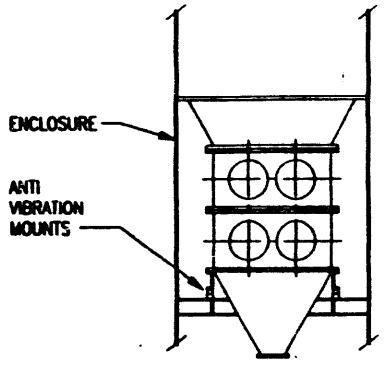
   ALT C1 = LOCAL EXHAUST- BRUSH SEAL
   ALT C2 = LOCAL EXHAUST- SLIDING HATCH COVER
   ALT C3 = LOCAL EXHAUST- NO SEAL
   ALT C4 = ENCLOSURE EXHAUST ONLY- BRUSH SEAL
   ALT C5 = ENCLOSURE EXHAUST ONLY- SLIDING HATCH COVER
   ALT C6 = ENCLOSURE EXHAUST ONLY- NO CONTAINMENT

2. ALL ALTERNATIVES EVALUATED

3. ALTERNATIVES ALSO APPLY FOR SINGLE SHREDDER

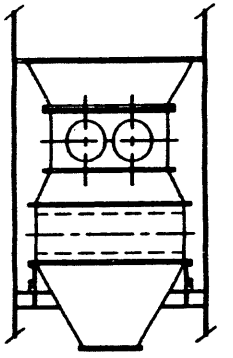
WRAP 2A CONCEPTUAL DESIGN
SHREDDER EVALUATION
DUST CONTROL AND HAZARDS

SHEET 6.3



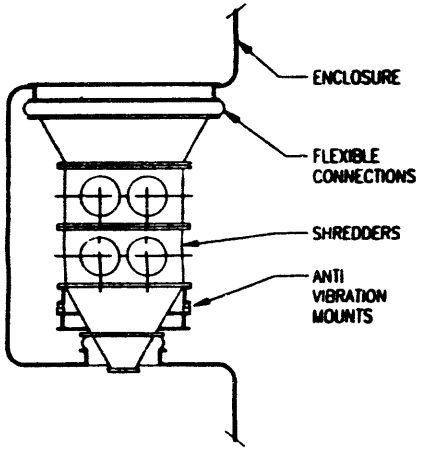
ALTERNATE D1

INSIDE ENCLOSURE
SHREDDERS IN LINE



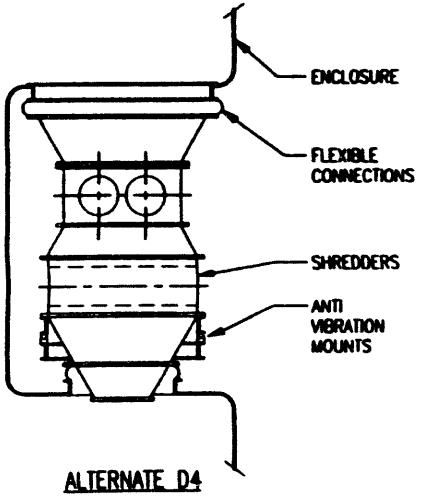
ALTERNATE D2

INSIDE ENCLOSURE
SHREDDERS AT 90°



ALTERNATE D3

OUTSIDE ENCLOSURE
SHREDDERS IN LINE



ALTERNATE D4

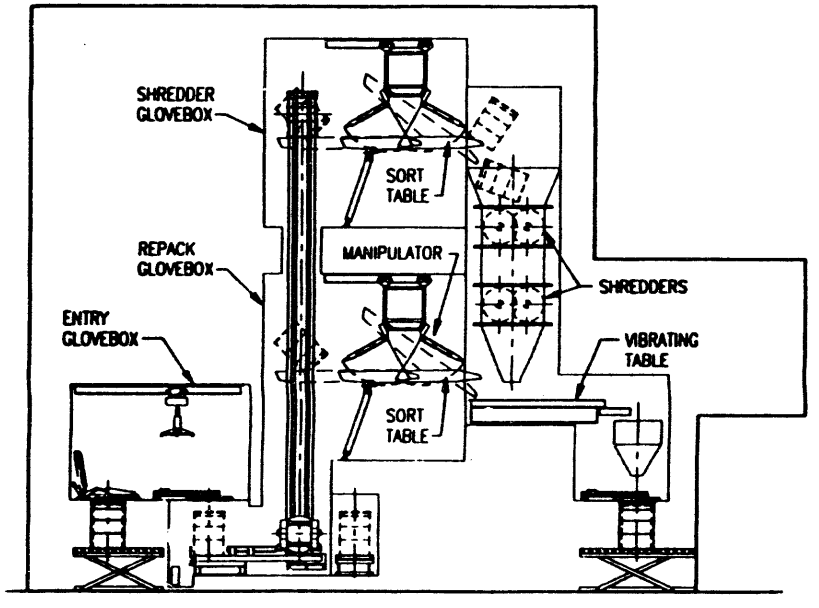
OUTSIDE ENCLOSURE
SHREDDERS AT 90°

NOTES

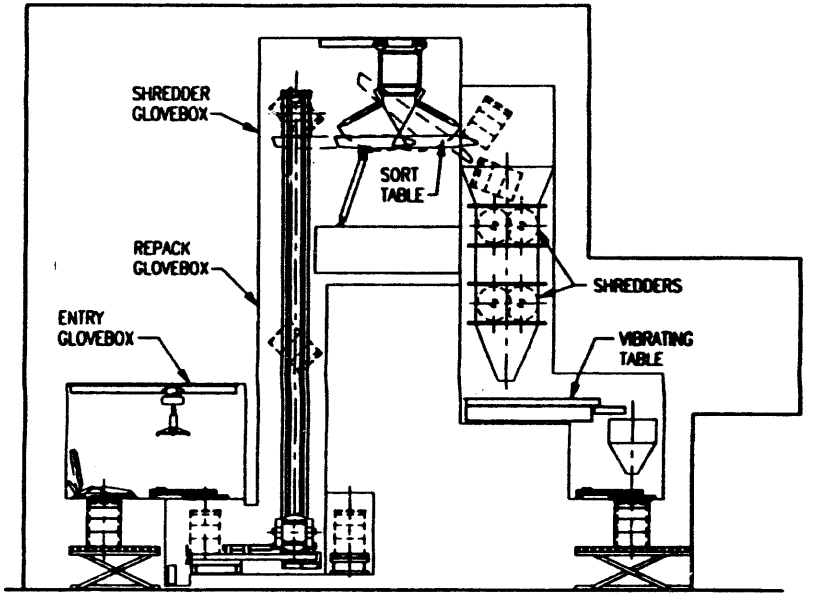
1. INITIAL LIST OF ALTERNATIVES
   - ALT D1 = INSIDE ENCLOSURE SHREDDERS IN LINE
   - ALT D2 = INSIDE ENCLOSURE SHREDDERS AT 90°
   - ALT D3 = OUTSIDE ENCLOSURE SHREDDERS IN LINE
   - ALT D4 = OUTSIDE ENCLOSURE SHREDDERS AT 90°
2. ALL ALTERNATIVES EVALUATED.
3. ALTERNATIVES SHOWN FOR TWO SHREDDER LAYOUT - MOUNTING AND ACCESS WILL BE SIMILAR FOR SINGLE SHREDDER.
4. SHREDDER MOUNTING REQUIRES ISOLATION TO LIMIT VIBRATION LOADING ON ENCLOSURE STRUCTURE.

WRAP 2A CONCEPTUAL DESIGN
SHREDDER EVALUATION
SHREDDER INSTALLATION

SHEET 6.4



ALTERNATE E1



ALTERNATE E2

NOTES

1. INTIAL LIST OF ALTERNATIVES

ALT E1 = DIRECT REPACK OF WASTE WHICH DOES NOT REQUIRE SHREDDING, SHREDDING OF WASTE WHICH REQUIRES SHREDDING

ALT E2 = ALL WASTE ROUTED THROUGH SHREDDERS

WRAP 2A CONCEPTUAL DESIGN
SINGLE ROUTE
SHREDDED/NON SHREDDED WASTE

SHEET 6.5

ALTERNATE F1

SHRED EMPTY DRUMS

EMPTY DRUMS ONCE CONTENTS HAVE BEEN EMPTIED AND REMOVED → SHRED AND REPACK EMPTY DRUMS → GROUT OR POLYMER IMMOBILIZE

ALTERNATE F2

COMPACT EMPTY DRUMS

EMPTY DRUMS ONCE CONTENTS HAVE BEEN EMPTIED AND REMOVED → INSPECT TO CONFIRM EMPTY DRUMS ARE LLW → TRANSFER EMPTY DRUM TO EMPTY DRUM COMPACTOR → COMPACT EMPTY DRUM → LOAD COMPACTED EMPTY DRUM INTO OVERPACK → DISPOSE OF AS LLW

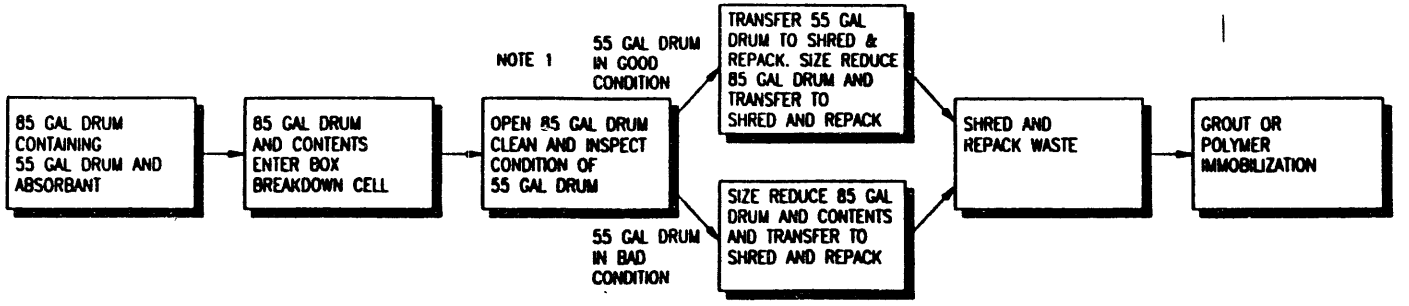
NOTES

1. INTIAL LIST OF ALTERNATIVES
   ALT F1 = SHRED EMPTY DRUMS
   ALT F2 = COMPACT EMPTY DRUMS
2. ALTERNATIVE F3 SCREENED FROM FURTHER EVALUATION

WRAP 2A CONCEPTUAL DESIGN
PROCESS ELEVAUATION
PROCESS ROUTES FOR EMPTY DRUMS
SHEET 6.6

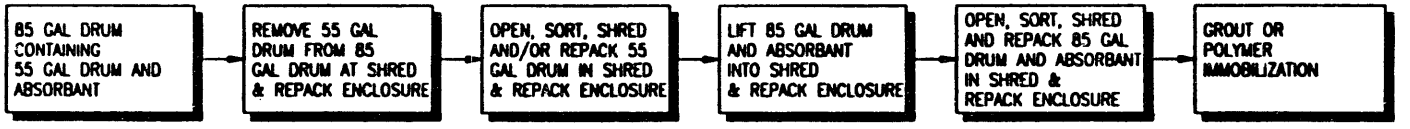
ALTERNATE G1

PRETREAT 85 GAL DRUM IN BOX BREAKDOWN



ALTERNATE G4

OPEN BOTH 85 AND 55 GAL DRUM AND PROCESS WASTE IN SHRED AND REPACK ENCLOSURE



NOTES

1. INTIAL LIST OF ALTERNATIVES

ALT G1 = PRETREAT 85 GAL DRUM IN BOX BREAKDOWN

ALT G2 = OPEN BOTH 85 AND 55 GAL DRUM AND PROCESS WASTE IN SHRED AND REPACK ENCLOSURE

ALT G3 = OPEN 85 GAL DRUM, REMOVE 55 GAL DRUM AND SHRED 55 GAL DRUM WITHOUT OPENING.

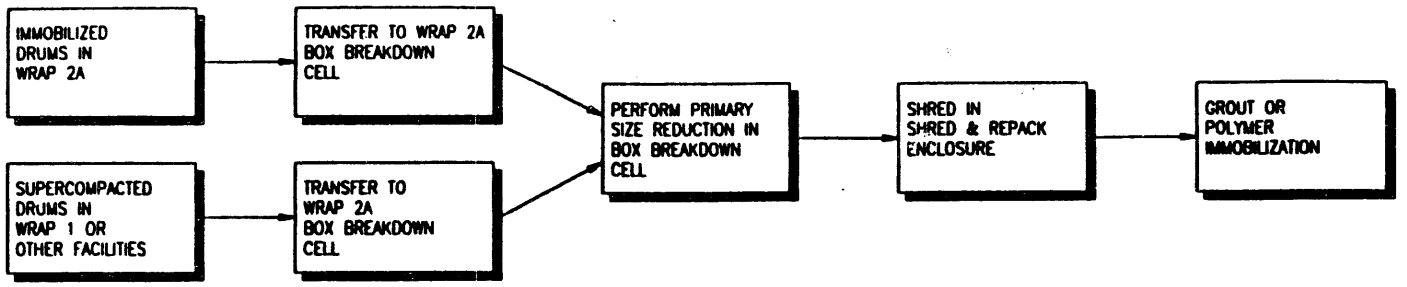
ALT G4 = SHRED 85 GAL DRUM WITHOUT OPENING

ALTERNATIVE G3 AND G4 SCREENED FROM FURTHER EVALUATION.

WRAP 2A CONCEPTUAL DESIGN
PROCESS EVALUATION
PROCESS ROUTES FOR 85 GALLON DRUMS WITH ABSORBANT
SHEET 6.7

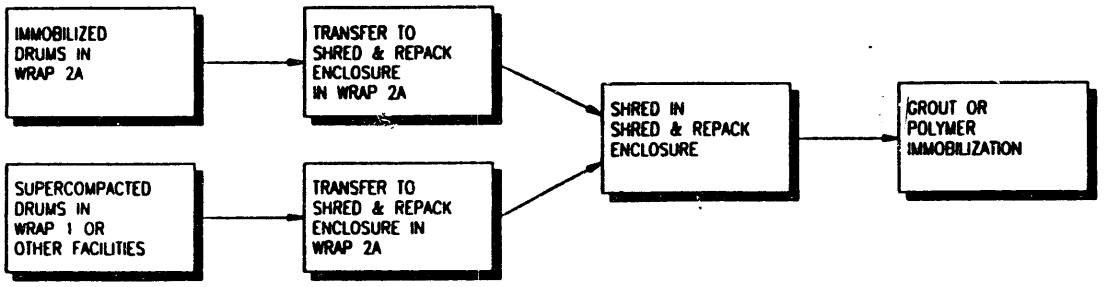
ALTERNATE H1

PRETREAT IMMOBILIZED WASTE AND SUPERCOMPATED DRUMS IN BOX BREAKDOWN



ALTERNATE H2

ROUTE DIRECTLY TO SHREDDER



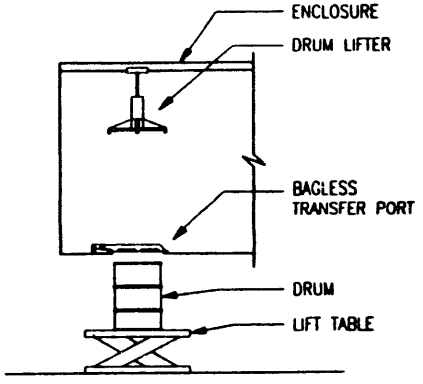
NOTES

1. INTIAL LIST OF ALTERNATIVES
   ALT H1 = PRETREAT IMMOBILIZED WASTE DRUMS IN BOX BREAKDOWN
   ALT H2 = ROUTE DIRECTLY TO SHREDDER
2. ALL ALTERNATIVES EVALUATED

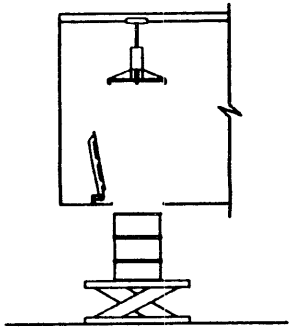
WRAP 2A CONCEPTUAL DESIGN
PROCESS EVALUATION
PROCESS ROUTES FOR IMMOBILIZED WASTE AND SUPERCOMPACTOR DRUM
SHEET 6 8

ALTERNATE J1

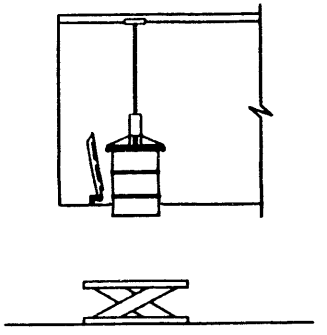
BAGLESS TRANSFER DRUMS OF WASTE INTO CONTAINMENT



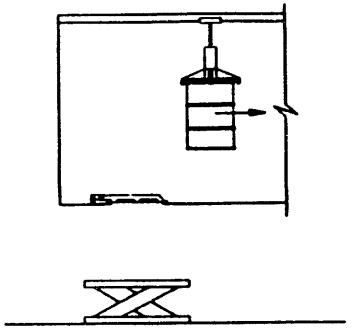
LIFT DRUM ADJACENT TO BAGLESS TRANSFER PORT



OPEN BAGLESS TRANSFER PORT



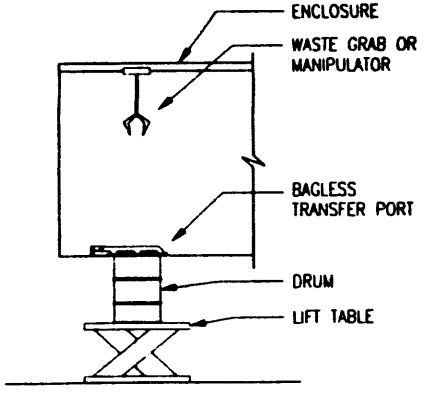
LIFT DRUM INTO CONTAINMENT



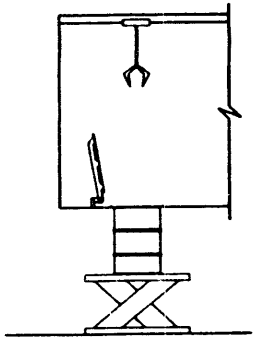
TRANSFER DRUM WITHIN ENCLOSURE AND CLOSE BAGLESS TRANSFER PORT

ALTERNATE J2

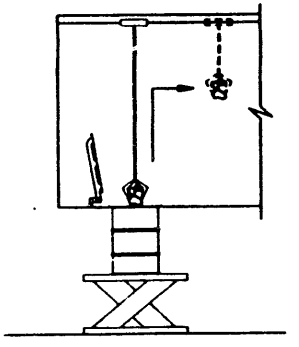
BAGLESS TRANSFER WASTE INTO CONTAINMENT



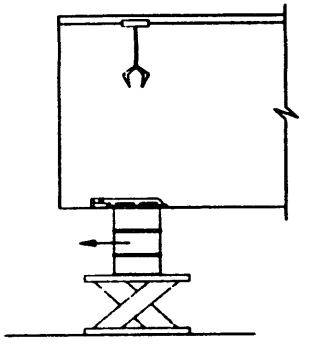
LIFT DRUM ADJACENT TO BAGLESS TRANSFER PORT



OPEN BAGLESS TRANSFER PORT



GRAB WASTE IN DRUM, LIFT AND TRANSFER TO PROCESS



CLOSE BAGLESS TRANSFER PORT AND REMOVE EMPTY DRUM

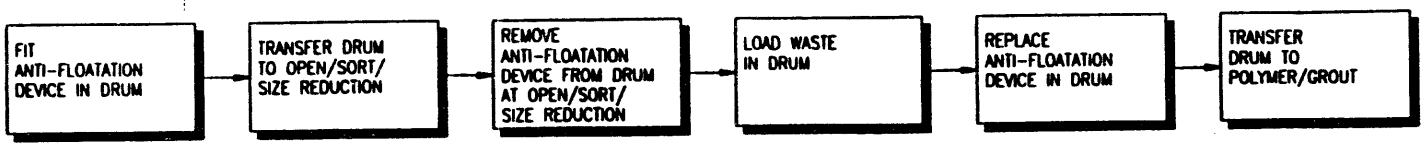
NOTES

1. INTIAL LIST OF ALTERNATIVES
   - ALT J1 = BAGLESS TRANSFER DRUMS OF WASTE INTO CONTAINMENT
   - ALT J2 = BAGLESS TRANSFER WASTE INTO CONTAINMENT
   - ALT J3 = BAG DRUMS OF WASTE INTO CONTAINMENT
   - ALT J4 = BAG WASTE INTO CONTAINMENT
2. ALTERNATIVES J3 AND J4 SCREENED FROM FURTHER EVALUATION

WRAP 2A CONCEPTUAL DESIGN
PROCESS EVALUATION
PROCESS ROUTE FOR WASTE ENTRY INTO CONTAINMENT
SHEET 6.9

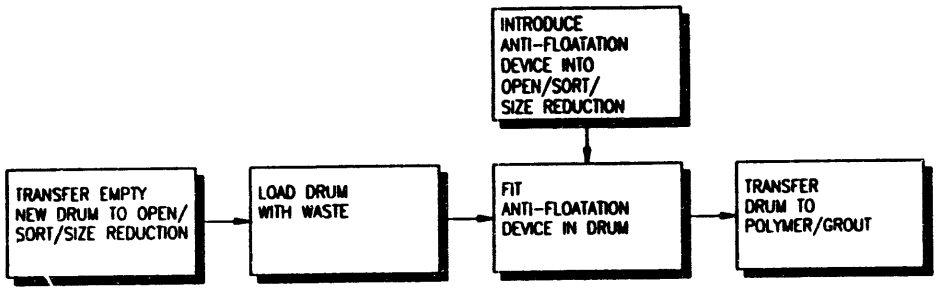
ALTERNATE K1

ANTI-FLOATATION DEVICE FITTED IN DRUM BEFORE DISPATCH TO OPEN/SORT/SIZE REDUCTION



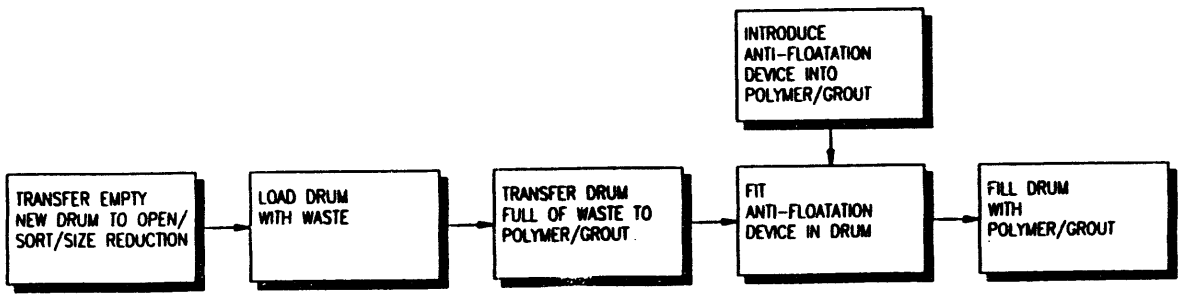
ALTERNATE K2

ANTI-FLOATATION DEVICE FITTED AT OPEN/SORT/SIZE REDUCTION AFTER FILLING WITH WASTE



ALTERNATE K3

ANTI-FLOATATION DEVICE FITTED AT POLYMER/GROUT AFTER IMMOBILIZATION



NOTES

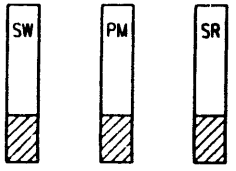
1. INTIAL LIST OF ALTERNATIVES
   - ALT K1 = ANTI-FLOATATION DEVICE FITTED IN DRUM BEFORE DISPATCH TO OPEN/SORT/SIZE REDUCTION
   - ALT K2 = ANTI-FLOATATION DEVICE FITTED AT OPEN/SORT/SIZE REDUCTION AFTER FILLING WITH WASTE
   - ALT K3 = ANTI-FLOATATION DEVICE FITTED AT POLYMER/GROUT AFTER IMMOBILIZATION
2. ALL ALTERNATES EVALUATED

WRAP 2A CONCEPTUAL DESIGN
PROCESS EVALUATION
IMPACT OF ANTI-FLOATATION DEVICES

SHEET 6.10

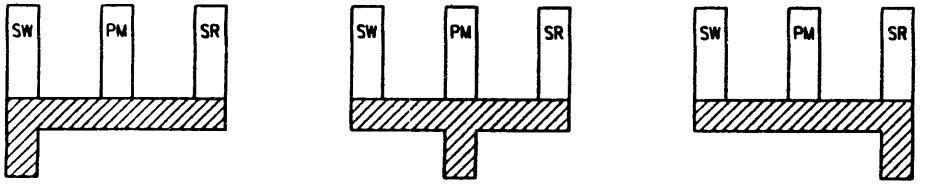
ALTERNATE L1

INDIVIDUAL ENTRY TO EACH PROCESS LINE



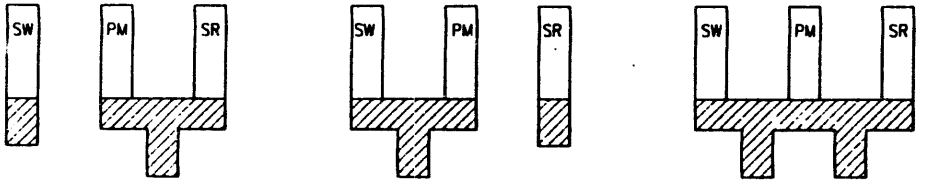
ALTERNATE L2

SINGLE COMMON ENTRY TO THE 3 PROCESS LINES (NOTE 2)



ALTERNATE L3

DOUBLE COMMON ENTRY TO THE 3 PROCESS LINES (NOTE 2)



NOTES

1. INTIAL LIST OF ALTERNATIVES
   - ALT L1 = INDIVIDUAL ENTRY TO EACH PROCESS LINE
   - ALT L2 = SINGLE COMMON ENTRY TO 3 PROCESS LINES
   - ALT L3 = DOUBLE COMMON ENTRY TO THE 3 PROCESS LINES
2. ALL ALTERNATES EVALUATED.
3. EACH SCHEME DRAWING REPRESENTS A PLAN VIEW ON THE SHREDDER & REPACK PUG MILL AND SPECIAL WASTE PROCESS LINES OF WRAP 2A.
4. EMPTY DRUM TRANSFER TUNNEL COULD POTENTIALLY BE USED TO TRANSPORT INCOMING WASTE DRUMS.

KEY

SW = SPECIAL WASTE PROCESS LINE

PM = PUG MILL PROCESS LINE

SR = SHREDDED & REPACK PROCESS LINE

= ENTRY ENCLOSURE

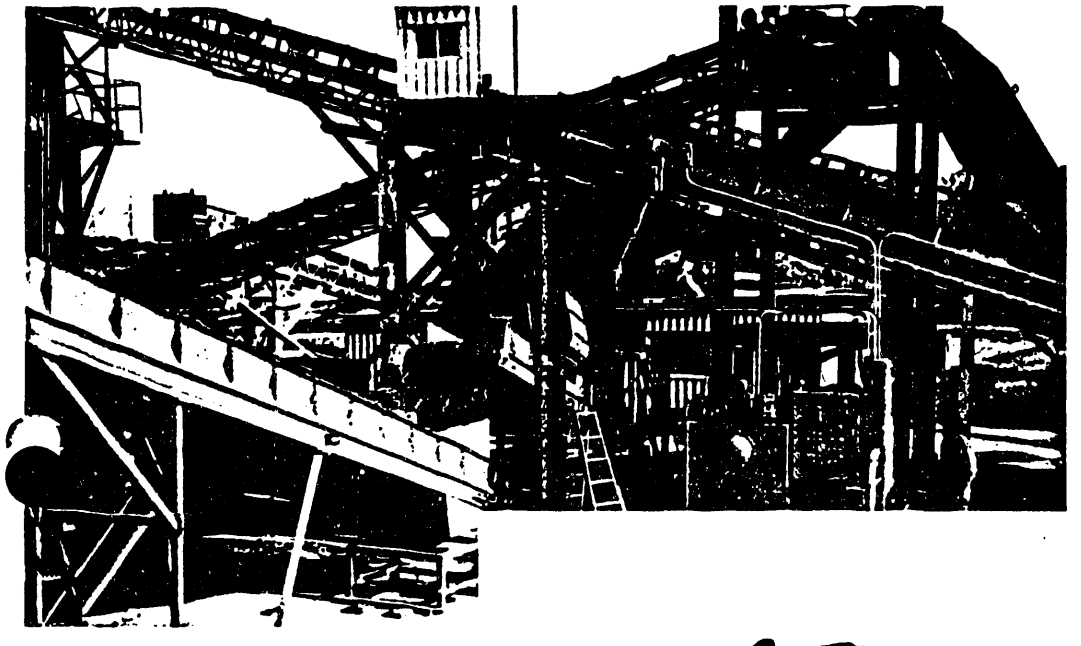
WRAP 2A CONCEPTUAL DESIGN
EQUIPMENT EVALUATION
AND CONFIGURATION
ENCLOSURE ENTRY SYSTEMS
SHEET 6.11

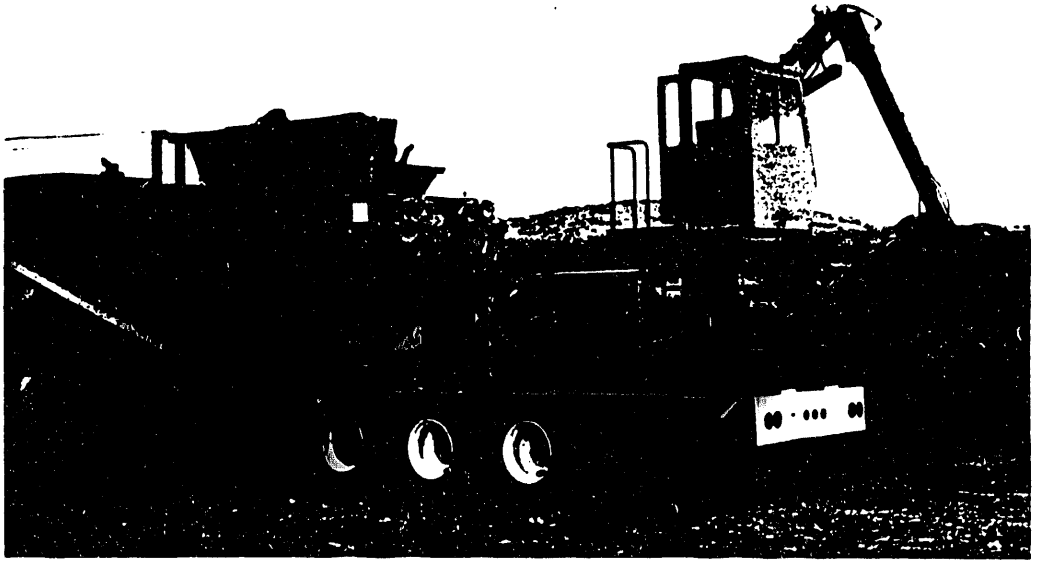
APPENDIX B
VENDOR DATA

WRAP 2A ACDR STUDY 1604-5	EQUIPMENT CONTACTS	6237008 5/01/93
Vendor/Supplier	Equipment Type	Telephone Contact
Saturn Grand Prairie, Texas	Shredders	John Crowley (214) 790-7800
Shred Pax Wood Dale, Illinois	Shredders	Jill Myers (708) 595-8780
SSI Wilsonville, Oregon	Shredders	Joyce Beasley (503) 682-3633
Williams St. Louis, Missouri	Shredders	Harold Groves (314) 621-3348

SATURN SHREDDERS

BY MAC

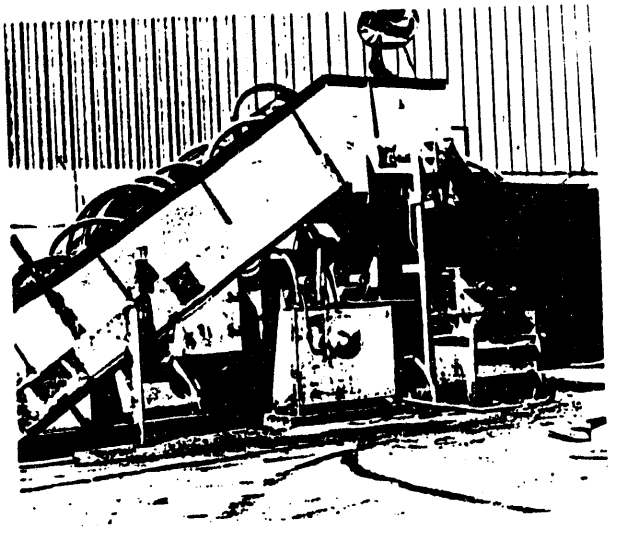




FOR ALL YOUR SHREDDING NEEDS!

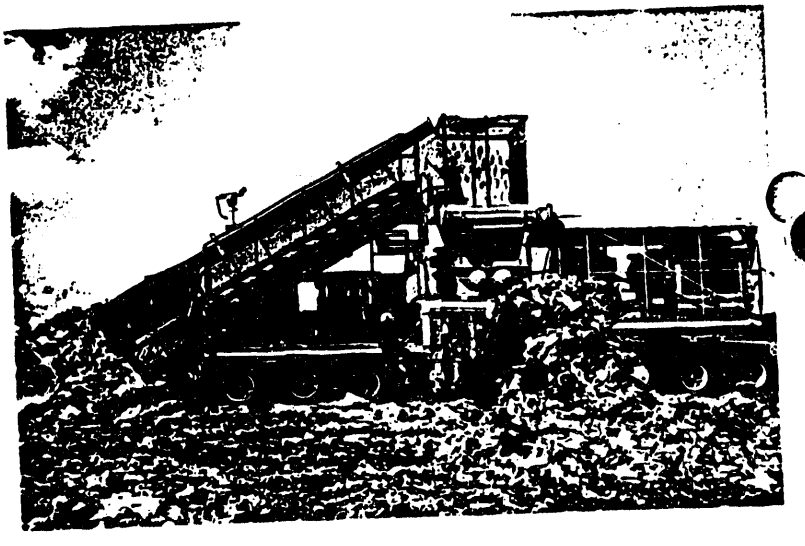
NON FERROUS METALS

Aluminum, magnesium and copper scrap size reduction utilizing a Saturn Model 62-40HT. Higher Torque, larger diameter shafts and wider gears make the new "HT Series" shredders the best choice for reducing cable, wire, tubing, sheet, extrusions, castings, etc. for granulation and/or melting.



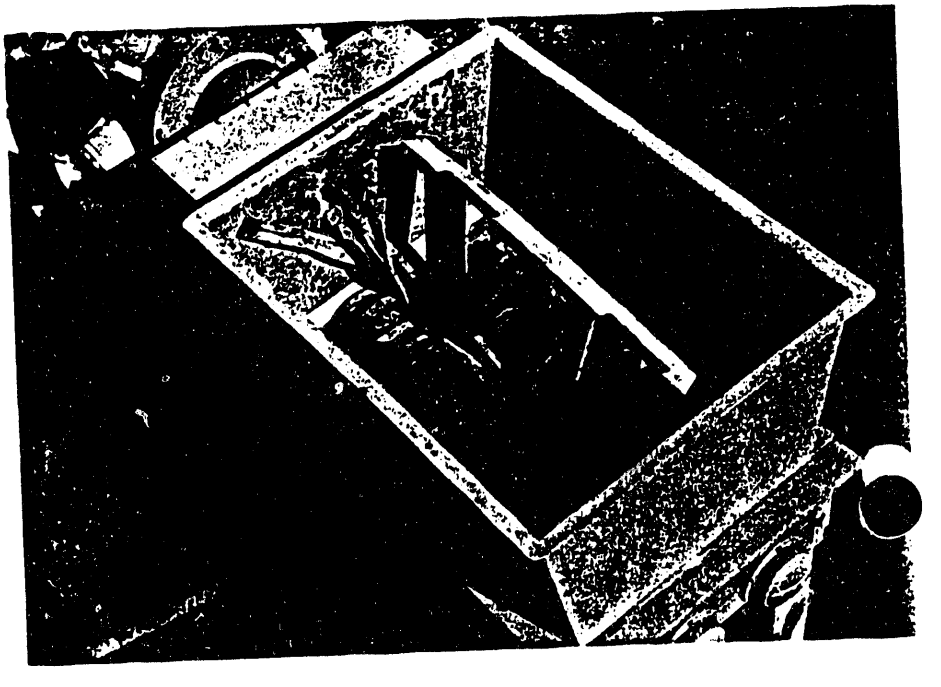
SOLID WASTE (MSW)

Municipal solid waste is processed as received from packer trucks in this Saturn Model 72-50 Mobile Shredder. MSW and bulky household waste are conveyed to the hopper by a metal belt infeed conveyor. The material is then shredded and discharged from an adjustable height conveyor. Saturn provides stationary or mobile systems with single source responsibility.



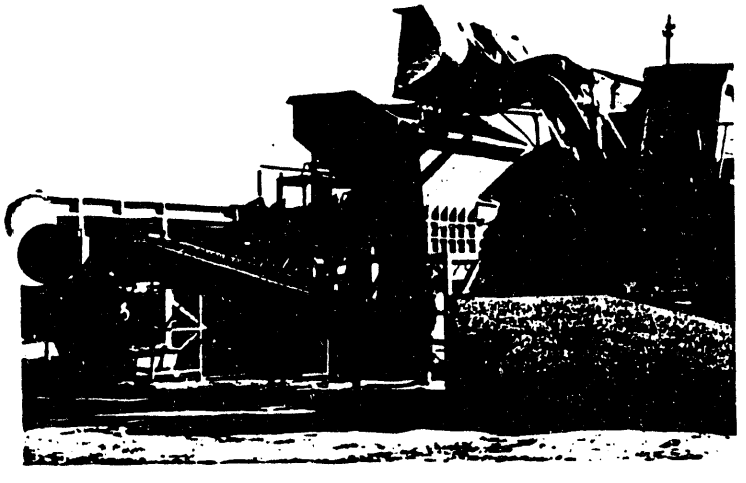
WASTE-TO-ENERGY

Saturn provides complete systems to shred and convert pallets and other in-plant solid wastes into usable boiler or furnace fuel. Through fast, cost efficient size reduction, incineration is improved and storage problems eliminated.



PLASTICS

Drools, flashings, purgings, and chunks of plastic are pre-processed to a uniform size suitable for secondary high speed grinding. Sawing and guillotining are virtually eliminated with Saturn's Rotary Shear Shredders. Other benefits include increased throughput capacity, more efficient downstream operation, and improved metal detection capabilities.



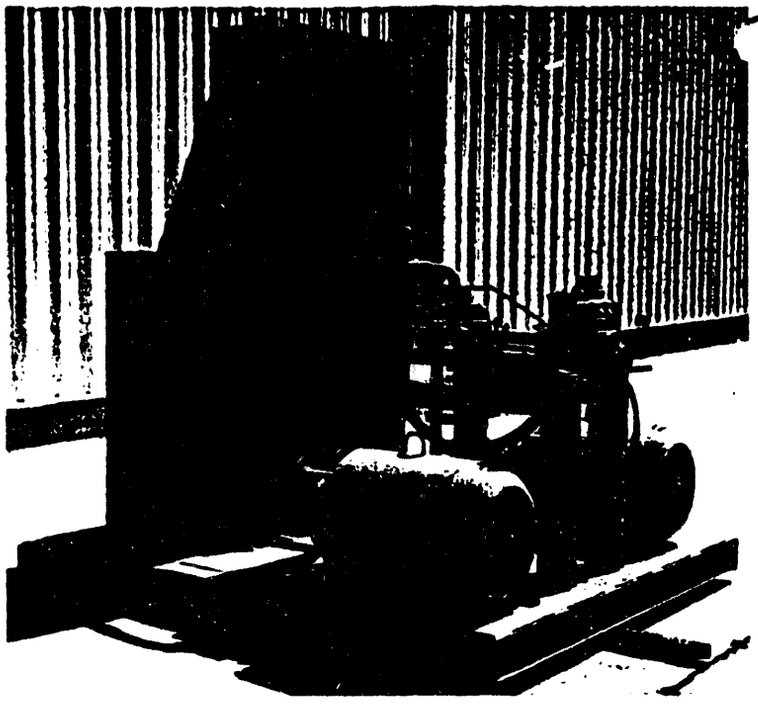
Wood waste is shredded and prepared for boiler fuel supplement. In-plant materials such as pallets, cardboard, crates, plastics, tires, and drums can be reduced for landfill disposal or fuel preparation.

. . . AND MOBILE

Saturn's Mobile Tire Shredder prepares tires for disposal at a major landfill. Saturn Mobile Shredders offer greater versatility along with conveyor in-feed and discharge for greater thru-put and ease of operation. Saturn Shredders are also used to prepare tires for use as a fuel supplement.

HYDRAULIC DRIVE

Saturn's hydraulic drive design, low cutting speed and high shaft torque significantly reduce costly repairs from self destruction damage commonly associated with high speed shredders.



SHREDDER SIZES

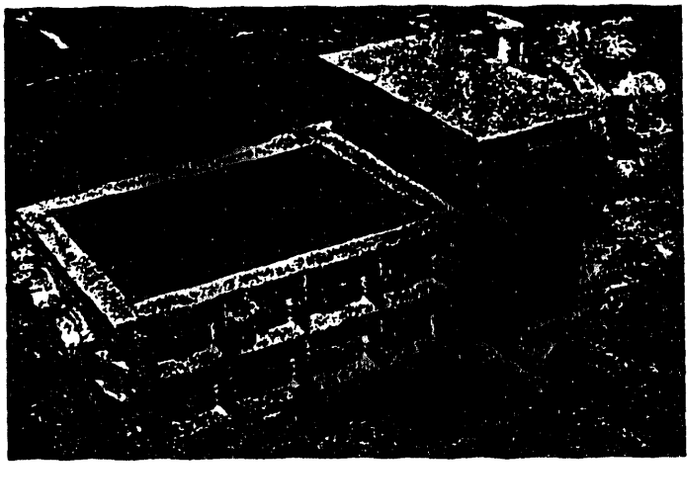
Shredder inlet feed openings are suited to each processing system requirement. Inlet openings range in length up to 96" and up to 50" in width. Shredder size is determined by system design requirements and available space.

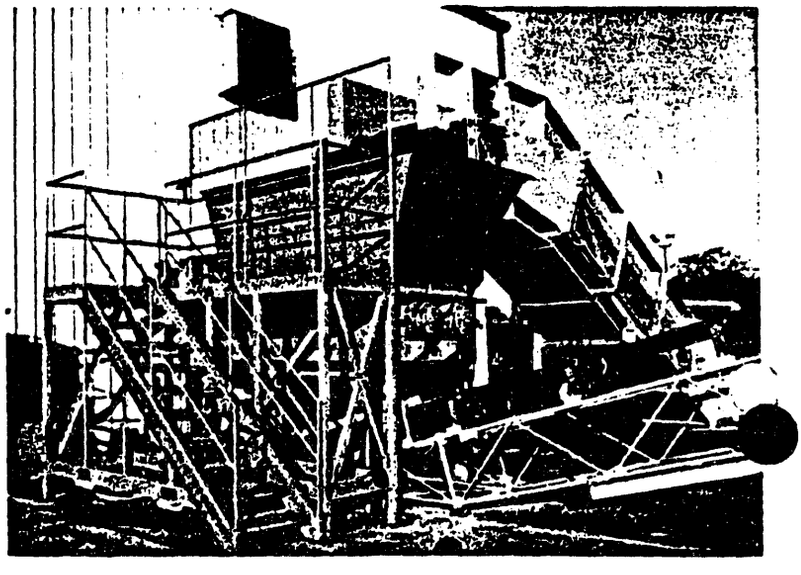
Saturn's patented Hydraulic Power Package is designed to provide the proper drive system to fit any need. Hydraulic Power Packages provide instant automatic reversing for anti-jamming capability. Size and horsepower of hydraulic units range from 50 HP to 600 HP. Chemical duty and explosion proof designs are available.

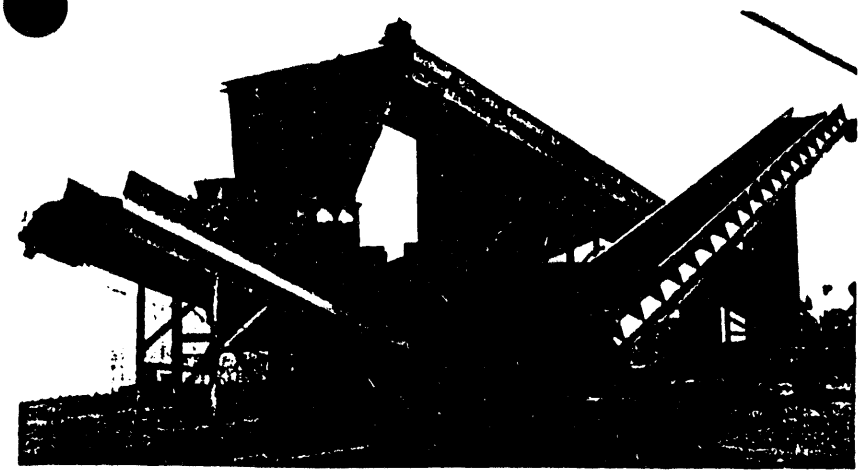
HIGH TORQUE

Saturn's low speed, high torque radial piston hydraulic motors provide the correct torque for optimum shredder performance. Motors vary in size up to a maximum of 19,520 foot-pounds of torque per motor.

Saturn offers conveyors for all types of systems, including a complete line of both steel and rubber belt conveyors. Strength, durability and versatility are all proven assets of the Saturn conveyor line. Saturn's experienced engineers can design and integrate an effective, economical conveyor system for virtually any facility.





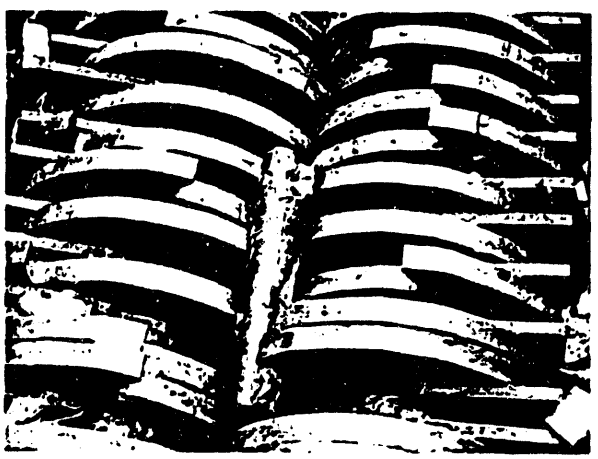


A modern, on-site test facility enables Saturn to evaluate customer requirements prior to the purchase of a Saturn Shredding System. Product samples can be conveyed, shredded and magnetically separated for analysis. If the customer is unable to attend the test in person, a complete test report with photographs or video tape will be provided.

All Saturn Shredders are pre-tested prior to shipment to the customer.

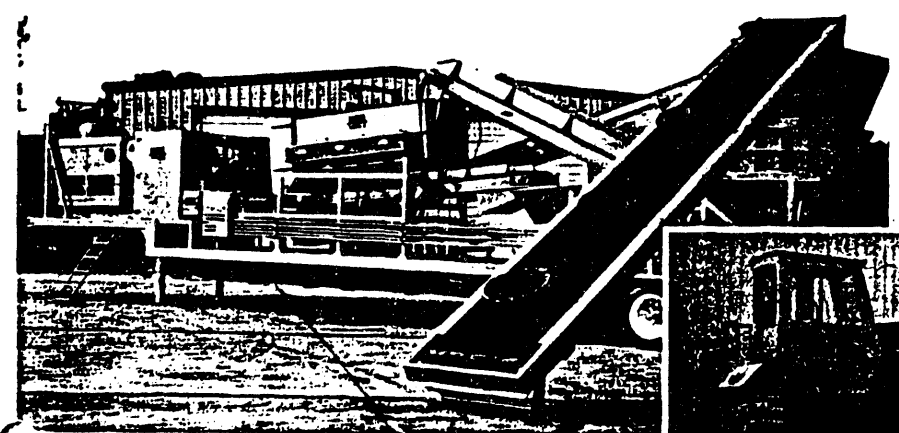
CUTTERS

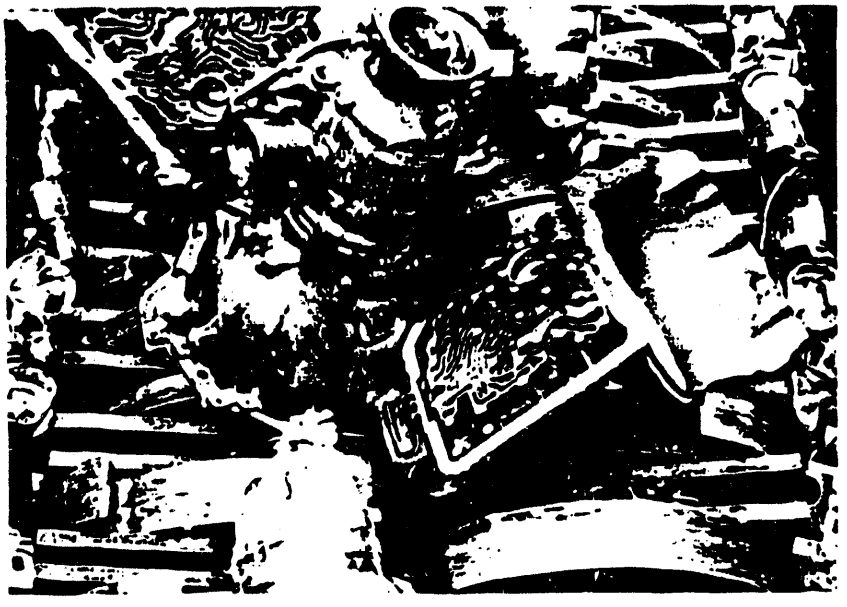
Saturn Shredder cutters can be mounted in various configurations to fit specific needs for end-product sizing and throughput. Note 2" and 4" arrangement shown.



MOBILE OR PORTABLE MODELS

Portable shredders are completely self-contained to service transfer stations, collection sites, remote landfills and multiple plant sites. Saturn's mobile systems reduce most solid wastes including wood, metal, paper, tires, cable, polycarbonates, etc., for recycling, energy generation or disposal. These self-sufficient models feature a diesel-hydraulic powered shredder, optional hydraulic crane with grapple, plus a discharge conveyor with winch for lowering or raising it to the desired angle.





ALUMINUM

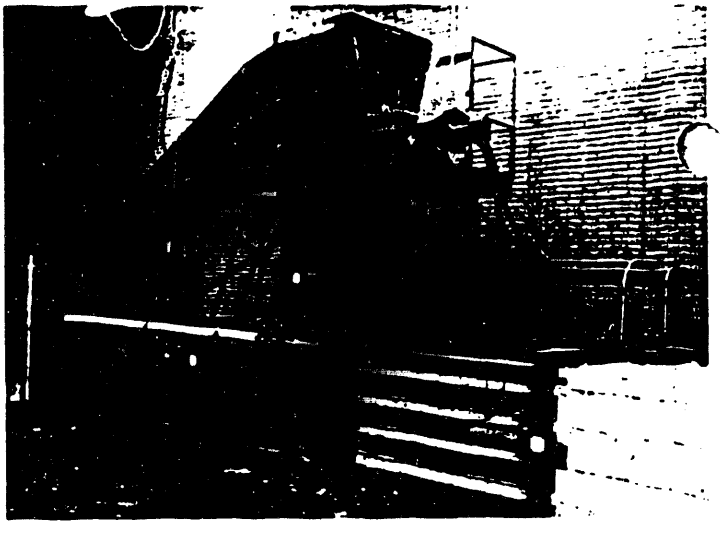
Aluminum transmission cases are shredded in Saturn's Model 72-50, which is designed for heavy industrial and large volume municipal or bulky waste shredding.

- ★ Patented hydraulic drive system
- ★ Rotary shear cutting action
- ★ Low-speed, high-torque shredding
- ★ Non-jamming instantaneous reversal

PAPER

Saturn Model 36-22 used for product security destruction prior to sale of paper bales to pulp mills.

- ★ Minimum noise, dust and energy requirments
- ★ No troublesome materials sorting
- ★ Low initial cost and maintenance
- ★ No expensive mounting foundations



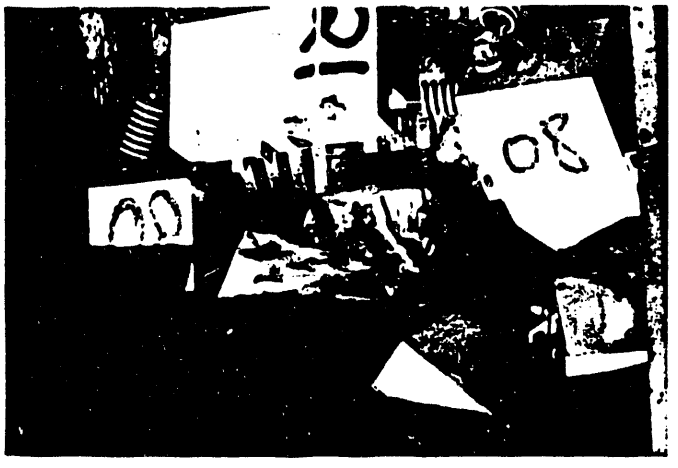
SATURN SHREDDER DATA

MODEL NUMBER	POWER	CUTTER SURFACE AREA	OVERALL (LxWxH)	ESTIMATED★ WEIGHT (POUNDS)
36-22	75 HP	36" x 22"	75" x 30" x 16"	8,000
44-28HT	100 HP	44" x 28"	109" x 36" x 28"	11,600
52-32HT	150 HP	52" x 31"	121" x 40" x 34"	18,000
62-40HT	200 HP	55" x 38"	130" x 48" x 40"	28,000
72-46HT	300 HP	72" x 45"	139" x 55.5" x 46"	38,000
72-50HT	400 HP	72" x 50"	150" x 70" x 49"	46,000
96-50HT	400 HP	96" x 50"	174" x 70" x 49"	52,000
96-50HT	600 HP	96" x 50"	180" x 78" x 48"	56,000

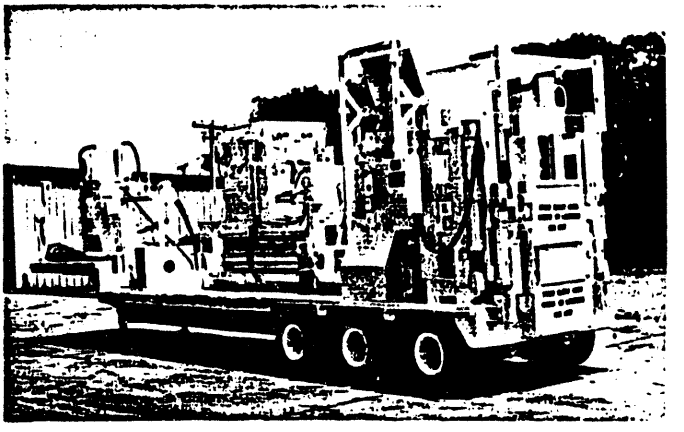
★ Weight without Hopper, Stand or Fluids.

COMPLETE MOBILE SYSTEMS AVAILABLE IN MOST MODELS

HAZARDOUS AND LOW RAD WASTE



PCB capacitors are shredded prior to incineration process.



The Saturn High Density Compaction System allows on-site shredding and compaction of low level activated waste (LLAW) at nuclear power plants.

MAC/Saturn offers a full line of stationary in-plant, or portable equipment for shredding contaminated materials at hazardous waste sites or pre-processing incineration facilities.

Typical applications include:

- ★ DRUMS
- ★ PCB CAPACITORS
- ★ MISC. DEBRIS AT HAZARDOUS WASTE CLEAN-UP SITES:
  Wood, Plastic, Metal, Concrete, Dirt, etc.

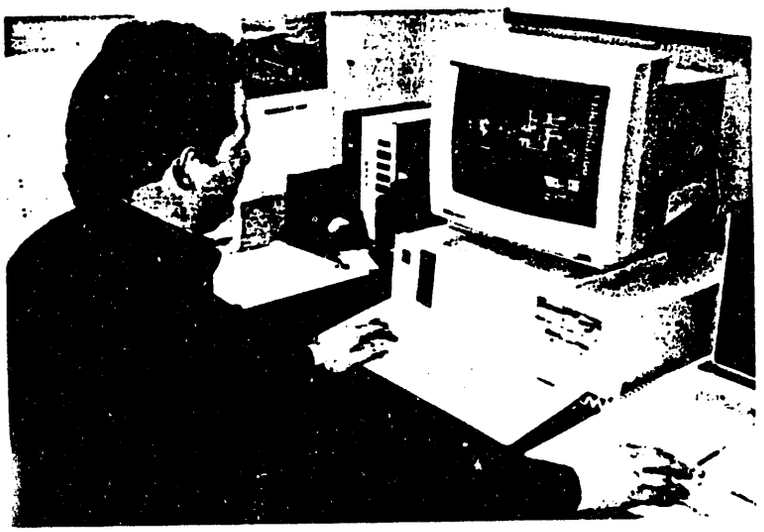
LOW LEVEL ACTIVATED WASTE

- ★ HEPA FILTERS
- ★ CONSTRUCTION/DEMOLITION DEBRIS
- ★ CLOTH (CANVAS, RAGS, CLOTHING)
- ★ PLASTIC SHEETING, BUCKETS
- ★ PALLETS
- ★ PVC PIPES & TUBES
- ★ METAL (DRUMS, WIRING, ETC.)
- ★ WOOD
- ★ CONCRETE

BULKY WASTE

Tree waste, industrial waste, furniture, mattresses, construction and demolition debris are all processed in Saturn's larger 300HP and 400 HP machines. Volume reduction of up to 6:1 is typical in these applications. Shredders can be fed by crane/grapple, front end loader or infeed conveyor. Saturn can also provide high speed grinders if additional size reductions is required for composting.

TOTAL SYSTEM DESIGN AND SERVICE



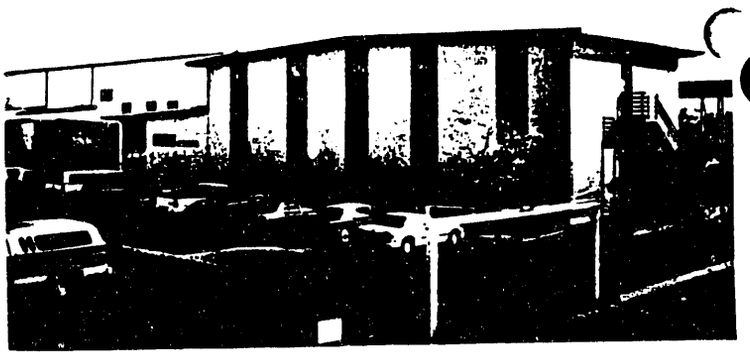
Saturn offers a complete line of shredding equipment to handle virtually any waste reduction requirement. Based on test runs in our on-site test facilities, our engineers will design a system specifically for your material. With Saturn's patented hydraulic drive and automatic anti-jamming capabilities, troublesome materials are readily reduced without stress on shredder or shredder drive system.

Our service department offers trained technicians available on 24 hour notice. Most replacement parts are available for immediate delivery. Saturn shredders are available in many sizes, in mobile or stationary designs, and with either electric-hydraulic, or diesel-hydraulic power.

SATURN SHREDDERS

For All Your Waste Reduction Needs!

- ★ IN-PLANT WASTE AND ENERGY RECOVERY
- ★ HAZARDOUS AND NUCLEAR LOW RAD
- ★ SOLID WASTE (MSW)
- ★ PALLETS AND WOOD PRODUCTS
- ★ TIRES AND RUBBER PROCESSING
- ★ FERROUS AND NON FERROUS MATERIALS INCLUDING DRUMS, WIRE CABLE, ETC.
- ★ BATTERY PROCESSING
- ★ PRODUCT DESTRUCTION
- ★ PLASTIC PRODUCTS AND SCRAP



CENTRAL LOCATION

Saturn's facilities, located seven (7) miles from the Dallas/Ft. Worth Airport, are easily accessible from any part of the country. Parts and service can be at your location in a minimal amount of time.

—Sales and Service—

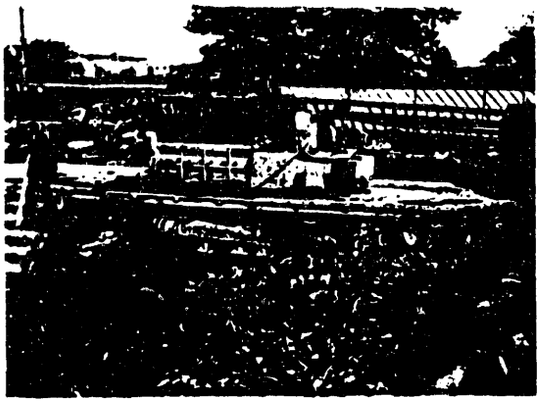
MAC Corporation / Saturn Shredders

(214) 790-7800 TELEFAX (214) 790-8733
201 East Shady Grove Road
Grand Prairie, Texas 75050

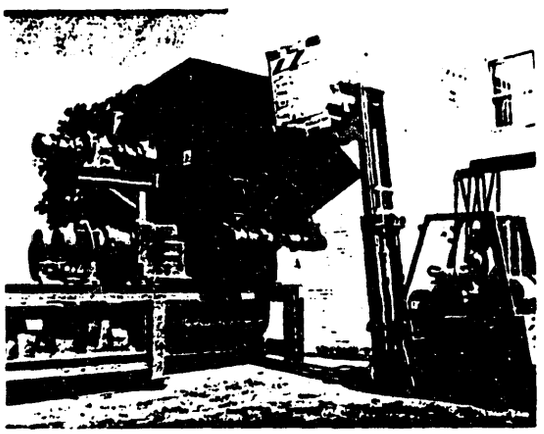
Services on Site 48 hrs (214) 790-7800

SHRED PAX

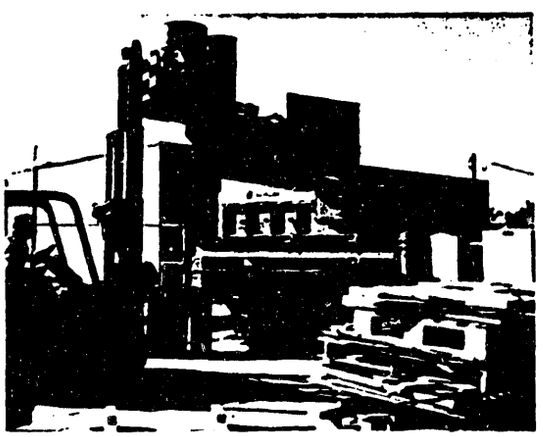
CORPORATION



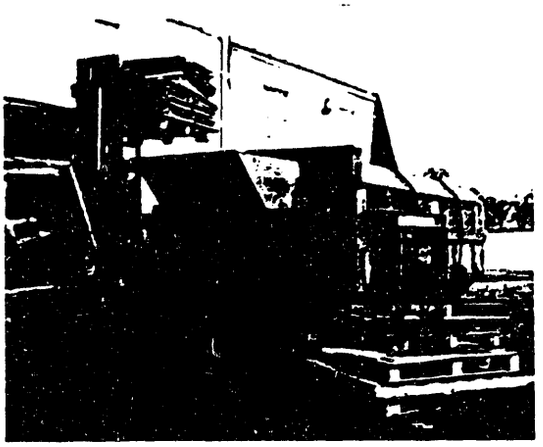
t drive transfers 100% of the available horse-
r to the cutting chamber.



y pre-processor directs and feeds material into
hredding chamber for increased through-put.



ted axial play feature allows shafts to flex and
virtually eliminating shaft fatigue and failure.



Z Pax easily shreds pallets and general waste,
compacts the shredded material into waiting

High Torque – High Production

Shred Pax's patented slow speed, high torque jam-resistant, design, insures efficient processing of a full range of materials.

Typical Shredding Applications Include:

- Circuit Boards
- Pallets
- Metal Castings
- 55 Gallon Drums
- Hospital Waste
- Asbestos
- Municipal Solid Waste
- Steel Turnings
- CPO
- Hazardous Waste
- White Goods
- Glass Products
- Steel Cans
- Construction Debris
- Metal Stampings
- Waste to Energy
- Plastic Products
- Auto and Truck Tires
- Corrugated Steel
- Aluminum Cans
- Pharmaceutical Products

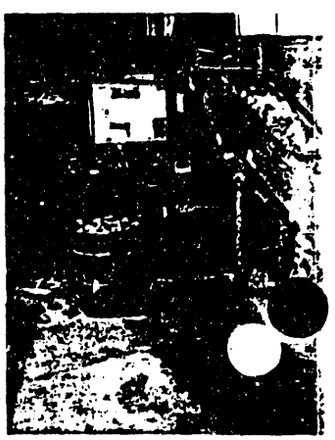
Shred Pax Meets the Challenge

In a comprehensive report commissioned by the U.S. Department of Energy, the Shred Pax shredder was compared in performance and design to other industrial slow speed, high torque shredding equipment. The results were dramatic. The patented Shred Pax "electro-mechanical, direct drive was shown to require less horsepower while producing maximum torque and through-put capacities" – even when compared to hydraulic units with over seven times the horsepower. Over-all the Shred Pax shredder was determined to be "the least expensive, most energy efficient; with the lowest anticipated maintenance cost."

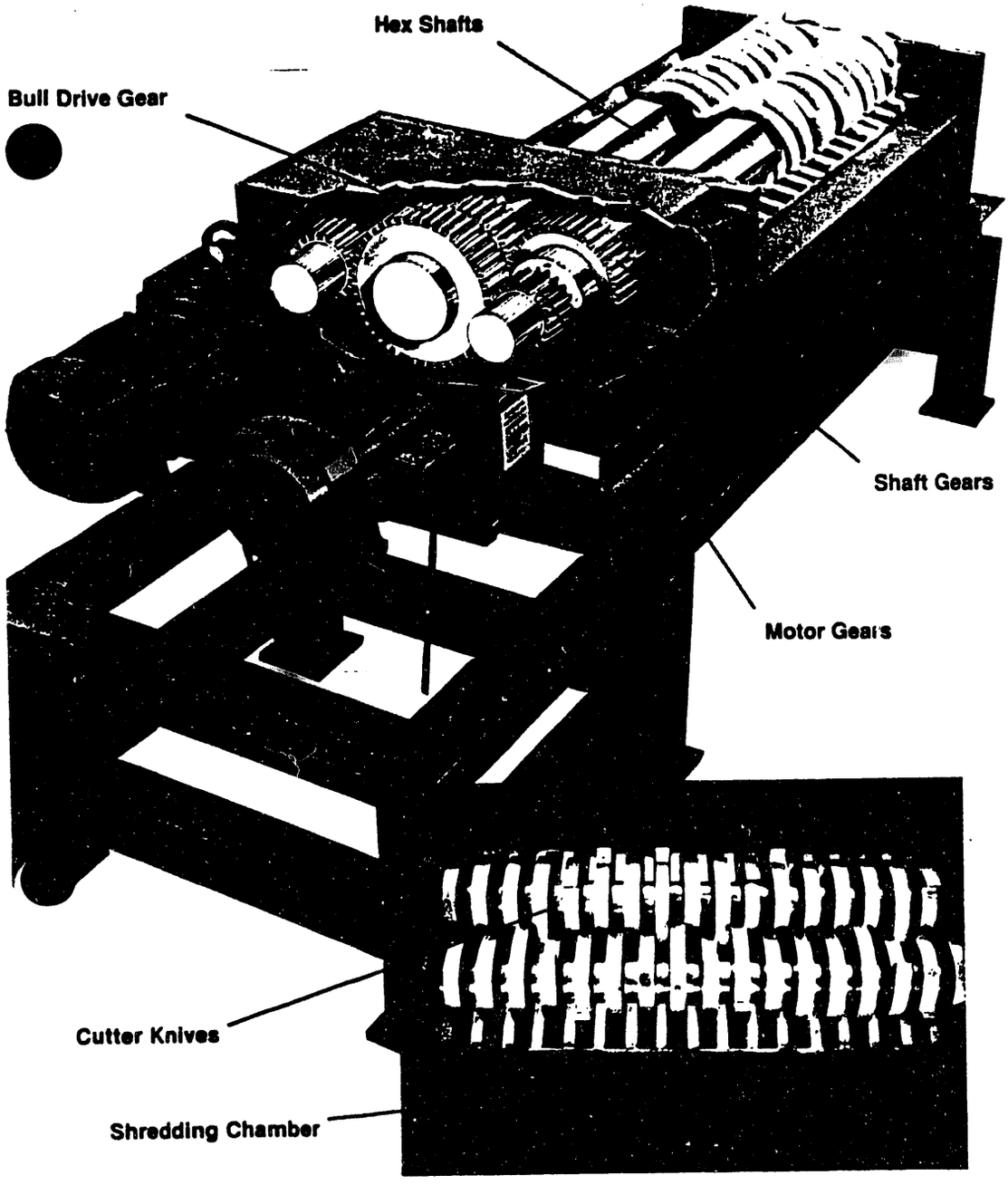
Free Testing

To meet your challenge. Put Shred Pax to the test – your representative will gladly arrange for a shredding test on any materials you provide. Your samples will be returned with a complete test report and video tape.

- Automatic in-line electrical overload sensors, instantly stop and reverse cutter direction, prevent-



- Product specification or gra
met by the knife spacing ar



- Single bull drive gear applies full power to both shafts for maximum torque.
- Heavy duty, hex shaped shafts easily withstand severe shock loads minimizing stress.
- Patented knife design.
- Variable cutter configuration for optimizing sizing and through-put.
- Low noise and dust.
- Models from 7-1/2 hp to 300hp to meet your requirements.
- Compact, modular design for ease of installation.
- Mobile or stationary installation.
- Performance engineered for long life and low maintenance.
- 2 year drive train warranty.
- Full parts and customer service support.
- Shred Pax low speed, high-torque shredders and accessories are manufactured under U.S. Patent Numbers 3845907, 3880361, 3981455, 4247056 and others pending.

requirements are

- Heavy duty knives provide years of service without

- Small diameter cutting knives provide maximum

SHRED PAX™...

We Cut Your Problems Down to Size

Acknowledged Leader.

In 1971, Shred Pax, the originator of slow speed, high torque shredder technology, introduced its first model, the AZ-7. Since then, Shred Pax has designed and built thousands of highly efficient, reliable shredders and shredder systems to meet and solve our customers needs.

Complete System Design.

Today, Shred Pax offers a complete line of shredding and auxiliary equipment capable of handling the most demanding requirements. Wherever there's a need for volume reduction and processing of waste for disposal, recycling or security, there's a Shred Pax shredder sized to meet that need.

Precision Engineered.

Shred Pax products are precision engineered, incorporating exclusive and patented design features which translate into superior shredder performance. Shred Pax shredders are built solid, under stringent quality control procedures, for years of satisfactory operation and low maintenance.

Customer Support.

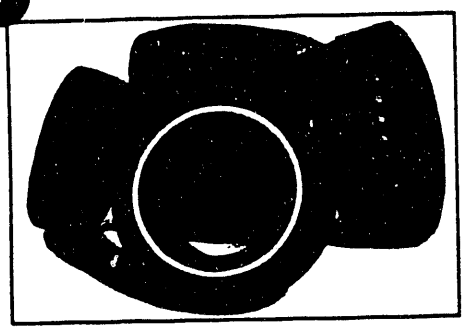
A factory directed parts and service department provides the back-up support you require. With a complete inventory of critical items in stock, customers can rely on rapid parts access and minimum processing interruption. Shred Pax shredders are economical to own and operate, offering outstanding investment payback ratios.

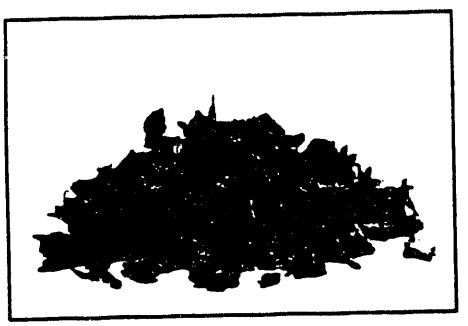
Let Shred Pax Go to Work for You

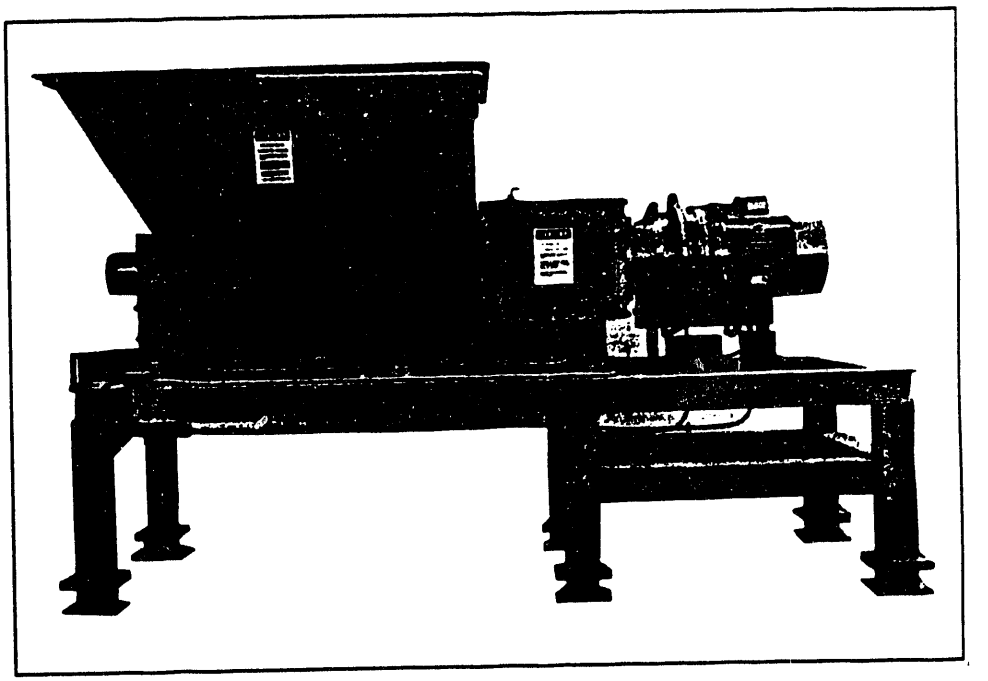
SHRED PAX CORPORATION
136 West Commercial Ave.
Wood Dale, IL 60191-1304
Phone: (708) 595-8780
Fax: (708) 595-9187

SHRED PAX

MODEL AZ-80







FEATURES & BENEFITS

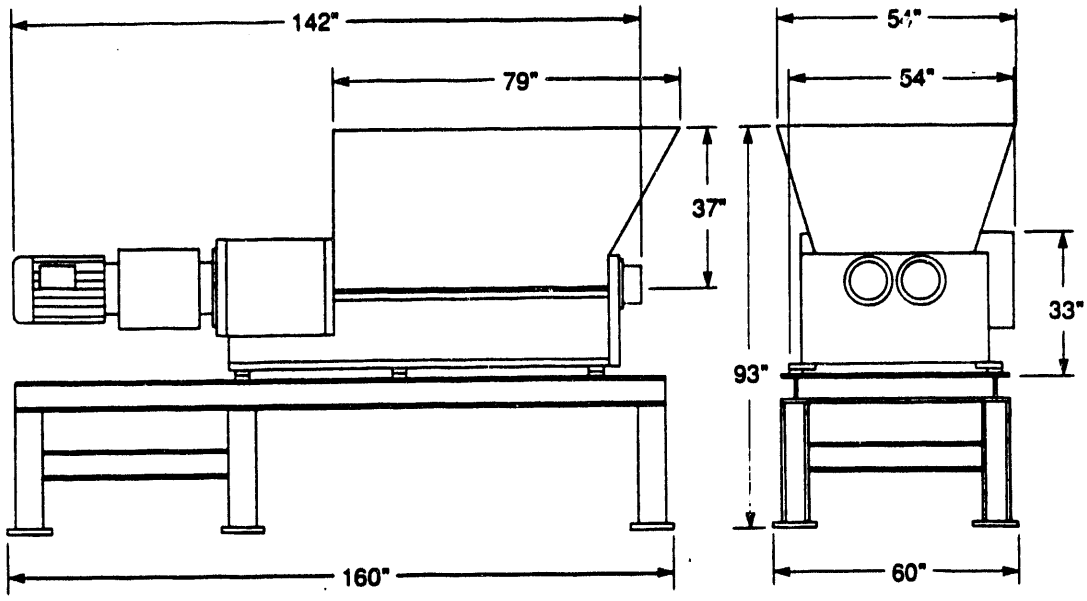
- ***Direct Drive Operation***
  100% power applied to cutters/no conversion loss.
- ***Patented Cutter Knife Design***
  Wear resistant for long service life.
- ***Spring Steel Hex Shaft Design: Patented Axial Play Control***
  Permits shaft Flex/Power distributed over entire shaft perimeter.
- ***Power Distributes To Either Shaft***
  Provides deliberate, consistent shredding action for all types of material.
- ***Exclusive Anti-Shock Gear Reducers***
  500% shock-load absorption: conservative service factor of two.
- ***Electro-Magnetic In Line Overload Sensors***
  Automatic reversing action during overload condition.
- ***Maximum Torque, Minimum Horsepower***
  Reduces material volume 50% to 80%.
- ***Electro-Mechanical Operation***
  Economical to use: Low energy consumption. Low operating costs.
- ***Slow Speed Operation***
  Quiet, minimum dust generation.
- ***Heavy Duty Construction***
  Requires no special foundation/low installation cost.
- ***Compact Modular Design***
  Minimum space requirements - mobile or stationary installation.
- ***Finest Quality Components; Precision Manufactured***
  Reliable performance, ease of maintenance and long life.
- ***In House Engineering and Design***
  Systems to meet all types of applications, gradation and thru-put requirements.
- ***2 Year Drive Train Warranty***
  Full parts and customer service support.

APPLICATIONS

Automobile Tires | Metal and Plastic Drums | Pallets | Construction Debris | Furniture Products | Purgings, Metal, Plastic | Truck Tires | White Goods | Aluminum, Steel Cans | Computer Hardware | Hazardous Waste | Corrugated Metal | Municipal Solid Waste | Rubber Products | Batteries | Electronic Products | General Plant Waste | Fiberglass | Heavy Gauge Metal Products | Corrugated Skid Boxes | Metal Castings | General Waste

SPECIFICATIONS

AZ-80



MODEL	AZ 80
H. P.	(2) 40
Motor(s)...3 PH.	TEFC
Voltage	460
Hertz	60
Approx. Wt.	18,000 lbs.

CUTTING CHAMBER	AZ 80
Width (inside)	32 in.
Length (inside)	62 in.
# of knives	32
*Std. Knife Thickness	47 mm (1 7/8")
Knife Arrangement	As Desired

****Stand and hopper dimensions** can be altered to fit customer specifications. Hopper dimensions will vary with application.

****Dimensions** (Machine Only): Dimensions shown are nominal and subject to change. If dimensions and/or specifications are critical, please consult the factory.

OPTIONS & ACCESSORIES

- Rotary Preprocessor
- Matched Pax Pump
- Automatic "Kick-Out" Doors
- Automatic Controls
- Mobile Installation
- Variable Knife Thicknesses
- Custom Designed Hoppers
- Pneumatic Feeders
- Electric Eye Sensor
- Infeed and Discharge Conveyors

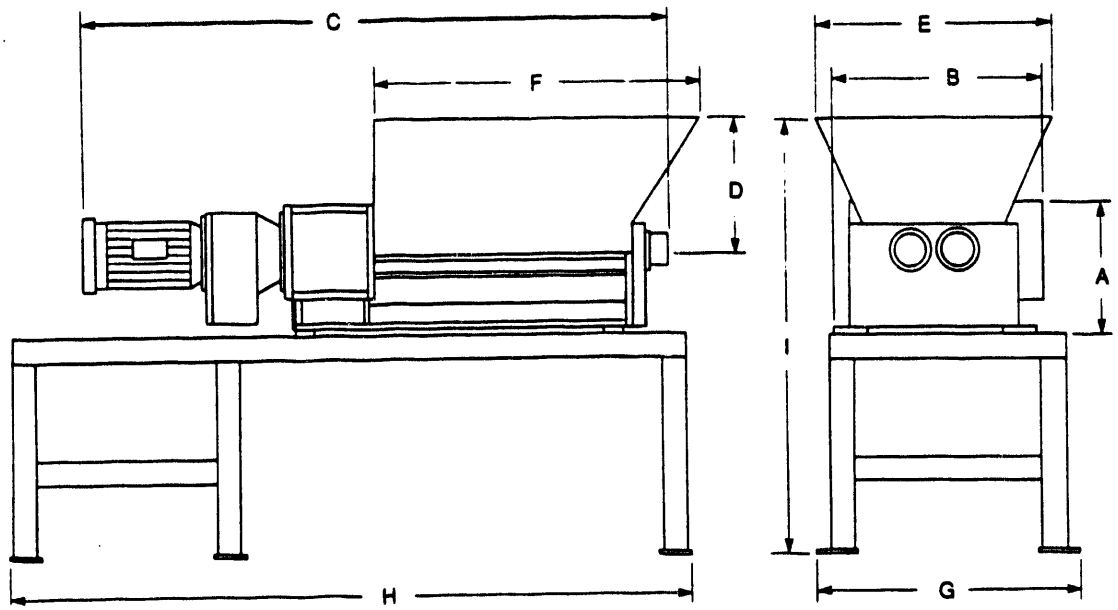
Shred Pax low-speed, high-torque shredders and accessories are manufactured under U.S. Patent Numbers 3845907, 3880361, 3981455, 4247056 and others pending.

SHRED PAX
136 West Commercial Ave.
Wood Dale, IL 60191-1304
Phone I (708) 595-8780
FAX I (708) 595-9187

Printed on Recycled Paper.

SPECIFICATIONS

AZ-45 / AZ 45P



MODEL	AZ 45	AZ 45P
H. P.	(2) 20	(2) 20
Motor(s)...3 PH.	TEFC	TEFC
Voltage	230/460	230/460
Hertz	60	60
CUTTING CHAMBER		
Width (inside)	20 in.	20 in.
Length (inside)	43 in.	53 in.
# of knives	34	42
*Std. Knife Thickness	31 mm (1 1/4")	31 mm (1 1/4")
Knife Arrangement	As Desired	As Desired
DIMENSIONS (Machine Only)		
Height A	22 in.	22 in.
Width B	39 in.	39 in.
Length C	99 in.	109 in.

MODEL	AZ 45	AZ 45P
****STANDARD HOPPER DIMENSIONS**		
Height D	28 in.	28 in.
Width E	40 in.	40 in.
Length F	56 in.	66 in.
FLOOR SPACE REQUIRED		
Width G	46 in.	46 in.
Length H	110 in.	120 in.
***Overall Ht. I	77 in.	77 in.
Approx. Wt.	5,800 lbs.	6,200 lbs.

****Stand and hopper dimensions** can be altered to fit customer specifications. Hopper dimensions will vary with application.
****Dimensions** (Machine Only): Dimensions shown are nominal and subject to change. If dimensions and/or specifications are critical, please consult the factory.

OPTIONS & ACCESSORIES

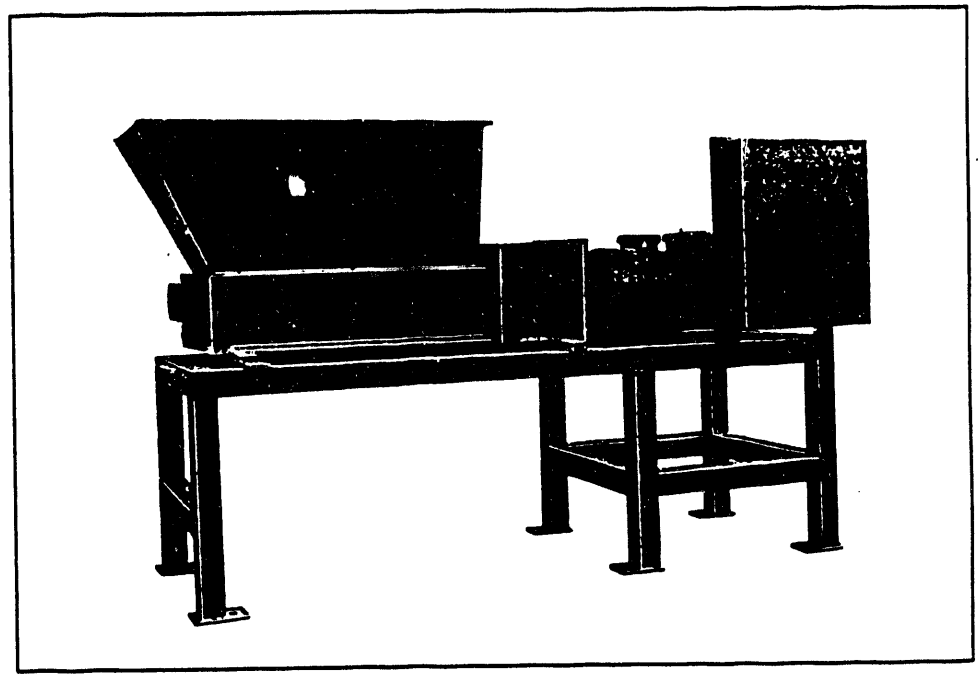
- Rotary Preprocessor
- Matched, Pax Pump
- Automatic "Kick-Out" Doors
- Automatic Controls
- Explosion Proof Motors and Electrical Panel
- Mobile Installation
- Variable Knife Thicknesses
- Special Application Knives
- Custom Designed Hoppers
- Pneumatic Feeders
- Electric Eye Sensor
- Infeed and Discharge Conveyors

Shred Pax low-speed, high-torque shredders and accessories are manufactured under U.S. Patent Numbers 3845907, 3880361, 3981455, 4247056 and others pending.

SHRED PAX
136 West Commercial Ave.
Wood Dale, IL 60191-1304
Phone I (708) 595-8780
FAX I (708) 595-9187

SHRED PAX

MODEL AZ-45/45P

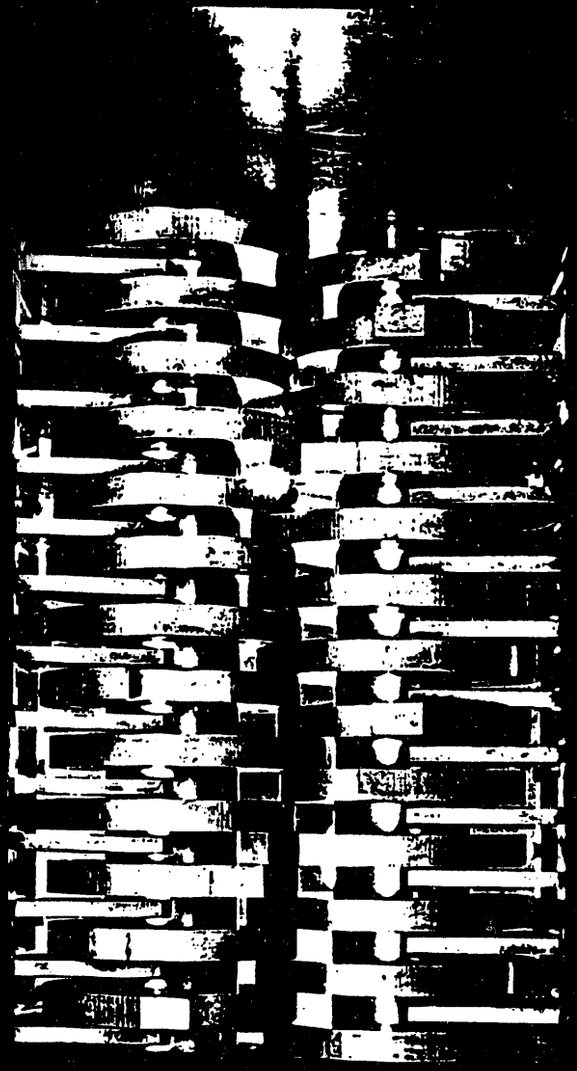


FEATURES & BENEFITS

- ***Direct Drive Operation***
  100% power applied to cutters/no conversion loss.
- ***Patented Cutter Knife Design***
  Wear resistant for long service life.
- ***Spring Steel Hex Shaft Design: Patented Axial Play Control***
  Permits shaft Flex/Power distributed over entire shaft perimeter.
- ***Power Distributes To Either Shaft***
  Provides deliberate, consistent shredding action for all types of material.
- ***Exclusive Anti-Shock Gear Reducers***
  500% shock loader absorbtion: conservative service factor of two.
- ***Electro-Magnetic In Line Overload Sensors***
  Automatic reversing action during overload condition.
- ***Maximum Torque, Minimum Horsepower***
  Reduces material volume 50% to 80%.
- ***Electro-Mechanical Operation***
  Economical to use: Low energy consumption. Low operating costs.
- ***Slow Speed Operation***
  Quiet, minimum dust generation.
- ***Heavy Duty Construction***
  Requires no special foundation/low installation cost.
- ***Compact Modular Design***
  Minimum space requirements - mobile or stationary installation.
- ***Finest Quality Components; Precision Manufactured***
  Reliable performance, ease of maintenance and long life.
- ***In House Engineering and Design***
  Systems to meet all types of applications, gradation and thru-put requirements.
- ***2 Year Drive Train Warranty***
  Full parts and customer service support.

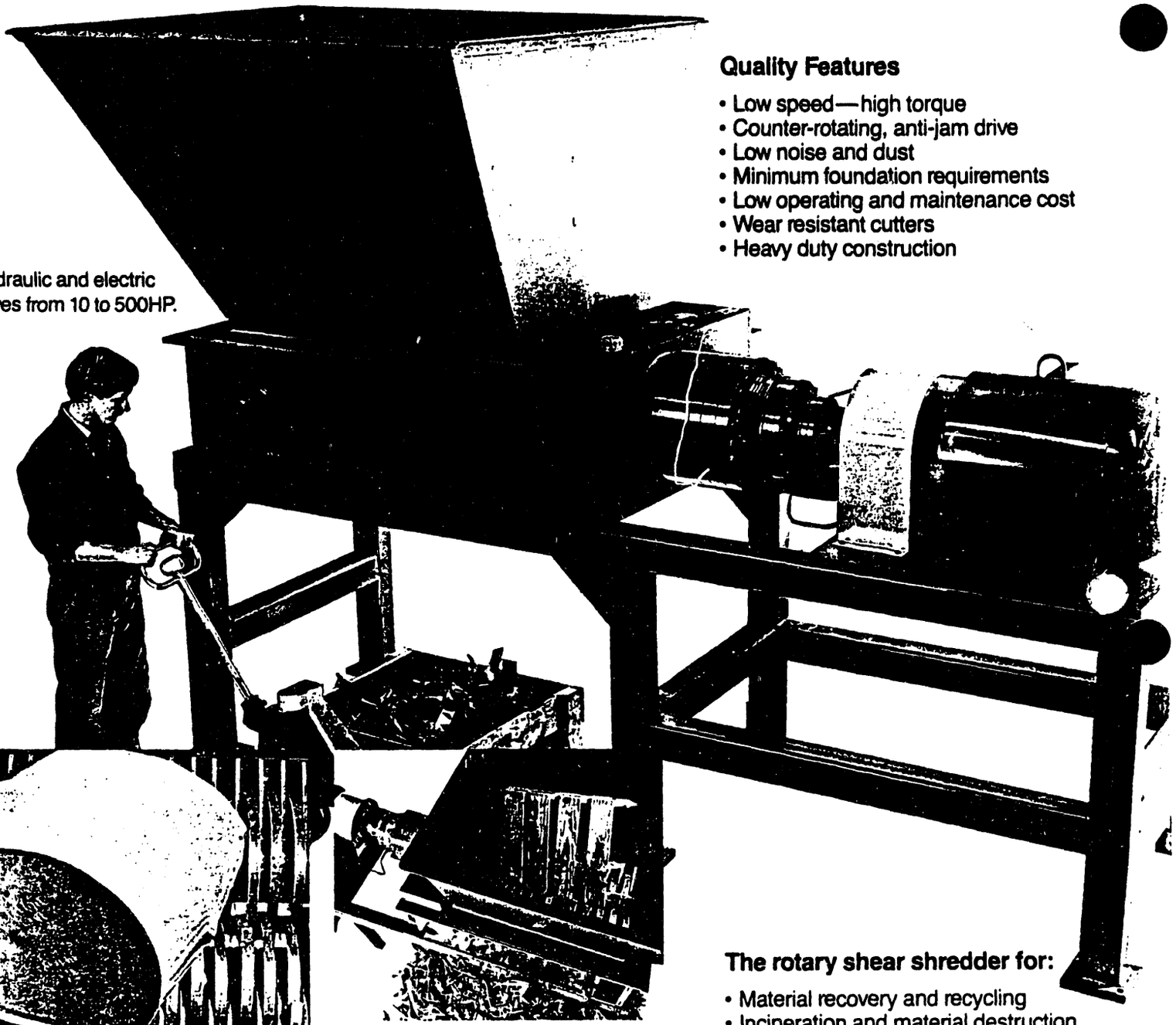
APPLICATIONS

Pallets I Aluminum, Steel Turnings I Aluminum, Steel Cans I Plastic Products I Light Gage Metals I Wood Scrap I Laminates I Corrugated I Drums I Glass I Hospital Waste I Defective Product I Automobile Tires I Office, Apartment Waste I Pharmaceutical Waste I Books, Newspaper, CPO's I Circuit Boards I Rubber Products I Product, Document Destruction I Fiberglass I Batteries I General Waste



SSI SHREDDING SYSTEMS

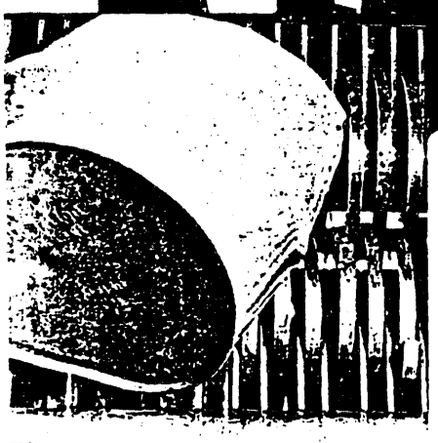
Shredding Systems, Inc., offers you electric or hydraulic shredders for rotary shear power.



Hydraulic and electric drives from 10 to 500HP.

Quality Features

- Low speed—high torque
- Counter-rotating, anti-jam drive
- Low noise and dust
- Minimum foundation requirements
- Low operating and maintenance cost
- Wear resistant cutters
- Heavy duty construction



Pallets

Drums

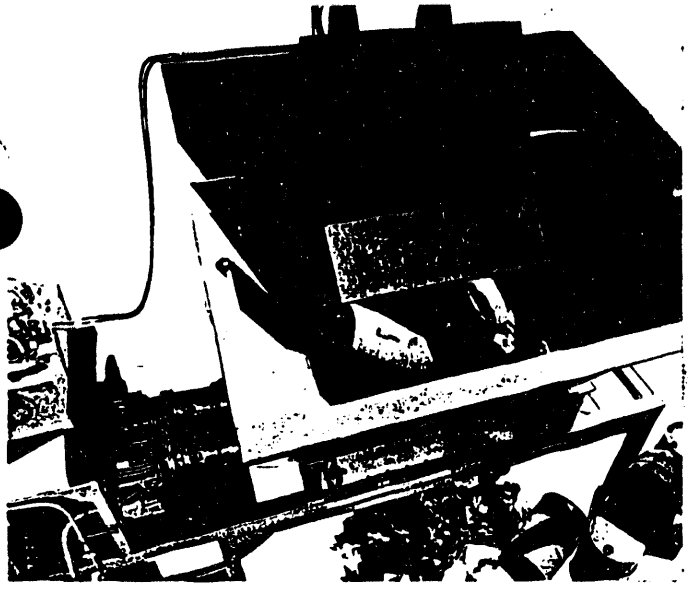
Tires

The rotary shear shredder for:

- Material recovery and recycling
- Incineration and material destruction
- Compaction and volume reduction

Types of material processed

- In-plant industrial waste
- Hazardous/nuclear waste
- Drums
- Hospital/pharmaceutical
- Pallets
- Paper/corregated
- Tires/rubber products
- Plastics/toys
- Municipal waste



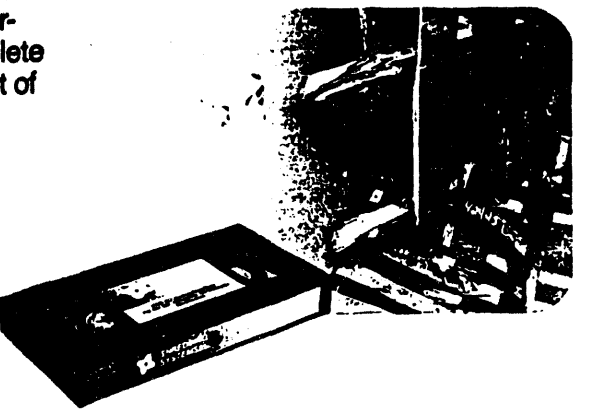
Shredder with optional ram assist

Models available with infeed openings from 20" x 15" to 100" x 52" to meet your processing requirements.

MODELS	DRIVE SYSTEM	MOTOR SIZES
Electric	Single Direct/In-Line	10-100HP
	Dual Direct/In-Line	60-300HP
Hydraulic	Single/Direct Couple	25-250HP
	Dual/Direct Couple	300-500HP
CUSTOM SIZING PER APPLICATION		

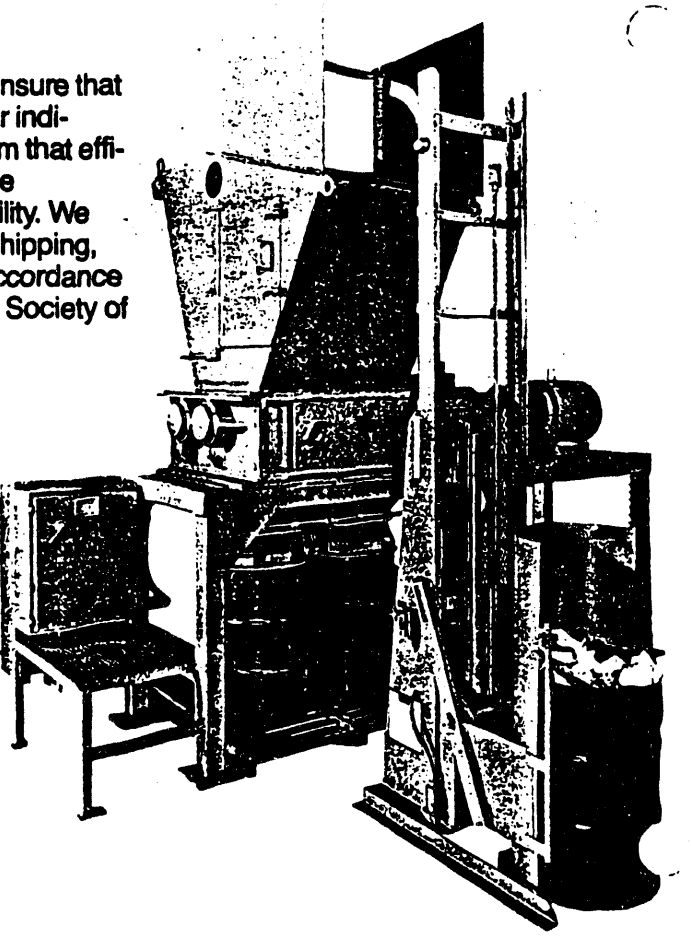
Material testing

Shredding Systems, Inc., performs a complete shredding test of any material your company provides. You are invited to witness the entire testing process. We provide you with a sample of the shredded material and a video tape of the test, accompanied by a complete test analysis. This test information enables us to determine the correct system for your shredding needs.



Complete system design and engineering support

Our staff of experienced engineers ensure that our technology is best applied to your individual needs. We will design a system that efficiently meets your requirements while maximizing on-line production reliability. We carefully test our equipment before shipping, maintaining strict quality control in accordance to the specifications of the American Society of Mechanical Engineers (ASME).



Custom designed systems

Shredding Systems, Inc., stands behind the quality and performance of every shredder we manufacture with responsive, reliable customer service. We are proud of the training, dedication and teamwork of our staff. Our satisfied customers are the true measure of our success and have established us as a leader in the industry.

Shredding Systems, Inc., offers complete system development, manufacturing, service and parts.

What makes Shredding Systems, Inc., a leader in the industry?

- Application expertise
- Engineering excellence
- Custom system design
- In-house manufacturing
- On-line system reliability
- On-going technical support
- Extensive parts inventory
- Nationwide 24 hour service

Customer satisfaction

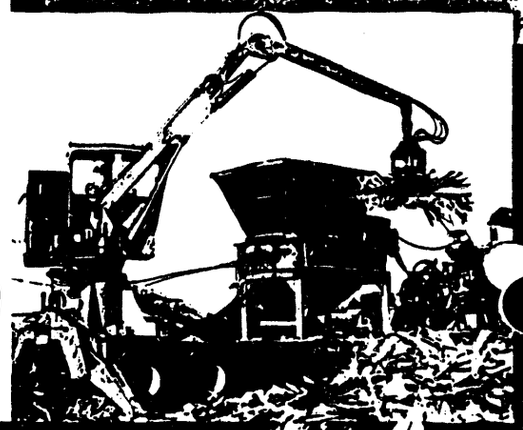
We strive to maintain the highest system performance, quality engineering, and support services to ensure complete customer satisfaction.

Systems development, engineering, manufacturing, service and parts.

Our engineering department can custom design an industrial shredder to fit most all applications. Shredding Systems' high quality is backed by a full service maintenance and repair staff equipped with a full line of precision parts.

Precision and quality

Portable shredding service



Spare parts inventory

Experienced staff

Journeyman machinists

Service and manufacturing

SSI SHREDDING SYSTEMS

Nationwide Sales and Service

9760 S.W. Freeman Drive
Wilsonville, Oregon 97070-9286

Phone: (503) 682-3633 FAX: (503) 682-1704

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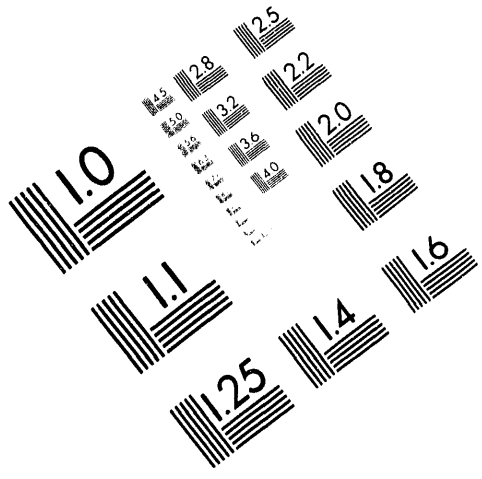
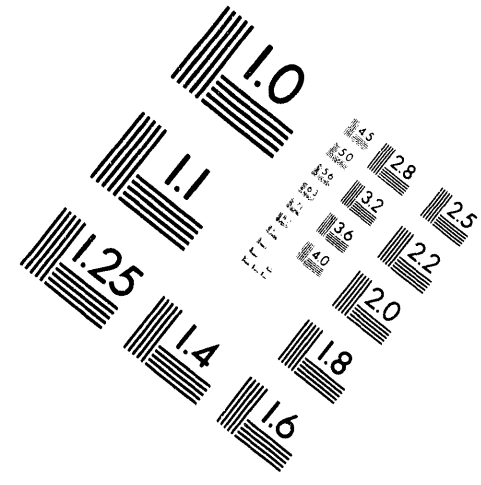
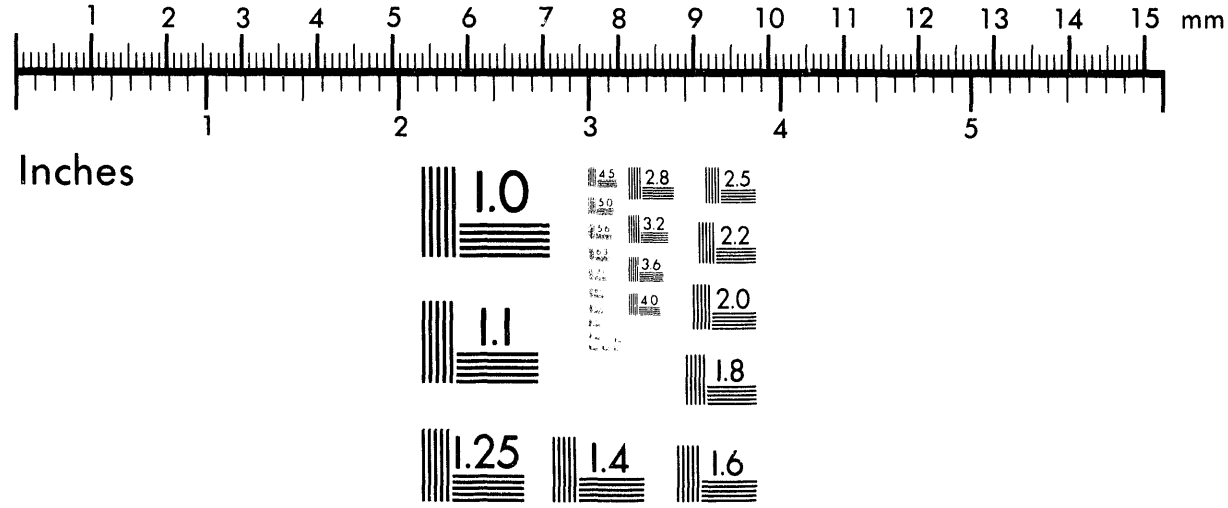
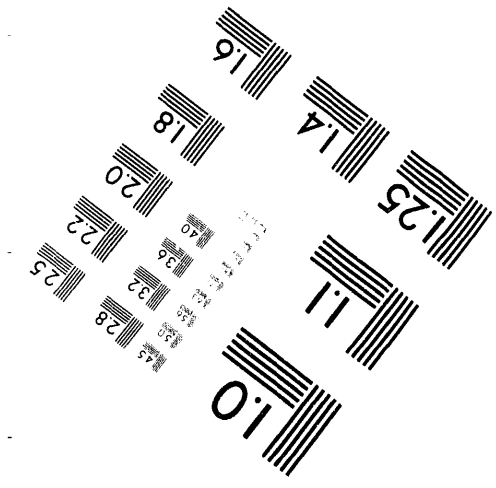


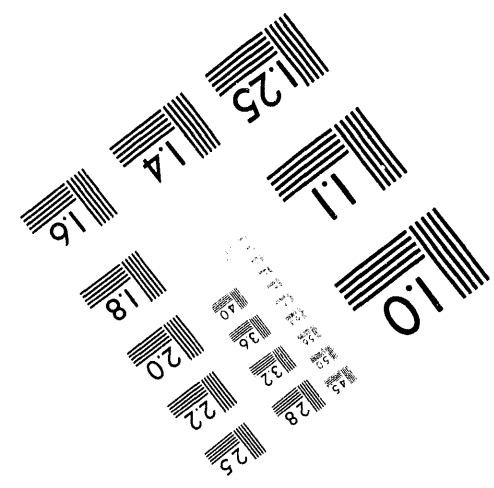
Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202



Centimeter







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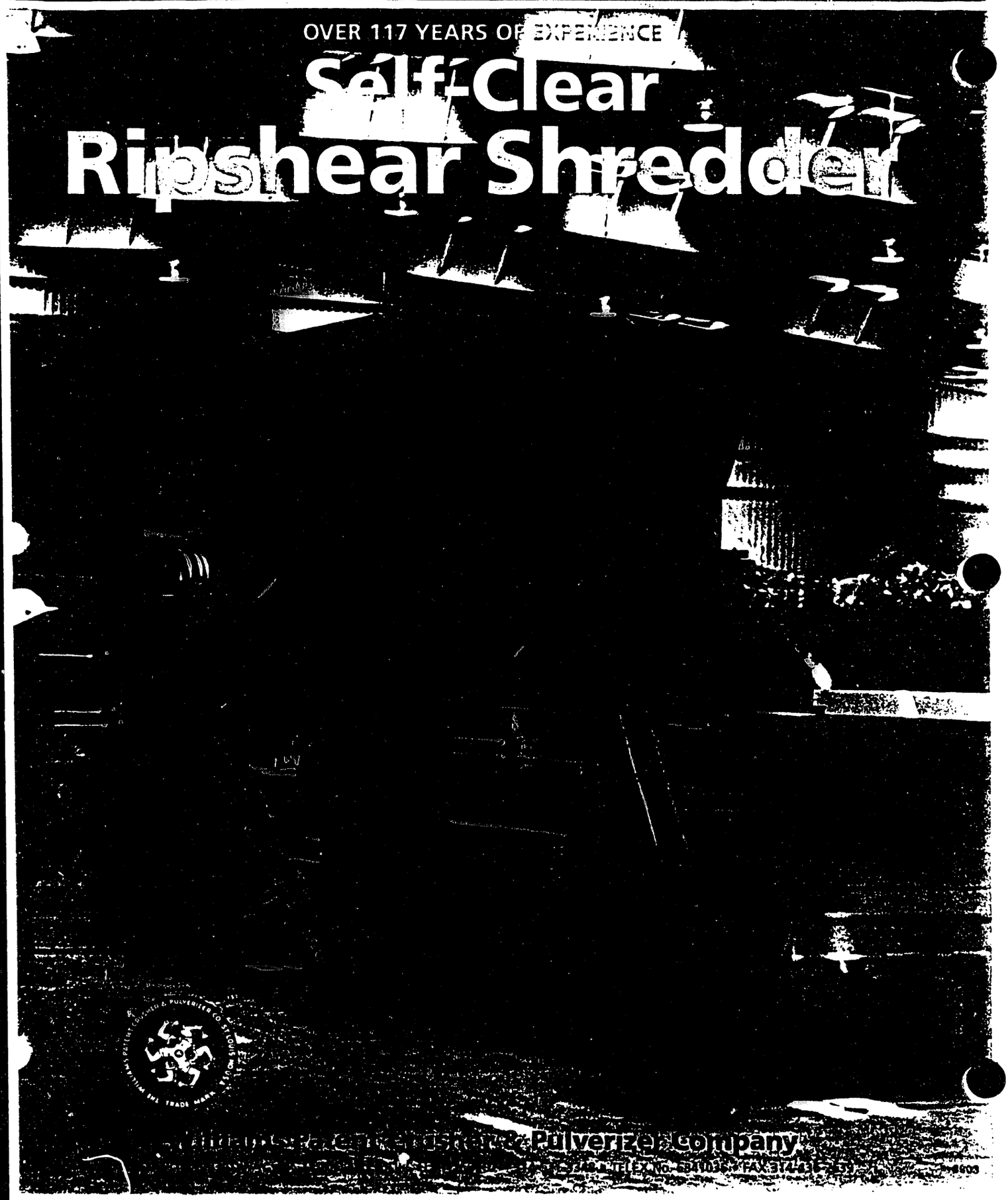
WILLIAMS

OVER 117 YEARS OF EXPERIENCE

Self-Clear Ripshear Shredder



Williams Patent Crusher & Pulverizer Company
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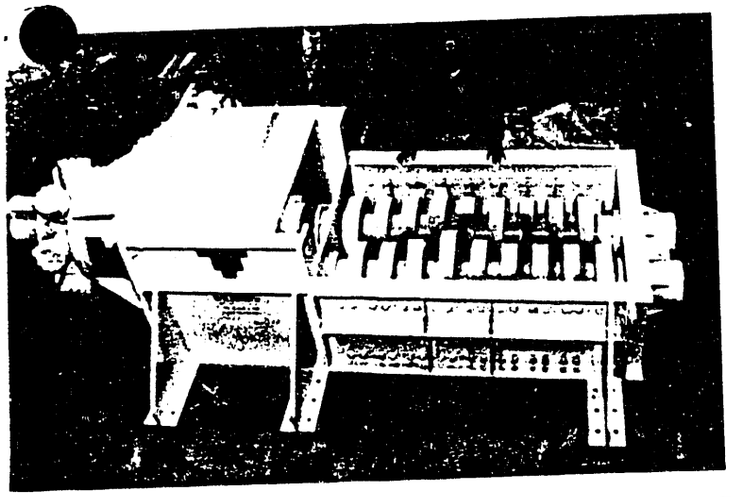
Advantages of Standard Ripshear Shredders



Low Horsepower

Low speed coupled with high torque hydraulic drive to reduce power requirements for certain jobs.

Easy, Low Cost Installation

Only minimal foundation of normal concrete slab, or equal leg support, required.

Low Maintenance

Rugged construction plus automatic unjamming action through rotor reversal and resetting to minimize shutdowns.

Low Hazard

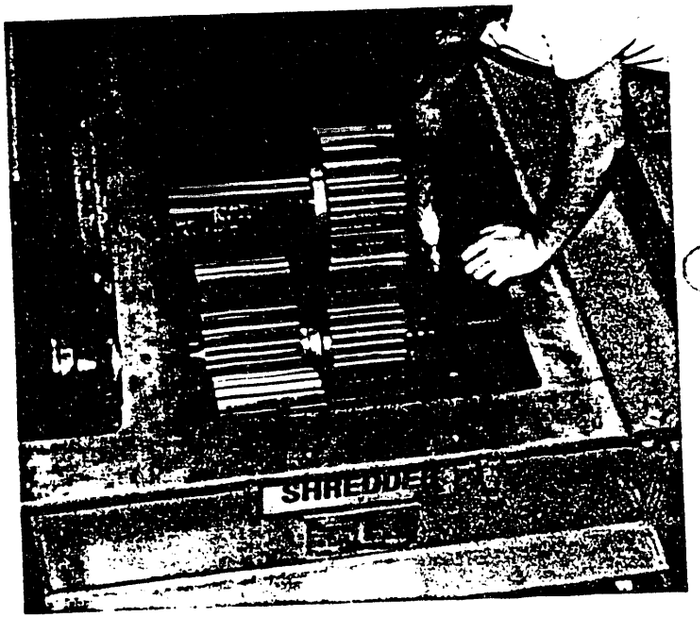
Low speed does not create high windage and ignition [illegible]s found in high speed shredders; minimizes fires and explosions.

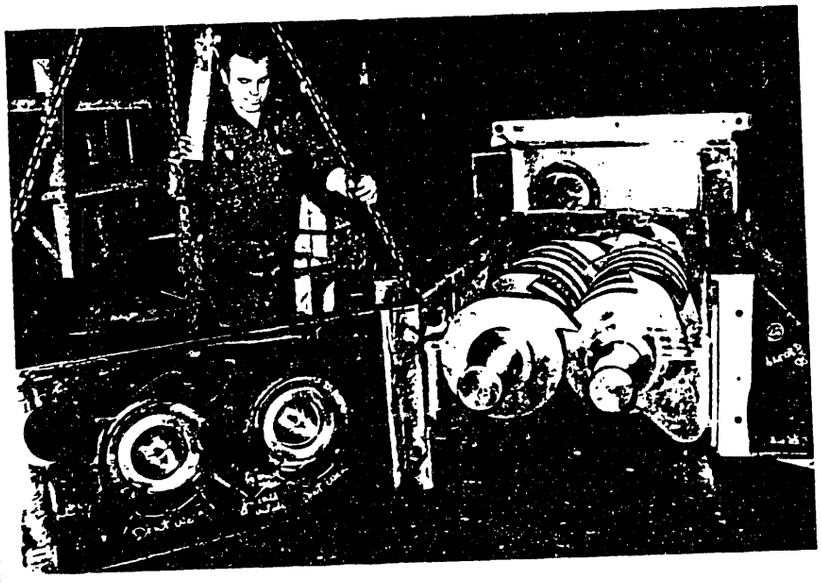
Environmentally Safe

Shearing action is quiet; creates little or no dust.

Gear Box

Forged billet spur gears are supported on either side by bearings to prevent transfer of gear separating loads to hydraulic drive motor bearings.





Ease of Accessibility

Bushings allow pull out and removal of front cover exposing shafts and cutter disks for maintenance without disassembling bearings. Shafts are fully supported at other end by double row, self aligning spherical roller bearings.

Open Bottom

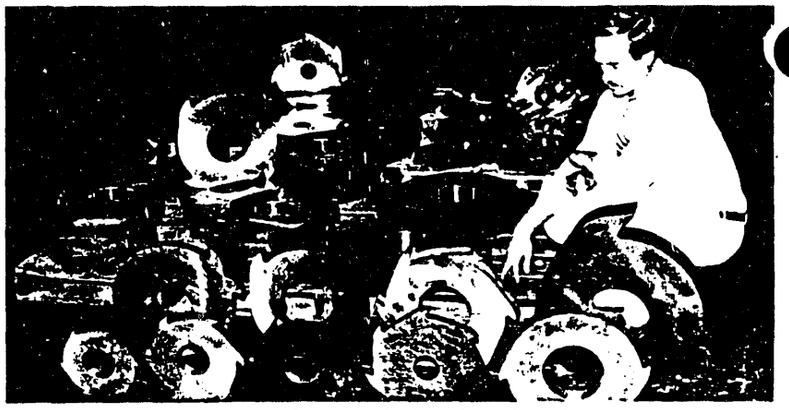
Permits maximum throughput with product size controlled by disk size and tooth pattern.

Other Features

Large feed opening. Removable hopper section. Oversized bearings and shafts. Heavy-duty construction throughout, and optional portability.

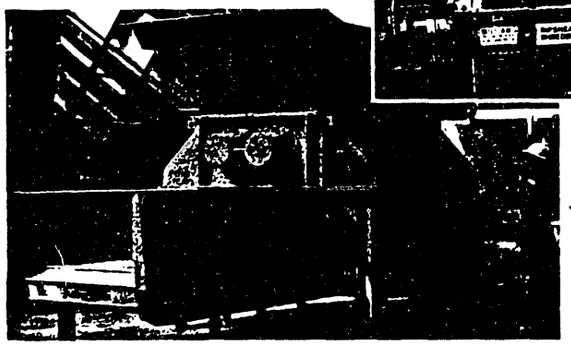
Ripshear™ Shredders

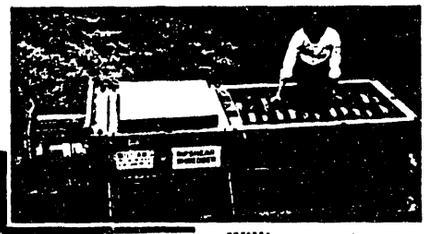
The Williams patented control system is independant of motor current or hydraulic pressure spikes that cause needless reversals. Onboard programmable computer* detects jams via actual shaft stoppage, permitting continuous operation at full hydraulic pressure without reversals.



Williams offers a full range of custom designed cutting discs, tailored for your particular application.

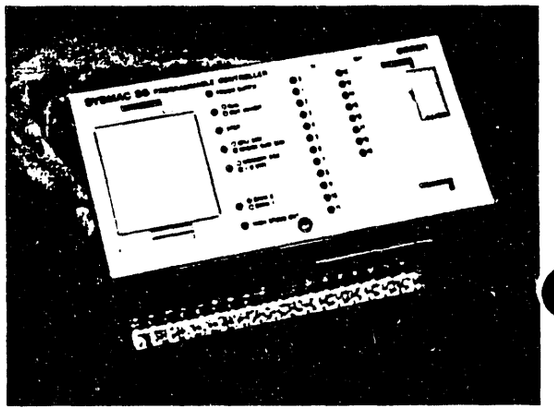
View of Ripshear with feed hopper removed shows counter-rotating, meshed disc cutters that effectively shred MSW/OBW.





Williams system supplied to shred OBW at a refuse to energy facility.

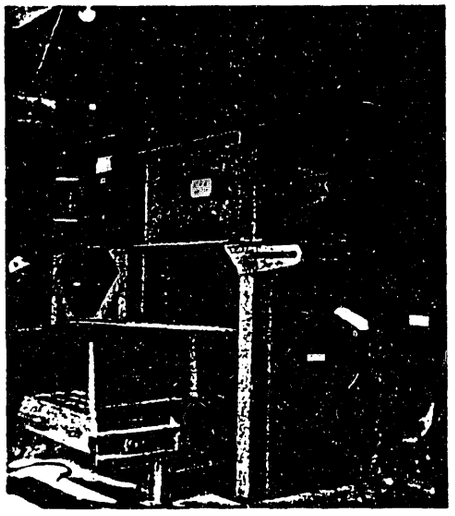
• Programmable, onboard computer provides self-clearing and self-discharge of uncrushables plus materials flow control.



Single Source for a Reduction System

Williams can engineer and build a reduction system to your specific needs with full responsibility. As shown here, a typical system could include:

- Custom Designed Infeed Hopper
- Ripshear Shredder
- Williams Century Mark Apron Pan Discharge Conveyor.



Typical installation of large Ripshear and Williams apron pan conveyor.

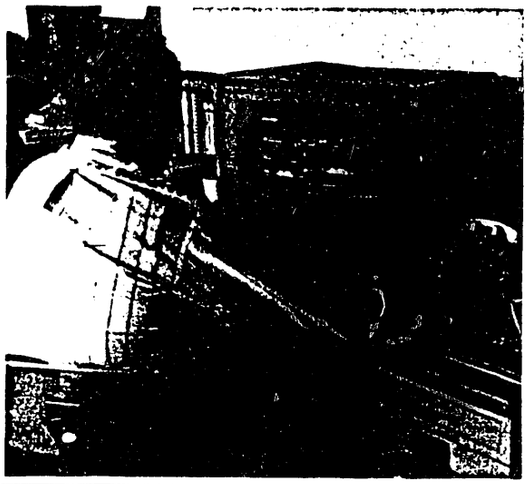
Programmable Computer

*As an exclusive, the Williams Ripshear offers a compact, onboard computer that detects a jam through actual shaft stoppage as opposed to the conventional, preset pressure limit. This permits continuous operation at *full pressure* without reversals...an exclusive feature.* The programmable computer also adds the dimension of distributive control to the Ripshear.

Some other hydraulic systems on shredders will reverse when they arrive at full operating pressure, even though the shredding process may be continuing. This is tantamount to a motor coming up to full load and then being reversed simply because it is at full load. With the Williams computer this cannot occur and the Ripshear can utilize the full pressure capabilities of its hydraulic components without reversing unless a true mechanical jam develops.

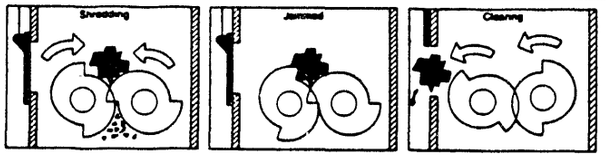
*Patent Nos. 4,721,257
4,452,400

for You



Let us show you how all the many features of the Ripshear can be personalized to your specific needs in our Customer Service Laboratory, consisting of a complete test-run facility and a CAD/CAM computer-backed engineering department. Contact your Williams representative for details. Or write direct.

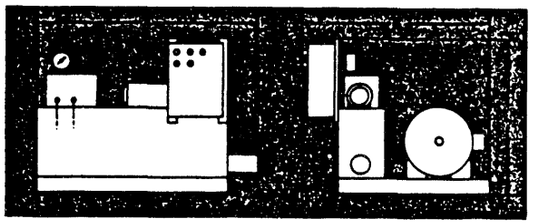
As you read about our products in this brochure, please remember we have a CAD/CAM backed engineering department that stands ready to help you meet any specific waste processing needs and objectives.



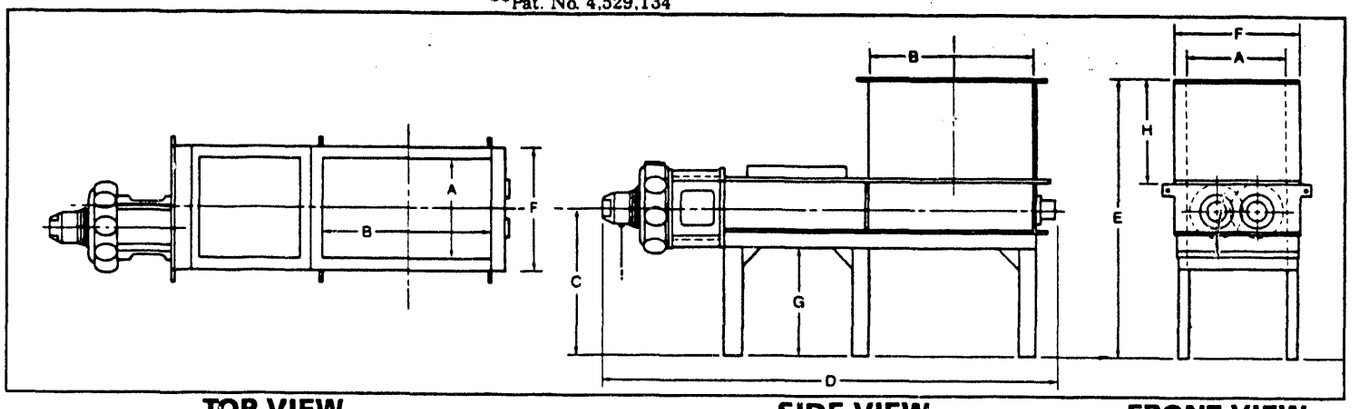
Exclusive side discharge**

permits automatic removal of uncrushables after detection of jams. A side door opens and the rotor nearest the door reverses to convey uncrushables out of chamber.

**Pat. No. 4,529,134



HYDRAULIC POWER UNIT



TOP VIEW SIDE VIEW FRONT VIEW

HP-Size	A (in./mm)	B (in./mm)	C (in./mm)	D (in./mm)	E (in./mm)	F (in./mm)	G (in./mm)	H (in./mm)	J (in./mm)	K (in./mm)	L (in./mm)	Total Wt (lb/kg)	Motor (hp/rpm)
[illegible]	24/ 610	[illegible]	40/ 1016	[illegible]	82/ 2083	[illegible]	34/ 864	[illegible]	54/ 1372	[illegible]	54/ 1372	[illegible]	(1) 50/ 1800
[illegible]	34/ 864	[illegible]	51/ 1295	[illegible]	96/ 2438	[illegible]	36/ 914	[illegible]	76/ 1930	[illegible]	54/ 1372	[illegible]	(1) 100/ 1200
[illegible]	34/ 864	[illegible]	51/ 1295	[illegible]	96/ 2438	[illegible]	36/ 914	[illegible]	76/ 1930	[illegible]	54/ 1372	[illegible]	(1) 100/ 1200
[illegible]	34/ 864	[illegible]	51/ 1295	[illegible]	96/ 2438	[illegible]	36/ 914	[illegible]	78/ 1981	[illegible]	68/ 1727	[illegible]	(1) 150/ 1800
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WASTE RECEIVING AND PROCESSING FACILITY

TITLE: **WRAP 2A ADVANCED CONCEPTUAL DESIGN REPORT STUDY 1604-6: SLUDGE REPACKING**

Rev. 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A **Raytheon** Company
Western Operations

June 1993

STUDY 1604-6 SLUDGE REPACKING

Prepared by: S A Thompson Date: 16 JULY 1993

Reviewed by: A. L Heckel Date: 7/16/93

Approved by: R Bass Date: 7-16-93

Approved by: R Bass for MJW Date: 7-16-93
Project Manager

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1.0 OBJECTIVE

1. The purpose of this study is to evaluate the sludge repacking facilities provided within the WRAP 2A CDR baseline such that the optimum equipment and waste processing routes can be established on which Title I design can proceed[1].

1.1 Scope

1. The scope of this study is to evaluate those areas of the Sludge Repacking processes and equipment for which potential risk or uncertainty exists within the Conceptual Design Report (CDR) baseline design[2]. Specific areas of study[1] are listed as follows:

   a. Evaluate equipment that is capable of processing both sludge and dry particulate feedstreams in WRAP 2A. This part of the study will identify the most suitable equipment for processing WRAP 2A sludges and dry particulates.

   b. Evaluate alternative process routes for the WRAP 2A sludge and dry particulate feedstreams. This part of the study will identify which feedstreams are routed through the equipment identified in section 1.1.1a above.

   c. Evaluate process routes for plastic bags.

   d. Identify additive requirements, if any, for the preferred sludge processing equipment.

3. The study will not re-evaluate those areas of interest which are common to both the sludge processing line and the shred and direct repack line, where these areas have already been addressed by the Open, Sort and Size Reduction Study[3], but will take the relative findings from this study. These are as follows:

   a. Process routes for empty drums.

   b. Process routes for 85 gallon drums containing absorbent.

   c. Waste entry into enclosures.

   d. Impact of anti-flotation devices.

   e. Drum entry into enclosures.

1.2 Background

1. In June 1992 UE&C prepared the CDR for WRAP 2A[2]. The CDR identified the requirement for processes and equipment to open, sort and size reduce and process drums and boxes of waste entering the facility and repack this waste into new drums for immobilization in either a grout or polymer matrix. The CDR baseline design defined a Size Reduction Repacking System for processing heterogeneous solids and dry active wastes, and a Sludge Repack System in which sludge or wet particulate wastes were to be processed.

2. The CDR baseline design identifies the requirement for two separate enclosures within the Size Reduction and Repacking area:

   a. Size Reduction and Repack Enclosure - In the CDR the Size Reduction and Repack enclosure is designated to process the bulk of the dry active wastes entering the facility via one of two processing lines within the enclosure. Large items of dry active waste will be shredded in the Shredding Line to a size which is suitable for immobilization using vibro encapsulation techniques. Materials such as soils and ash will be directly repacked into new drums in the Direct Repack line. The two lines utilize a common vibrating table and weigh hopper system to load waste into new drums. Uncertainties identified in the CDR relating to the Size Reduction and Repack enclosure are addressed in the Open Sort and Repack Study[3].

   b. Sludge Repack Enclosure - In the CDR waste forms which are sludge like in nature are designated to be processed within the Sludge Repack enclosure in order to homogenize, pretreat and meter the sludge into new drums. An illustration of the CDR baseline design Sludge Repack enclosure is shown in **Appendix A, Figure 1-1**.

3. The CDR review identified some uncertainties in the sludge repack process and equipment for which further investigation is required to confirm their suitability or establish alternative handling methods.

4. The following CDR design review comments will be addressed in this study:

Comment #	Comment
13	Sludge processing feedstream to be confirmed for compatibility with equipment design.
81	Assess lubricating requirements for the sludge feedstreams.
135	The pug mill should be sized and considered for use for feedstreams 2A, 2B, 2C, 7 and 8. The pug mill will be necessary to homogenize some (if not all) of these feedstreams due to clumping or aggregation that might be characteristic of the waste or has occurred to the waste during storage.

5. The following CDR uncertainties will be assessed by this study[2].

   a. The determination of whether, and if so how much, of an appropriate fluid is required to assist sludge, crystalline solid and absorbed chemicals to be processed in the sludge processing equipment.

   b. The ability of the sludge processing equipment to process plastic bags or the requirements for removing plastic bags at the sorting table..

   c. The accuracy to which the weight of waste can be measured in a weigh hopper when being continuously fed from the sludge processing equipment.

1.3 Purpose and Need

1. The purpose is to define a system which resolves uncertainties identified in the CDR and to resolve CDR comments to ensure that the processes and equipment specified will achieve the required FDC in a cost effective way.

2. The study is needed to determine the optimum equipment and process routes for the Sludge Repack area on which Title I design can proceed.

3. The optimum equipment will have the following process objectives:

   a. Delumping

   b. Homogenization

   c. Controlling moisture content of waste by either adding absorbent for free water removal or adding water for dilution.

   d. Mixing waste and chemical additives capability to carry out chemical pretreatment.

   e. Transportation and metering waste.

   f. Ability to deal with waste having physical characteristics from dry powders, clumps of friable material and wet sludges.

4. The optimum process routes for the feedstreams (that do not require shredding) will be based on the following objectives:

   a. Operability and Maintainability

   b. Flexibility

   c. Plant Throughput

   d. Waste Minimization/Secondary Waste Generation

2.0 SUMMARY

1. This study evaluates those areas of the Sludge Repacking process and equipment for which potential risk or uncertainty exists within the CDR baseline design. The study identifies the process objectives that equipment must meet for processing both sludge and dry particulate wastes, and systematically evaluates a range of equipment to achieve these objectives against a pre-determined set of evaluation criteria. The study concludes that the most suitable equipment, to process both WRAP 2A sludge and dry particulate feedstreams, is a pug mill to delump and homogenize the waste followed by a screw feeder to meter the processed waste into new drums.

2. The preferred waste feedstreams process routes selected by this study are provided in **Table 2-1** below:

TABLE 2-1
PREFERRED PROCESS ROUTES FOR WRAP 2A FEEDSTREAMS

WRAP 2A Feedstream	Dry Particulate	Wet Particulate	Ion Exchange Resins	Sludge Repack	Direct Repack
1B 183 H Crystalline Solid	●			Preferred	
1C 183 H Sludge		●		Preferred	
2A Ammonium Sulfate	●			Preferred	Optional [1]
2B Ion Exchange Resins			●	Preferred	
2C Metal Sludge		●		Preferred	
6 Absorbed Chemicals	●			Preferred	
7 Incinerator Ash	●			Preferred	Optional [2]
8 Contaminated Soils	●			Preferred	Optional [3]

Notes:

1. Requires routing through the sludge repack line to size reduce lumps of friable material, if they occur after packaging by the generator due to the hygroscopic nature of the material. If a dry powder state is maintained the material can go through the direct repack line as selected in the CDR.

2. This waste stream should be considered for optional routing through the direct repack area. Preliminary information indicates that the streams will contain lumps of metal and large pieces of concrete. These materials which are not friable and form only a portion of the feedstream can be isolated for additional size reduction by shredding while the particulate is loaded into drums for later agitated treatment.

3. This waste stream should be handled in a manner similar to feedstream 7 if many non-friable materials (i.e. stones) are present.

3. The study also evaluates process routes for the disposal of plastic bags in which waste has been contained within a drum. This study confirms the preferred process option is to route plastic bags to the Size Reduction enclosure for shredding.

4. The study also discusses and identifies additive requirements to assist sludge and dry particulate waste processing. Addition of VES or styrene to the pug mill to assist polymer processing in the pug mill is not a preferred option due to the safety problems of fire and explosion associated with these materials. Although the polymer process can accept waste containing a certain water content, this should be as low as practical. In order to dry out the sludge for processing in polymer the preferred additive is absorbent. Wastes which are to be immobilized in grout can be diluted into a slurry by adding water and mixing in the pug mill.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Equipment Evaluation

1. Conclusions

a. It is recognized that some pretreatment of waste may be required for sludge and dry particulate wastes which are to be immobilized using agitated mixing techniques. Although the extent of this pretreatment is at present unknown it is estimated that the equipment required to process the waste must be able to carry out the following objectives:

1) Delump and deagglomerate friable components.

2) Achieve a product of homogeneous regular particle size and consistency of mix, by visual inspection.

3) Control moisture/water content (primarily free water removal).

4) The capability to mix dry or liquid additives.

5) Control particle size. The maximum output particle size is anticipated to be 1/2"x1/2"x1/2".

6) The capability to transport and meter waste into a new drum within a target accuracy of ±2% by mass. This target is based on similar waste loading accuracies used by BNFL in the UK.

7) Handle densities up to 90 lbs/ft^3. It is anticipated that the density of the waste will effect sizing of the selected equipment (i.e. motor HP) rather than be a major factor in selecting the generic type of Sludge Repacking equipment.

8) Handle viscosities up to 120,000 cp.

9) The equipment selected must be capable of a maximum feed rate of 30 ft^3/hr. This is based on the ability to handle a maximum plant throughput of approximately 25 input drums per day (150 ft^3/day, assuming the drums are not 100% full) as identified by the CDR baseline design. Assuming the maximum density of waste, the equipment must be capable of achieving a maximum mass feed rate of 2700 lbs/hr.

b. The most suitable piece of equipment to meet process objectives for the WRAP 2A sludge and dry particulate feedstreams is a pug mill to mix the wastes followed by a screw feeder to meter the processed waste into the new drums.

2. Recommendations

a. The WRAP 2A Title I design should progress on the basis that the combination of a pug mill and screw feeder should be incorporated into the WRAP 2A facility to process those wastes which require pretreatment prior to immobilization.

3.2 Process Routes Evaluation

1. Conclusions

   a. As a result of the uncertain physical characteristics of the WRAP 2A wastes, agglomeration of dry powder and particulate wastes cannot be disregarded. Consequently, it has been assumed that all non shredded wastes require delumping and homogenizing prior to immobilization. The preferred process routes for non shreddable feedstreams is provided in **Table 2-1**.

2. Recommendations

   a. The WRAP 2A Process documentation should be revised to route all wastes which do not require shredding through the sludge repack line. A continual review of the WRAP 2A waste characteristics, particularly with respect to feedstreams 2A, 7 and 8, must be performed in order to optimize the waste treatment process routes and minimize unnecessary treatment and handling. Additionally administrative controls particularly with respect to scheduling waste campaigns are important in terms of minimizing equipment downtime for clean up.

3.3 Process Routes For Plastic Bags

1. Conclusions

   a. Plastic bags arising from drum opening operations in the sludge repack enclosure should be transferred to the Size Reduction and Repack enclosure and shredded. The pug mill and screw feeder are not capable of processing plastic bags.

2. Recommendations

   a. The WRAP 2A Title I design should progress on the basis that empty plastic bags from the sludge repack area should be shredded in the Size Reduction enclosure.

3.4 Sludge Additive Requirements

1. Conclusions

   a. Addition of VES or styrene to assist processing in the pug mill is not a preferred option due to the safety problems of fire and explosion associated with these materials.

   b. Although limited information exists on the characteristics of the sludge it is likely that some of the sludge will be water based, having high moisture content or even contain free water. Although the polymer process can accept waste containing a certain water content, this should be as low as possible. In order to dry out the sludge for processing in polymer the preferred additive is absorbent.

   c. The addition of water to the sludge when being homogenized in the pug mill may assist start up of the paddle in the drum for grout immobilization.

2. Recommendations

   a. The WRAP 2A Title I design should progress on the basis that provision to add either absorbent or water to sludge in the pug mill is included in the Sludge Repacking enclosure.

4.0 UNCERTAINTIES

1. Limited information exists at present on the physical and chemical characteristics of the wastes to be processed in WRAP 2A. In order for the Sludge Repacking study to be carried out, assumptions have been made for the characteristics of the WRAP 2A wastes such that alternative processes and equipment could be evaluated and a preferred baseline design identified. Accurate information on the actual characteristics of the WRAP 2A wastes will hence give greater confidence in the preferred baseline design.

2. The type of immobilization process(es) to be used in WRAP 2A will be determined by the Single Immobilization Study. As this information is at present unavailable, this study assumes the CDR baseline design of both grout and Vinyl Ester Styrene (VES) polymer lines being required to immobilize waste. As long as the CDR baseline design of polymer and grout are current this study is valid. It is recognized that the Single Immobilization Study could recommend a combined grout and Polyethylene (PE) polymer process to immobilize waste however, it is not anticipated that this would have any significant impact on the selection of the Sludge Repacking equipment.

3. The sludge processing equipment is required to homogenize sludge (and if required mix pretreatment additives) to assist paddle start up and in drum mixing in the agitated mixing lines in WRAP 2A. The extent of homogenization required in the sludge processing equipment has yet to be defined and will effect retention/mixing times in the sludge processing equipment. The level of homogenization required from the sludge processing equipment will be established by the agitated mixing tests carried out by WHC.

4. The potential impact of the Debris Rule on WRAP 2A is currently unknown and is not addressed in this study at the request of WHC. However, it is anticipated that the Debris Rule will not have any major impact on the Sludge Repacking equipment in WRAP 2A.

5. Some uncertainty exists as to the physical condition of the waste feedstreams from drum to drum (i.e., has agglomeration occurred or is waste a free flowing particulate). Accordingly, the study will identify potential feed conditions and preferred and optional process routes and verify that equipment is sized and selected in accordance with the most flexible and conservative case, which is to assume the limiting physical characteristics and to route all waste which does not require shredding through the pug mill.

6. As a result of the uncertain physical characteristics of the WRAP 2A wastes, lumping of dry powder and particulate wastes cannot be disregarded. Consequently, it has been assumed that all waste which does not require shredding, require delumping and homogenizing prior to immobilization.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC Requirements

1. The criteria for the processes and equipment evaluated in this study are subject to the following general (FDC)[4] requirements.

   a. Minimize waste generated by maintenance and operations.

   b. Transfer systems for all dry materials shall be enclosed and have adequate provisions for the collection of dust and particulate materials.

   c. Transfer systems shall be provided which reduce or eliminate waste generated during transfer operations.

   d. All equipment shall be designed and constructed to be resistant to any expected corrosive conditions.

   e. Capability to determine and control the weight of containers of waste.

   f. Ability to screen all particulate waste to remove lumps and foreign objects.

   g. Surfaces are to be suitable for decontamination and manufactured to minimize potential for accumulation of contamination.

   h. Equipment should be configured to optimize in place maintenance.

   i. Equipment should be configured to minimize the effects of component failure (including; control, monitoring and utility failure).

   j. Throughput shall be based on single shift operation 5 days per week with a 70% facility availability.

   k. The facility shall be designed to minimize the release of radioactive and hazardous materials.

   l. Equipment shall be designed to meet the criteria for special equipment.

   m. The process enclosure and equipment shall be designed for operation, decontamination and decommissioning.

5.1.2 Process Objectives

1. These objectives and requirements are the basis for selection and evaluation of the Sludge Repacking components:

   a. Delump and deagglomerate friable components.

   b. Achieve a product of homogeneous regular particle size and consistency of mix, by visual inspection.

   c. Control moisture/water content (primarily free water removal).

d. The capability to mix dry or liquid additives.

e. Control particle size. The maximum output particle size is anticipated to be 1/2"x1/2"x1/2".

f. Transport and meter waste into a new drum within a target accuracy of ±2% by mass. This target is based on similar waste loading accuracies used by BNFL in the UK.

g. Handle densities up to 90 lbs/ft^3. It is anticipated that the density of the waste will effect sizing of the selected equipment (i.e. motor HP) rather than be a major factor in selecting the generic type of Sludge Repacking equipment.

h. Handle viscosities up to 120,000 cp.

i. The capability to handle WRAP 2A sludges, wet particulate, dry particulate and ion exchange resin feedstreams as identified in **Table 5-1**.

j. The equipment selected must be capable of a maximum feed rate of 30 ft^3/hr. This is based on the ability to handle a maximum plant throughput of approximately 25 input drums per day (150 ft^3/day, assuming the drums are not 100% full) as identified by the CDR baseline design. Assuming the maximum density of waste, the equipment must be capable of achieving a maximum mass feed rate of 2700 lbs/hr.

5.2 Equipment Screening and Evaluation Logic

1. The alternative pieces of equipment and equipment combinations will undergo a two stage assessment to determine the most suitable piece of equipment to meet the process objectives. An initial screening of the equipment will be carried out to eliminate alternatives which do not meet the process objective. A more detailed evaluation will then be carried out to assess those alternatives which pass the initial screening, against a predetermined list of evaluation criteria. A diagram illustrating the logic used to carry out the screening and evaluation process is given in **Appendix A, Figure 5-1**.

5.2.1 Screening Criteria

1. The purpose of the screening criteria is to eliminate alternatives which do not meet process objectives for all physical characteristics of the waste and there is no overriding reason to support further evaluation.

2. Screening criteria are as follows:

   a. <u>Functional Criteria ("Shall")</u>

      FDC and other mandatory requirements are to be reviewed in this section. Each alternative shall be compared to that criteria.

   b. <u>No Justification for Further Evaluation</u>

      Alternatives which do not merit further evaluation can be eliminated from further study at this stage providing a technical justification to support the elimination is given.

TABLE 5-1
WRAP 2A FEEDSTREAM PHYSICAL CHARACTERISTICS SUMMARY

WRAP 2A Feedstream		Dry Particulate	Wet Particulate	Dry Size Reduced/ Oversized	Wet Size Reduced/ Oversized	Ion Exchange Resins	Lead Bricks[2]
1A	183 H Solidified Liquid				20,625 (2.8%)		
1B	183 H Crystalline Solid	32,500 (4.5%)					
1C	183 H Sludge		35,000 (4.8%)				
1D	183 H Miscellaneous Cleanup			4,813 (0.7%)	4,813 (0.7%)		
2A	Ammonium Sulfate	261,500 (36.1%)					
2B	Ion Exchange Resins					53,500 (7.4%)	
2C	Metal Sludge		76,250 (10.5%)				
2D	RO Filter Elements						
3	Dry Active Waste			52,500 (7.2%)	8,750 (1.2%)		
4	Construction Debris			28,875 (4.0%)			
5A	Mercury/Mercury Contaminated Waste			12,900 (1.8%)			
5B	Reactive Metals	440 (<0.1%)					
5C	Lead/Lead Contaminated Waste			735 (0.1%)			11,764 (1.6%)
5D	Miscellaneous Metals			3,035 (0.4%)			
6	Absorbed Chemicals	42,500 (5.9%)					
7	Incinerator Ash	57,500 (7.9%)					
8	Contaminated Soils	17,000 (2.3%)					
	Total[1] Plant Feed	411,440 (56.8%)	111,250 (15.3%)	102,858 (14.2%)	34,188 (4.7%)	53,500 (7.4%)	11,764 (1.6%)

Notes:

1 Values are FT^3 volume
Values in ( ) are volume %

2 Lead bricks are considered part of the dry sized reduced/oversized waste type for physical characterization

3 _____ streams considered for equipment evaluation

5.2.2 Evaluation Criteria

1. Alternatives which are not eliminated by the screening evaluation, are considered against a list of evaluation criteria. Each individual evaluation criteria is given :

   a. A weighting factor.

   b. A raw score in the range 1-5, reflecting the potential relative merits of the alternative. The raw score is determined by comparing the alternatives against each other rather than against absolute criteria.

2. The total scoring is calculated by multiplying the raw score selected and the weighting factor.

3. Evaluation Criteria, Weighting Factors and Raw Score

   a. Criteria: Potential Hazards

      1) Weighting Factor: 15%

      2) Raw Score

      All processes must be safe, however equipment arrangement or complexity may increase the potential for hazards to develop. Factors to consider include operator dose exposure; human factors; potential for operator puncture wounds; potential for leaks, spills or uncontrolled releases; potential for dropping objects; potential for flammable gas generation. This category is judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

   b. Criteria: Plant Throughput

      1) Weighting Factor: 15%

      2) Raw Score

      All processes must meet the required FDC throughput. Alternatives are compared against each other to determine which offers the greatest potential to exceed the FDC throughput. This category is judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

c. Criteria: Operability and Maintainability

1) Weighting Factor: 15%

2) Raw Score

Ability of the operator to view and carry out all required routine operations and maintenance activities. Labor requirements for operations and maintenance. Potential for modularization of equipment. Complexity of equipment and process configuration. Materials of construction in relation to their conditions of service (corrosivity, temperature etc).

Operability and maintainability also represents a direct reflection of how the equipment performs in carrying out the specified task. In order to be considered for evaluation each alternative must be judged as capable of achieving the required task with various degrees of effectiveness.

This category is judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

d. Criteria: Demonstrated Technology/Development Requirements

1) Weighting Factor: 15%

2) Raw Score

The ability to demonstrate that the equipment has been successfully operated within the nuclear industry over a reasonable period of time. Whether the equipment has operated successfully outside the nuclear industry over a reasonable period of time. Whether the equipment requires a development program. This category will be judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

e. Criteria: Flexibility

1) Weighting Factor: 15%

2) Raw Score

The ability to meet potentially changing criteria. The capability to accommodate future expansion, change out requirements or potential waste conditioning. This category will be judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

f. Criteria: Equipment Cost

1) Weighting Factor: 15%

2) Raw Score

The cost of each alternative will be calculated and scores awarded which reflect the comparative cost of each alternative. This category will be judged subjectively, and the scores will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

g. Criteria: Equipment Procurement Schedule

1) Weighting Factor: 5%

2) Raw Score

An assessment will be made to determine how each alternative meets the project schedule. Scores will then be awarded based on the following:

Improves to schedule	5
Meets schedule	3
Delays schedule	1

h. Criteria: Waste Minimization/Secondary Waste Generation

1) Weighting Factor: 5%

2) Raw Score

The ability to reduce the overall waste volume. Generation of no significant secondary wastes. Generation of additional waste which can be dealt with in WRAP 2A. Generation of additional waste which has to be dealt with in another facility. This category will be judged subjectively, and the scoring will be as follows:

Best	5
Good	4
Above average	3
Average	2
Fair	1

5.3 Process Routes Evaluation

1. Having carried out the equipment screening and evaluation assessment, the most suitable piece of equipment capable of processing both sludge, wet particulate, dry particulate and ion exchange resin feedstreams will be identified. Having established this equipment, and recognizing the uncertainty of the waste characteristics, the option exists to route the waste feedstreams through either the sludge repack equipment or the direct repack line.

2. The purpose of the process routes evaluation is to identify which feedstreams should be routed to the sludge repack equipment and which may optionally be routed to the direct repack line, based on the treatability requirements and/or physical characteristics of the waste.

3. Alternatives will be considered against the following evaluation criteria and ranked against each other for the individual evaluation criteria.

a. Operability and Maintainability

1) Labor requirements for operations and maintenance. Complexity of carrying out process operations. Operational clean up and decontamination requirements. Degree of routine and breakdown maintenance.

2) Operability and maintainability also represents a direct reflection of how the equipment performs in carrying out the specified task. In order to be considered for evaluation each alternative must be judged as capable of achieving the required task with various degrees of effectiveness.

b. Flexibility

1) The ability of the process to meet potentially changing criteria, i.e. physical characteristics of the waste, waste lots of varying sizes.

c. Plant Throughput

1) All processes must meet the required FDC throughput. Alternatives are compared against each other to determine which offers the greatest potential to exceed the FDC throughput.

d. Waste Minimization/Secondary Waste Generation

1) The ability to reduce the overall waste volume. Generation of no significant secondary wastes. Generation of additional waste which can be dealt with in WRAP 2A. Generation of additional waste which has to be dealt with in another facility.

5.4 Assumptions

5.4.1 Study Prerequisites

1. There are no prerequisites to initiate the vendor and literature search for sludge repacking processes and equipment.

2. CDR baseline design.

5.4.2 Study Assumptions

1. The particle size of material after processing in the sludge processing equipment is anticipated to be 1/2"x1/2"x1/2". The maximum particle size after processing is at present not known, and the target size of 1/2"x1/2"x1/2" is at present an estimate based on engineering judgement.

2. The density of the sludge to be processed is up to 90 lbs/ft^3. It is anticipated that the density of the waste will effect sizing of the selected equipment (i.e. motor HP) rather than be a major factor in selecting the generic type of Sludge Repacking equipment.

3. Any solid waste items which may exist in the sludge (metal clumps, tools, rocks etc) are be removed using the sorting manipulators before the sludge enters the sludge processing equipment.

4. Viscosities up to 120,000 cp.

5. Waste is to be metered into a new drum within a target accuracy of $\pm 2\%$ by mass. This target is based on similar waste loading accuracies used by BNFL in the UK.

6. As a result of the uncertain physical characteristics of the WRAP 2A wastes, agglomeration of dry powder and particulate wastes cannot be disregarded. Consequently, it has been assumed that all non shredded wastes require delumping and homogenizing prior to immobilization.

6.0 SELECTION OF ALTERNATIVES AND SOLUTIONS

6.1 Equipment Evaluation

1. Introduction

   a. The purpose of this assessment is to evaluate equipment that is capable of processing both sludge and dry particulate feedstreams in WRAP 2A. This study will identify the most suitable equipment for processing WRAP 2A sludges and dry particulates.

2. List of Alternatives considered

   a. ALT A1 = Pug Mill

   b. ALT A2 = Pug Mill with Screw Feeder

   c. ALT A3 = Screw Feeder

   d. ALT A4 = Ribbon Blender

   e. ALT A5 = Ribbon Blender with Screw Feeder

   f. ALT A6 = Single/Multiple Shaft Agitator

   g. ALT A7 = Single/Multiple Shaft Agitator with Screw Feeder

   h. ALT A8 = Double Arm Kneading Mixer

   i. ALT A9 = Double Arm Kneading Mixer with Screw Feeder

   j. ALT A10 = Intensive Mixer

   k. ALT A11 = Intensive Mixer with Screw Feeder

   l. ALT A12 = Porcupine Processor

   m. ALT A13 = Porcupine Processor with Screw Feeder

   n. ALT A14 = Positive Displacement Pump

   o. ALT A15 = Positive Displacement Pump with Screw Feeder

3. General Discussion of Alternatives

a. The alternative arrangements consist of 8 major categories of mixing components arrayed with various metering components. Only one type of component (screw feeder) is capable of metering and mixing. However, the screw configuration which optimizes metering capabilities tends to minimize the equipments capability to homogenize the feedstream. This will be discussed further in the evaluation section. Additionally, the alternatives can be grouped as, batch mixers ALT A4, A6, A8 A10 and A3 (cone and screw) which require a transport mechanism to load and unload, and continuous mixers ALT A1 and A3 (trough and screw) and ALT A15 which are capable of unloading and transporting as part of their basic design.

b. In some cases, for the purpose of evaluation, we have reviewed a mixer type such as trough and screw and also listed a derivative type, i.e., porcupine processor which is a variation of a screw feeder with segmented flights and breaker bars to aid agitation.

4. Specific Descriptions of Alternatives[5]

a. Alternate A1 Pug Mill **(Figure 6-1, Appendix A)**

1) This equipment consists of single or multiple shafts (co or counter rotating) fitted with short heavy paddles or knives. The shafts are mounted in a trough or cylinder to hold and transport of the material being processed. The paddles may or may not intermesh. The clearances are wide so that there is considerable mass mixing with little likelihood of jamming or damaging paddles. The paddles impact the material and push it forward as they cut through it. Pug mill development has progressed from the original low speed (up to approximately 60 RPM) to new higher speed adaptations (up to 2500 RPM). When used in higher RPM ranges the material to be mixed is essentially suspended in the air in the shell. This permits liquid/solids mixing without forming lumps and promotes mixing of dry materials.

b. Alternate A2 Pug Mill with screw Feeder **(Figure 6-2, Appendix A)**

1) This is a combination of A1 and A3. In this arrangement, the pug mill is the mixing element and the means of transport from where the drum is sorted/emptied to a fill hopper on a screw feeder which meters feed into a new drum. Utilizing a combination of weigh scales and volumetric control of feeds allows diversity in achieving/monitoring waste loading.

c. Alternate A3 Screw Feed

1) This equipment is available in two broad categories for continuous or batch processing.

a) Continuous Mixing (Figure 6-3, Appendix A) - For continuous processing (trough and screw) this equipment may consist of single or multiple shafts (rotors) which continuously roll the feed over as it is transported towards the discharge. In its simplest form a single shaft continuous screw flight is utilized. This can provide for accurate metering (provided there are no void spaces) as material displacement is directly related to shaft rotation. However, this efficient transport limits mixing to a localized rolling of independent sections of material and does not provide for mixing through the batch. In order to enhance mixing various adaptations exist such as; variation in pitch configurations, segmented flights, discontinuous flights etc. These adaptations seek to improve mixing by recirculating portions of the feedstream thereby increasing retention time intermingling different portions of the feedstream and improving homogeneity throughout the batch. This, however, limits the equipment metering capability.

b) Batch Mixing (Cone and Screw) (Figure 6-4, Appendix A) - This equipment is generally configured vertically. An orbiting screw from the bottom of the vessel to the top in a continuous pattern. This may be supplemented by a high speed delumper (shearer) in the bottom of the vessel.

d. Alternative A4 Ribbon Blender (**Figure 6-5, Appendix A**)

1) A ribbon type blender is generally operated at lower RPM's (up to 60 RPM). It mixes in the laminar range (if materials are high viscosity) as it forces viscous materials to follow a torturous path. Depending upon clearances with the vessel wall it is generally referred to as a gentle mixing action. It is not exceptionally good at eliminating agglomerates and if utilized in a process which adds liquids to the feedstream it would require the installation of Mullers which are a broad paddle type agitator designed to eliminate clumps of agglomerate by rubbing them against the vessel wall.

e. Alternative A5 Ribbon Blender with Screw Feeder

1) This is simply a combination of A4 and A3 using the ribbon blender as the primary mixing element and a hopper and volumetric screw feeder for metering waste into the new drum.

f. Alternative A6 single/Multiple Shaft Agitator (**Figure 6-6, Appendix A**)

1) These mixers are high intensity mixers combing vortex flow and high shear rates. Blades at the bottom of the vessel scoop batch material upward. The resulting high shear stresses and blade impact reduce agglomerates and aid dispersions. However, energy requirements are quite high at least 8 hp/ft^3 plus mechanical losses. These mixers are particularly suited for rapid mixing of powers and granules with liquids or dissolving of resins or solids in liquids.

2) A variation of this mixer developed by Charles Ross & Son Company utilizes a disperser blade in conjunction with an anchor type agitator.

g. Alternative A7 Single/Multiple Shaft Agitator with Screw Feeder.

1) This is a combination of A6 and A3.

h. Alternative A8 Double Arm Kneading Mixer (**Figure 6-7, Appendix A**)

1) This machine consists of two counter-rotating blades in a rectangular trough curved at the bottom to form two longitudinal half cylinders and a saddle section. The mixing action is a combination of bulk movement, smearing, stretching, folding, dividing and recombining. Clearances are generally quite tight between the blades and the trough. Blades may be tangential or overlapping. Optional blade configurations are available for a number of materials. This equipment is well suited to pastes or plastic mass types of material.

i. Alternative A9 Double Arm Kneading Mixer with Screw Feeder.

1) This is a combination of A8 and A3.

j. Alternative A10 Intensive Mixer (Banbury Type)

1) This is really a variation of the double arm kneading mixer. It's mixing blades or rotors are entirely enclosed in cylindrical chambers that meet tangentially with a saddle. The limited clearances between the blades, which resemble parallel helices, and the wall provide high intensity mixing. This equipment is widely used in the rubber and plastics industry.

k. Alternative A11 Intensive Mixer with Screw Feeder.

1) This is a combination of A10 and A3.

l. Alternative A12 Porcupine Processor (**Figure 6-8, Appendix A**)

1) This is a variation of A3. It is a screw feeder which has evolved to segmented flights in order to recirculate material and increase retention time. It is also commonly fitted with breaker bars to increase agitation. In site remediation operations it is frequently used in bulk treatment of soils. The scale is generally large and the unit may be heated to drive off Volatile Organic Compounds (VOC's).

m. Alternative A13 Porcupine Processor with Screw Feeder

1) This is a combination of A12 and A3.

n. Alternative A14 Positive Displacement Pumps.

1) This category is intended to cover all "Solids Handling Pumps". The most common examples are slurry pumps (centrifugal), diaphragm pumps (reciprocating) and positive displacement shaft pumps (twisted shaft/ elastomer jacket) "Moyno" type pumps. These pumps all require significant fluids (adequate to suspend solids) in order to function and therefore can not accommodate the full range of physical properties. They generally do not deagglomerate or mix by design. However, self wiping zero clearance combination mix and positive displacement pumps are available. Dense phase pneumatic pumps are not considered to be at all suitable due to extensive contamination issues.

o. Alternative A15 Positive Displacement Pump with Screw Feeder

1) This is a combination of A14 and A3.

5. <u>Sludge Drying</u>

a. The option exists to provide thermal drying capabilities to the equipment listed in ALT 1 to ALT 15 to primarily drive of free water from the waste. The thermal drying capability would be provided by surrounding the mixing equipment with a heating jacket. This alternative is not considered worthy of further evaluation, for the following reasons:

1) The quantity of free water present in a drum is expected to be small.

2) Free water which is present in waste to be immobilized in grout can be mixed back into the waste.

3) Free water which is present in waste to be immobilized in polymer can be absorbed using absorbent added to remove this free water will also be small.

4) Adding heating jackets to the mixing and metering equipment alternatives will give rise to additional maintenance and clean up problems.

6. Equipment Screened From Further Evaluation

a. A summary of the number of process objectives each alternatives satisfies is given in **Table 6-1**. Alternatives that have been screened from further evaluation are as follows:

1) Alternative - A 14

a) The positive displacement pump (ALT A14) does not have the ability to delump, homogenize, pretreat or control the particle size of waste to any degree by design and hence is not considered worthy of further evaluation.

2) Alternatives - A3 & A15

a) The screw feeder (ALT A3) and the combination of positive displacement pump & screw feeder (ALT A15) have a limited ability to delump, homogenize and pretreat waste and are not considered for further evaluation.

3) Alternatives - A1, A4, A6, A8, A10 & A12

a) The pug mill, ribbon blender, single/multiple shaft agitator, double arm kneading mixer, intensive mixer and porcupine processor all posses the ability to delump, homogenize, pretreat and control the particle size of materials, but do not possess the ability to meter waste to any degree of accuracy.

b. When combined with a screw feeder to transport and meter the delumped, homogenized and pre-treated wastes, each of the mixing devices listed have the ability to satisfy all process objectives. The alternatives which meet these process objectives and are considered suitable for further evaluation are listed as follows:

ALT A2 - Pug mill with screw feeder

ALT A5 - Ribbon blender with screw feeder

ALT A7 - Single/multiple shaft agitator with screw feeder

ALT A9 - Double arm kneading mixer with screw feeder

ALT A11 - Intensive mixer with screw feeder

ALT A13 - Porcupine processor with screw feeder

TABLE 6-1
SLUDGE REPACK - EQUIPMENT SCREENING

NO.	EQUIPMENT ALTERNATIVE	PROCESS OBJECTIVES ACHIEVED	SCORE	REMARKS
1	PUG MILL	1234578	7	LIMITED METERING CAPABILITY
2	PUG MILL WITH SCREW FEEDER	12345678	8	MEETS ALL PROCESS OBJECTIVES
3	SCREW FEEDER	678	3	LIMITED ABILITY TO DELUMP, HOMOGENIZE AND PRETREAT
4	RIBBON BLENDER	1234578	7	WILL NOT METER
5	RIBBON BLENDER WITH SCREW FEEDER	12345678	8	MEETS ALL PROCESS OBJECTIVES
6	SINGLE/MULTIPLE SHAFT AGITATOR	1234578	7	WILL NOT METER
7	SINGLE/MULTIPLE SHAFT AGITATOR WITH SCREW FEEDER	12345678	8	MEETS ALL PROCESS OBJECTIVES
8	DOUBLE ARM KNEADING MIXER	1234578	7	WILL NOT METER
9	DOUBLE ARM KNEADING MIXER WITH SCREW FEEDER	12345678	8	MEETS ALL PROCESS OBJECTIVES
10	INTENSIVE MIXER	1234578	7	WILL NOT METER
11	INTENSIVE MIXER WITH SCREW FEEDER	12345678	8	MEETS ALL PROCESS OBJECTIVES
12	PORCUPINE PROCESSOR	1234578	7	LIMITED METERING ABILITY
13	PORCUPINE PROCESSOR WITH SCREW FEEDER	12345678	8	MEETS ALL PROCESS OBJECTIVES
14	POSITIVE DISPLACEMENT PUMP (SOLIDS PUMP)	678	3	WILL NOT DELUMP, HOMOGENIZE AND PRETREAT FULL RANGE OF PHYSICAL CHARACTERISTICS
15	POSITIVE DISPLACEMENT PUMP WITH INTEGRAL MIXER AND WITH SCREW FEEDER	678	3	WILL NOT DELUMP, HOMOGENIZE AND PRETREAT FULL RANGE OF PHYSICAL CHARACTERISTICS

Process Objectives
1. Delump and Deagglomerate Friable Components
2. Homogenize
3. Control Moisture/Water Content
4. Ability to Mix Additives
5. Control Particle Size to 1/2"x1/2"x1/2"
6. Continuous Transport and Meter Waste to ± 2% by Mass
7. Handle Densities Up to 90 lbs/ft^3
8. Handle Viscosities Up to 120,000 cp

Physical Characteristics of the Waste
Dry Powder (Flowable)
Dry Powder with Lumps and Agglomerates
Wet Particulates
Wet Particulates with Lumps and Agglomerates
Clay Type Sludges
Clay Type Sludges with Lumps and Agglomerates
Wet Sludges
Wet Sludges with Lumps and Agglomerates

Notes
1. A positive displacement pump could be used as an alternative to a screen feeder for any option.

7. Description of Equipment Evaluation Matrix

a. The sludge repack equipment evaluation matrix is given in **Table 6-2**.

b. Potential Hazards

1) General

a) It is intended that each alternative will require operator involvement at the sorting table and that the sludge/dry particulate processing operations will be automatic. Operational exposure will hence be similar for each alternative.

2) Alternative A7 - Single/multiple shaft agitator with screw feeder and Alternate A9 - Double arm kneading mixer with screw feeder

a) These pieces of equipment require that the mixing vessel is inverted to discharge the processed waste. This increases the potential for waste to spill material during the discharge operation and hence additional clean up operations. These two alternatives have subsequently been awarded lower scores.

c. Plant Throughput

1) General

a) Plant throughput is more dependent on the operating mode of the equipment and supporting systems (loading, unloading etc.) than equipment sizing. This is because at this stage of the design equipment of any capacity (horse power, volume etc.) can be provided by vendors. Therefore, this section will consider operational modes which include, but are not limited to, batch verses continuous operation, mixing cycles, load and discharge operations, material retention etc.

2) Alternative A2 - Pug mill with screw feeder

b) This functions as a continuous mixer with no downtime for loading or unloading. There is little material retention, even with sludge feeds, because of the smooth paddle and mixing cylinder design and therefore drum to drum processing can probably proceed with minimal downtime for inspection and clean up. The screw feeder is not integral with the mixer but functions independently to control the drum filling process and therefore the equipment can be operated in parallel rather than sequentially if the series of feed drums is compatible.

TABLE 6-2

SLUDGE REPACK EQUIPMENT EVALUATION MATRIX SUMMARY SCORING

ALT A2 = Pug mill with screw feeder
ALT A5 = Ribbon blender with screw feeder
ALT A7 = Single/multiple shaft agitator with screw feeder
ALT A9 = Double arm kneading mixer with screw feeder
ALT A11 = Intensive mixer with screw feeder
ALT A13 = Porcupine processor with screw feeder

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT A2		ALT A5		ALT A7		ALT A9		ALT A11		ALT A13	
			RS	WS	RS	WS	RS	WS	RS	WS	RS	WS	RS	WS
Potential Hazards	15%	1-5	3.0	0.45	3.0	0.45	2.5	0.38	2.5	0.38	3.0	0.45	3.0	0.45
Throughput	15%	1-5	5.0	0.75	3.0	0.45	2.0	0.30	2.0	0.30	1.0	0.15	4.5	0.68
Ops & Main	15%	1-5	5.0	0.75	4.0	0.60	3.0	0.45	2.0	0.30	2.0	0.30	4.0	0.60
Dem Tech/Dev	15%	1-5	3.0	0.45	2.0	0.3	2.0	0.3	1.0	0.15	1.0	0.15	3.0	0.45
Flexibility	15%	1-5	5.0	0.75	3.0	0.45	3.0	0.45	2.0	0.30	1.0	0.15	4.0	0.60
Equipment Cost	15%	1-5	4.0	0.60	3.0	0.45	2.0	0.30	1.0	0.15	1.0	0.15	3.0	0.45
Equipment Procurement Schedule	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15	3.0	0.15
Waste Minimization	5%	1-5	3.0	0.15	3.0	0.15	3.0	0.15	2.0	0.10	2.0	0.10	2.5	0.13
				4.05		3.0		2.48		1.83		1.60		3.51
Total														

3) Alternative A5 - Ribbon blender with screw feeder

a) The ribbon blender functions primarily as a batch type mixer. Unloading requires an intermediate step to open the bottom discharge and power the mixer to drive out the material. There is a much higher likelihood of sludge retention due to the broad continuous configuration of the paddles

4) Alternative A7 - Single/multiple shaft agitator with screw feeder

a) The single/multiple shaft agitator functions primarily as a batch type mixer. Unloading requires several intermediate steps to open and unload the mixing vessel. Material retention is likely particularly with sludges.

5) Alternative A9 - Double arm kneading mixer with screw feeder

a) This is a batch type operation. Unloading requires tipping the vessel or use of an integral screw feeder located between the blades in order to discharge material. After the mixing cycle is complete the mixer must be powered to force material to the unloading screw feeder. This integral screw feeder would be independent of the screw feeder used to meter processed waste into drums in order to allow for unload of the mixer in a continuous fashion. Material retention is likely particularly with slurries.

6) Alternative A11 - Intensive mixer with screw feeder

a) This functions in a batch mode similar to the double arm kneading mixer. However, its design requires the use of a ram type feeder in order to present material to the mixing blades. The clearance between the mixing blades and the mixing vessel are very small which results in high operational power requirements and small batch sizes. This equipment is least likely to accommodate plant throughput and hence is awarded a low score.

7) Alternative A13 - Porcupine processor with screw feeder

a) The porcupine processor operates in a continuous mode with no intermediate steps for loading or unloading. However, mixing is enhanced by the use of static breaker bars. These porcupine processor can however, accumulate waste between the breaker bars and the screw flight, particularly between campaigned lots of differing waste types, i.e. sludges followed by dry particulates. Accumulation of this waste over a period of time may result in downtime for inspection and cleaning.

d. Operability and Maintainability

1) General

a) It is intended that each alternative will require operator involvement at the sorting table and that the sludge/dry particulate processing operations will be automatic. Each of the alternatives will hence require a similar number of operators.

2) Alternative A2 - Pug mill with screw feeder

   a) The pug mill is a very robust piece of equipment which is designed to process material such as soil and sludge. Consequently, it is less susceptible to damage as a result of processing hard items which may be present in the waste, and hence will require minimal breakdown maintenance and repair. The pug mill mixing paddles are individually mounted on the mixing shaft and damage to one blade will not result in the equipment being shut down, this also allows paddles to be easily replaced or adjusted without removing the mixing shaft. Limited clean up is required between campaigns.

3) Alternative A5 - Ribbon blender with screw feeder

   a) In general, ribbon blenders are designed to mix regular type feeds and hence are more likely to be susceptible damage when mixing a wide variety of waste. Replacement of the ribbon blade necessitates that the both the ribbon blade and the mixing shaft are removed from the mixing vessel. In addition, scheduled clean up will be required due to cumulative material accumulation.

4) Alternative A7 - Single/multiple shaft agitator with screw feeder

   a) The single/multiple shaft agitator is a relatively large/complex piece of equipment which will be difficult to maintain/dismantle. In addition, scheduled clean up will be required due to cumulative material accumulation.

5) Alternative A9 - Double arm kneading mixer with screw feeder and Alternative A11 - Intensive mixer with screw feeder

   a) These pieces of equipment require that the mixing vessel is inverted to discharge the processed waste, this is an additional operation not required by the other alternatives. The double arm kneading mixer and the intensive mixer utilize counter rotating shafts and are hence more complex and difficult to maintain than the other options. The intensive mixer operates with very low clearance between the mixing shaft and the mixing vessel which causes the equipment to operate at higher stresses and necessitates the equipment to require cooling. In general the double arm kneading mixer and the intensive mixer are used to mix regular feeds. In addition, scheduled clean up will be required due to cumulative material accumulation.

6) Alternative A13 - Porcupine processor with screw feeder

a) The porcupine processor is a very robust piece of equipment which is designed to process material such as soils. Consequently, it is less susceptible to damage as a result of processing hard items which may be present in the waste, and hence will require minimal breakdown maintenance and repair. The porcupine processor mixing flight rotates between breaker bars which will accumulate material and require more clean up than the pug mill. In addition, if the sludge/dry particulate contains any hard object which may not be removed from the waste while on the sorting table (i.e. rocks in the basin sludge, shredded drums or cinders in the ash) then these may jam between the breaker bars and the screw flight of the porcupine processor thus resulting in the equipment being shut down until the blockage is removed. Replacement of the mixing flight will require the full mixing shaft to be replaced. In addition, scheduled clean up will be required due to cumulative material accumulation.

e. Demonstrated Technology/Development Requirements

1) General

a) None of the alternatives have been demonstrated to delump and homogenize waste in the nuclear industry.

2) Alternative A2 - Pug mill with screw feeder

a) Pug mills are commonly used to process sludges, soils, clay etc. outside the nuclear industry. Concord Resources Group (commonly known as Highway 36) intend to use a pug mill to mix hazardous waste prior to immobilization.

3) Alternative A5 - Ribbon blender with screw feeder

a) Ribbon blenders are used outside the nuclear industry to mix regular feeds such as powders and dry particulates.

4) Alternative A7 - Single/multiple shaft agitator with screw feeder

a) BNFL uses a single shaft in-drum agitator paddle to mix dilute radioactive slurries and cement powder in order to immobilize the slurry in a grout matrix. Standard single/multiple shaft agitators are used outside the nuclear industry to dissolve powders and dry particulates in liquids.

5) Alternative A9 - Double arm kneading mixer with screw feeder and Alternative A11 - Intensive mixer with screw feeder

a) Double arm kneading mixers and intensive mixers are mainly used outside the nuclear industry to mix rubber, plastics and resins.

6) Alternative A13 - Porcupine processor with screw feeder

a) Porcupine processors are used outside the nuclear industry to break up and mix soils. They are frequently used in the land remediation of hazardous waste and contaminated soils.

f. Flexibility

1) Alternative A2 - Pug mill with screw feeder

a) The pug mill is a very robust piece of equipment which can be used to process a wide variety of materials and consequently is likely to be able to accommodate a greater variety of waste feedstreams. Throughput is increased by increasing mixer speed while verifying adequate mixing.

2) Alternative A5 - Ribbon blender with screw feeder and Alternative A7 - Single/multiple shaft agitator with screw feeder

a) These pieces of equipment are used to process regular feeds such as powders and hence cannot be used to mix a wide variety of materials. Throughput is a function of load, unload and mixing times.

3) Alternative A9 - Double arm kneading mixer with screw feeder and Alternative A11 - Intensive mixer with screw feeder

a) These pieces of equipment utilize very small clearances between the mixing blade and the mixing vessel and are most suitable for processing smooth paste type materials. Throughput is a function of load, unload and mixing times.

4) Alternative A13 - Porcupine processor with screw feeder

a) The porcupine processor is a very robust piece of equipment which is suitable for handling a variety of wastes. However, the porcupine processor operates by passing the screw flight past breaker bars mounted from the mixing vessel wall, this consequently increases the likelihood of material being caught in this clearance and subsequent jamming of the machine. Jamming of waste between the breaker bar and the screw flight of the porcupine processor will place some restrictions on the range of waste that can be processed by the machine.

g. Equipment Cost

1) Alternative A2 - Pug mill with screw feeder

	Equipment Cost $K
Pug Mill	20.0
Screw Feeder	10.0
Total	30.0

2) Alternative A5 - Ribbon blender with screw feeder

	Equipment Cost $K
Ribbon Blender	30.0
Screw Feeder	10.0
Total	40.0

3) Alternative A7 - Single/multiple shaft agitator with screw feeder

	Equipment Cost $K
Single/Multiple Shaft Agitator	70.0
Screw Feeder	10.0
Total	80.0

4) Alternative A9 - Double arm kneading mixer with screw feeder

	Equipment Cost $K
Double Arm Kneading Mixer	500.0
Screw Feeder	10.0
Total	510.0

5) Alternative A11 - Intensive mixer with screw feeder

	Equipment Cost $K
Intensive Mixer	500.0
Screw Feeder	10.0
Total	510.0

6) Alternative A13 - Porcupine processor with screw feeder

	Equipment Cost $K
Porcupine processor	30.0
Screw Feeder	10.0
Total	40.0

h. Equipment Procurement Schedule

1) General

a) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

i. Waste Minimization/Secondary Waste Generation

1) General

a) All alternatives will be required to process a wide variety of wastes such as sludges, soils, dry particulates etc. and will consequently require a high degree of clean up, particularly between feedstream campaigns.

2) Alternative A2 - Pug Mill with screw feeder, Alternative A5 - Ribbon blender and screw feeder and Alternative A7 - Single/multiple shaft agitator with screw feeds.

a) No significant differences are considered to exist between each alternative from a waste minimization/secondary waste generation stand point.

3) Alternative A9 - Double arm kneading mixer with screw feeder and Alternative A11 - Intensive mixer with screw feeder

a) The high forces which occur between the mixing shaft and the mixing vessel will press waste into the shaft and vessel surface and will subsequently make clean up more difficult and possibly require decontamination.

4) Alternative A13 - Porcupine processor with screw feeder

a) The porcupine processor will accumulate material between the screw flight and the breaker bar which will result in additional clean up requirements.

8. Conclusions

a. It is recognized that some pretreatment of waste may be required for sludge and dry particulate wastes which are to be immobilized using agitated mixing techniques. Although the extent of this pretreatment is at present is unknown it is estimated that the equipment required to process the waste must be able to carry out the following objectives:

1) Delump and deagglomerate friable components.

2) Achieve a product which is visibly homogeneous.

3) Control moisture/water content

4) The capability to mix dry or liquid additives.

5) Control particle size. The maximum output particle size is anticipated to be 1/2"x1/2"x1/2".

6) The capability to transport and meter waste into a new drum within an accuracy of ±2% by mass.

7) Handle densities up to 90 lbs/ft^3.

8) Handle viscosities up to 120,000 cp.

9) The equipment selected must be capable of a maximum feed rate of 30 ft^3/hr. This is based on the ability to handle a maximum plant throughput of approximately 25 input drums per day (150 ft^3/day, assuming the drums are not 100% full) as identified by the CDR baseline design. Assuming the maximum density of waste, the equipment must be capable of achieving a maximum mass feed rate of 2700 lbs/hr.

b. The most suitable piece of equipment to meet process objectives for the WRAP 2A sludge and dry particulate feedstreams is a pug mill to mix the wastes followed by a screw feeder to meter the processed waste into the new drums.

9. Recommendations

a. The WRAP 2A Title I design should progress on the basis that the combination of a pug mill and screw feeder should be incorporated into the WRAP 2A facility to process those wastes which require pretreatment prior to immobilization.

6.2 Process Routes Evaluation

1. Introduction

   a. For the purpose of discussion five options are described as limiting conditions for normal process operation. These options envelope all possible variations of the two available process routes. After an optimum case is selected, that maximizes process flexibility and related evaluation criteria, then the waste feedstreams will be discussed individually, describing the physical characteristics of the feed that are controlling methods of treatment.

2. List and Description of Alternatives

   a. Alternative B1 (Fixed Routes)

      All dry particulate feedstreams are processed through direct repack line. Ion exchange resins and wet particulate are processed through the sludge repack line.

   b. Alternative B2 (Single Route)

      All feedstreams are processed through the sludge repack line.

   c. Alternative B3 (Single Route)

      All feedstreams are processed through the direct repack line.

   d. Alternative B4 (Prioritized Routes)

      All feedstreams routed to sludge repack line as primary process route. The direct repack line is available as a secondary route.

   e. Alternative B5 (Prioritized Routes)

      All feedstreams are routed to the direct repack as the primary process route. The sludge repack line is available as a secondary route.

3. Evaluation of Process Routes

   a. As a result of the uncertain physical characteristics of the WRAP 2A wastes, agglomeration of dry powder and particulate wastes cannot be disregarded. Consequently, it has been assumed that all which do not require shredding will require delumping and homogenizing prior to immobilization.

   b. The summary scoring of the process route evaluation is given in **Table 6-3**. The table indicates that the sludge repack line should be utilized as the primary process route for all subject feedstreams with the direct repack line maintained as an optional (secondary) process route.

TABLE 6-3
SCORING SUMMARY PROCESS ROUTES EVALUATION

ALT	Oper & Maint	Flexibility	Plant Throughput	Waste Generation	Average	Remarks
B1	2	3	3	5	3.25	Lack of absolute control of incoming wastes physical state reduces this options viability.
B2	4	4	4	4	4	This option is slightly less flexible than the optimum option.
B3	1	1	1	1	1	This option's not acceptable in any category.
B4	5	5	5	3	4.5	This option is the most flexible and most likely to exceed existing plant throughput rates.
B5	3	2	2	2	2.25	Places too high a priority on direct repack.

c. Having identified the primary and secondary process routes available **Table 6-4** provides operations logic for each feedstream campaign:

TABLE 6-4
PROCESS ROUTE DISCUSSION

Feedstream	Process Route Discussion
1B 183H Crystalline Solid	Requires routing through sludge repack in order to size reduce lumps of friable material. However, if determined upon inspection to be consistently dry powder direct repack is acceptable.
1C 183H Sludge	Requires routing through sludge repack as it is identified as wet to semi dry sludge with crystalline inclusions. Therefore it requires size reduction of friable material and subsequent homogenization.
2A Ammonium Sulphate	Requires routing through sludge repack to size reduce lumps of friable material; if they occur after packaging at generator due to hygroscopic nature of the material. If dry powder state is maintained material can go through the direct repack line as selected in the CDR.
2B Ion Exchange Resin	Requires routing and metering via the sludge repack line. May be wet slurry.
2C Metal Sludge	Requires routing and via the sludge repack line. Will be a clay like material.
6 Absorbed Chemicals	Requires routing through the sludge repack line in order to delump and homogenize.
7 Incinerator Ash	This waste stream should be considered for primary routing through the direct repack area; if it is likely that the stream will contain lumps of metal and large pieces of concrete. These materials which are not friable and form only a portion of the feedstream can be isolated for additional size reduction by shredding while the particulate is loaded into drums for later agitated treatment.
8 Contaminated Soils	This waste stream should be handled in a manner similar to 7 if many non friable materials (large stones) are present.

4. Conclusions

a. As a result of the uncertain physical characteristics of the WRAP 2A wastes, agglomeration of dry powder and particulate wastes cannot be disregarded. Consequently, it has been assumed that all wastes which do not require shredding will require delumping and homogenizing prior to immobilization. The preferred process routes for non shredded feedstreams is provided in **Table 6-5**.

5. Recommendations

a. The WRAP 2A Process documentation should be revised to route all wastes which do not require shredding through the sludge repack line. A continual review of the WRAP 2A waste characteristics, particularly with respect to feedstreams 2A, 7 and 8, must be performed in order to optimize the waste treatment process routes and minimize unnecessary treatment and handling. Additionally administrative controls particularly with respect to scheduling waste campaigns are important in terms of minimizing equipment downtime for clean up.

TABLE 6-5
PREFERRED PROCESS ROUTES FOR WRAP 2A FEEDSTREAMS

WRAP 2A Feedstream	Dry Particulate	Wet Particulate	Ion Exchange Resins	Sludge Repack	Direct Repack
1B 183 H Crystalline Solid	32,500 (4.5%)			Preferred	
1C 183 H Sludge		34,00 (4.8%)		Preferred	
2A Ammonium Sulfate	261,500 (36.1%)			Preferred	Optional
2B Ion Exchange Resins			53,500 (7.4%)	Preferred	
2C Metal Sludge		76,250 (10.5%)		Preferred	
6 Absorbed Chemicals	42,500 (5.9%)			Preferred	
7 Incinerator Ash	57,500 (7.9%)			Preferred	Optional
8 Contaminated Soils	17,000 (2.3%)			Preferred	Optional

Notes:

1. Values are ft^3 volume

2. Values in ( ) are % volume of total plant feed

6.3 Process Routes For Plastic Bags

1. Introduction

   a. The purpose of this assessment is to determine the most suitable method of processing the plastic bags after the bag is opened and the sludge removed onto the sorting table.

2. List of Alternatives

   a. ALT C1 = Feed into sludge processing equipment

   b. ALT C2 = Shred the plastic bags

3. Description of Alternatives

   a. ALT C1 Feed into sludge processing equipment

      1) This alternative proposes that the plastic bags are processed along with the sludge in the sludge processing equipment. The plastic bag will be have to be size reduced during this process such that, after processing, the size of any piece of the bag is acceptable for processing in either grout or polymer.

   b. ALT C2 Shred the plastic bags

      1) Once the plastic bag and the sludge has been separated using the sorting manipulators, the bag is transferred to the Size Reduction and Repack enclosure in an empty drum for shredding.

   c. It is likely a plastic bag which has contained sludge will remain as LLRMW and cannot be classified as purely LLW when empty. Therefore, compaction and disposal of plastic bags as LLW has not been considered as part of this study. In addition there is a possibility that some plastic bags will have degraded/leaked over a period of time in storage or become torn during filling or emptying operations. Hence it is likely that some drums that have contained plastic bags will be contaminated with sludge and cannot be classified as purely LLW when the plastic bags have been removed and also could not be routed for compaction.

4. Description of Evaluation Matrix

   a. In section 6.1 the pug mill type mixer was identified to be the most suitable piece of equipment to process sludge and dry particulate materials in the Sludge Repacking enclosure. This section will hence evaluate the alternatives of processing plastic bags in the pug mill and shredding plastic bags in the Size Reduction and Repack enclosure.

b. In order to evaluate the most suitable method of processing plastic bags, the number of plastic bags expected to be processed must be established. The baseline CDR design is based on information that all waste to be processed in WRAP 2A is packaged within plastic bags which are in turn contained within drums. Currently existing waste is packaged in plastic bags and all future waste will be packaged in rigid liners. Approximately 25,000 drums of waste will be processed in the Sludge Repack enclosure, if it is assumed that 85% of these drums will contain rigid liners and 15% contain plastic bags, then approximately 4,000 plastic bags will arise in the Sludge Repack enclosure.

c. Although limited Information exists at present on the 90 mil liners, it will not be possible to process them in the pug mill. As for the plastic bags, it is likely that a rigid liner which has contained sludge will remain as LLRMW and cannot be classified as purely LLW. Consequently the only viable process alternative for the rigid liners is shredding in the Size Reduction and Repack enclosure.

d. The evaluation matrix for this study is given in **Table 6-6**.

e. Safety

   1) Neither alternative has major safety implications.

f. Plant Throughput

   1) Processing plastic bags in the pug mill will inhibit the ability of the equipment to homogenize the sludge, increase the required mixing time and hence reduce throughput.

   2) Alternative C2 represents the baseline CDR design in which it is proposed that plastic bags be removed from the waste when on the sorting table, placed back into the empty drum and transferred to the Size Reduction enclosure for shredding. Drum liners can also be transferred to the Size Reduction and Repack enclosure for shredding in the same manner.

g. Operability and Maintainability

   1) Processing plastic bags in the pug mill will cause the plastic bags to become entangled around the pug mill shafts and blades, this will require additional operator involvement to remove the plastic bags.

   2) Although there are more operations involved to transfer the plastic bags to the Size Reduction enclosure for shredding, these can be carried out automatically and will not require significant operator involvement. An the number of plastic bags to be shredded is anticipated to be relatively low (approximately 15% of the drums will have waste contained in plastic bags) it is proposed that the cheapest and simplest method of handling and transporting the plastic bags to the shredder is individually in the drum in which the plastic bag and waste was contained.

   3) Both the shredder and pug mill can be configured such that prime movers are mounted outside containment with through wall drives to the equipment.

TABLE 6-6
PROCESS ROUTES FOR PLASTIC BAGS

ALT C1 = Feed into Sludge Processing Equipment
ALT C2 = Shred Plastic Bags

RS = Raw Score
WS = Weighted Score

Evaluation Criteria	Weighting Factor	Score Range	ALT C1		ALT C2	
Safety	15%	1-5	3.0	0.45	3.0	0.45
Throughput	15%	1-5	3.0	0.45	3.0	0.45
Ops & Main	15%	1-5	2.0	0.30	3.0	0.45
Dem Tech/Dev	15%	1-5	2.0	0.30	3.0	0.45
Flexibility	15%	1-5	3.0	0.45	3.0	0.45
Equipment Cost	15%	1-5	3.0	0.45	3.0	0.45
Equipment Procurement Sched	5%	1-5	3.0	0.15	3.0	0.15
Waste Min	5%	1-5	3.0	0.15	2.5	0.13
Total	100%			2.7		2.98

h. Demonstrated Technology

1) Shredding of soft wastes such as plastic bags is carried on outside the nuclear industry. The Waste Treatment Complex at BNFL's Sellafield Site in the UK was originally built to shred soft wastes.

2) Pug mills are not normally used for processing waste mixed with plastic bags.

i. Flexibility

1) No significant differences in flexibility are considered to exist between each alternative.

j. Equipment Cost

1) The alternatives of processing plastic bags in the pug mill or in the shredder requires no additional equipment than that identified in the baseline CDR design and there is no difference between each alternative from an equipment cost standpoint.

k. Equipment Procurement Schedule

1) No significant differences are considered to exist between each alternative from an equipment procurement schedule standpoint.

l. Waste Minimization Including Secondary Waste Generation

1) Shredding plastic bags which have contained sludge is likely to result in some of the sludge coated on the inside of the plastic bag to be transferred onto the shredder. This will increase shredder clean up requirements and secondary waste generation. The amount of sludge transferred from the plastic bag to the shredder is not expected to be significant.

5. Conclusions

a. Plastic bags arising from drum opening operations in the sludge repack enclosure should be transferred to the Size Reduction and Repack enclosure and shredded.

6. Recommendations

a. The WRAP 2A Title I design should progress on the basis that empty plastic bags from the sludge repack area should be shredded in the Size Reduction enclosure.

6.4 Sludge Additive Requirements

1. The current CDR baseline design proposes that waste from the sludge repacking enclosure is immobilized in either a polymer or grout matrix. Addition of either polymer or grout based liquors may therefore be required to assist mixing or dilution of the sludge:

   a. Grout

      If the sludge is to be immobilized in grout, then water will be used for mixing and dilution. Addition of water to dry particulate material is likely to give rise to additional cleaning requirements although in general, addition of water to the sludge will not give rise to additional safety problems.

   b. Polymer

      If the sludge is to be immobilized in polymer then either Vinyl Ester Styrene (VES) or Styrene (solvent) should be used for mixing and dilution. Addition of either material to the sludge in the sludge repacking enclosure will give rise to additional safety problems, in particular fire and explosion. Either VES or Styrene have a greater potential to interact with the waste if added prior to mixing. This may lead to either premature polymerization or deactivation of the resin due to catalytic or inhibiting effects of compounds within the waste. This may cause additional clean up problems in the sludge processing equipment and also additional problems in achieving satisfactory immobilization in the polymer process.

   c. The type of immobilization process(es) to be used in WRAP 2A will be determined by the Single Immobilization Study. As this information is at present unavailable, this study will assume the CDR baseline design of both grout and polymer lines being required to immobilize waste.

2. The type of additive introduced into the pug mill to assist processing is related to the characteristics of the sludge. The three additives that could be introduced in the pug mill are:

   a. Absorbent to dry sludge with a high moisture/water content.

   b. Water to dilute solidified waste that is to be immobilized in grout.

   c. VES/Styrene to dilute solidified waste that is to be immobilized in polymer.

3. Addition of VES or styrene to assist processing in the pug mill is not a preferred option due to the safety problems of fire and explosion associated with these materials.

4. Although limited information exists on the characteristics of the waste it is known that some of the sludge is water based having high moisture content or even contain free water. VES resin or Styrene are immiscible with water. Therefore, any free water must be emulsified to be contained within the VES or Styrene liquid phase as the discontinuous (Droplet) phase. The mixing intensity required for emulsification is in the order of 0.1 HP/ft^3. It is therefore preferable to reduce the free water content in the waste before being immobilized in polymer. In order achieve this, it is proposed that the water in the sludge is absorbed prior to being transferred to the polymer process.

5. The sludge which is fed to WRAP 2A will have varied moisture/liquid content which may range from dried out cake to a liquid type sludge. In order to immobilize the sludge in grout, water will have to be added to the waste prior to the addition of cement powder. This water can either be added at the grouting process area or in the sludge repack area or both. In the grouting process it is proposed that the in drum mixing paddle is activated and the sludge stirred in the drum prior to the addition of water or grout powder. In order to assist start up of the paddle in the drum it may be beneficial to add water to the sludge in the pug mill. WHC immobilization trials will provide information on mixing paddle performance, from which the water addition requirements can be established.

6. The WRAP 2A Title I design should progress on the basis that provision to add either absorbent or water to the waste processed in the pug mill is included in the Sludge Repacking enclosure.

7.0 DISCUSSION OF PREFERRED ALTERNATIVES

7.1 Sludge Processing Equipment

1. Discussion with vendors indicates that a single shaft pug mill style blender with a drive of approximately 5 HP would be suitable to process WRAP 2A sludge. The pug mill utilizes individually mounted paddles which are staggered along the mixer shaft to provide impact energy, mixing and forward motion to the material being treated. Material progression can be adjusted by altering the pug mill shaft speed. The pug mill will be constructed from stainless steel to eliminate corrosion problems associated with processing the sludge. The pug mill drive will be located external to the glovebox enclosure to simplify maintenance and replacement operations. A breaker bar can be integrally mounted on the front end of the equipment to breakdown lumps and assist in homogenizing sludge in the pug mill. The pug mill is primarily used for mixing, homogenizing and transferring sludge forward, and is of limited use for accurately metering sludge into new drums. Discussions with vendors has identified a surge hopper and volumetric feeder to accumulate treated material and meter it into new drums.

7.2 Sludge and Dry Particulate Process Routes

1. Process route selection has been arrived at by reviewing the subject potential feedstreams and assuming the most conservative physical state, (i.e. All sludge and dry particulate feedstreams include large irregular agglomeration and lumping) that requires pre-treatment. It should be noted that three feedstreams in particular should be considered for treatment in other than the Sludge Repack line. Two; contaminated soils and incinerator ash may contain large dense chunks of non friable material together with dry particulate. If this is the case and these items either cannot satisfactorily or efficiently be removed from the waste using the manipulators before being charged into the pug mill, then neither of these waste feedstreams is truly compatible with the sludge repack line. Ammonium sulfate which may be a relatively fine light all dry powder which is easily repacked without physical pre-treatment may give rise to contamination problems if processed in the pug mill. In order to maximize facility flexibility, the direct repack line is sized to accommodate all potential feedstreams.

7.3 Process Routes For Plastic Bag and Rigid Liners

1. Initial information from WHC indicates that sludge will arrive at the Sludge Repack enclosure in the following containers:

   a. Sludge which is contained in HDPE 90 mil rigid liners inside 55 Gallon drums.

   b. Sludge which is contained in 10 mil plastic bags inside 55 Gallon drums.

   c. Sludge which is contained in 10 mil plastic bags inside HDPE 90 mil rigid liners which in turn have been placed in 55 Gal drums.

2. As stated previously it is likely that both plastic bags and rigid liners which have been in direct contact with the sludge will remain as LLRMW and cannot be classified as purely LLW when empty. In addition it is possible some drums that have contained plastic bags will be contaminated with sludge as a result of the plastic bag leaking and also cannot be classified as purely LLW. Therefore, compaction and disposal as LLW of plastic bags, rigid liners and some drums is unlikely to be possible. Consequently the only viable process alternative for the plastic bags and rigid liners is shredding in the Size Reduction and Repack enclosure.

3. In order to shred the plastic bags, the empty container in which the sludge and plastic bag was contained, can be used to transport the plastic bag to the Size Reduction and Repack enclosure. Once at the Size Reduction and Repack enclosure both plastic bag and empty drum will be shredded.

7.4 Sludge Additive Requirements

1. Addition of Water to waste to assist Immobilization in Grout

   a. At present it is not known whether addition of water to the sludge during homogenization in the pug mill will be required to assist in drum mixing operations for the grout process. However the possible range of water which might be added the Sludge in the Sludge Repack enclosure can be estimated as follows:

      1) Lower Limit of Water Additive

         If WHC grouting trials determine that there is limited or no benefit in adding water to the sludge or dry particulate waste prior to being processed in the grout area, then the addition of water to the waste in the Sludge Repack enclosure will not be required.

         Upper Limit of Water Additive

         In order to estimate the Upper Limit of water which might have to be added in the pug mill, consider the following assumptions:

         a) All water is added to the waste in the pug mill and not in the grouting area.

         b) The quantity of water present in the sludge will be deducted from the quantity required for the grout formulation.

         c) The composition of the grout is 0.35 H_2O : 1.0 Ordinary Portland Cement (OPC)/Blast Furnace Slag(BFS)

         d) The density of grout is 90 lb/ft^3

         e) The density of sludge is 90 lb/ft^3

f) The density of water is 62.5 lb/ft^3

g) The minimum moisture content of the waste is 0% by weight.

h) The average moisture content of the waste is 20% by weight.

i) The quantity of water which may be added to the sludge is calculated in **Table 7-1** below:

TABLE 7-1
ADDITION OF WATER TO SLUDGE

The mass of sludge in a drum	=	Vol of drum X % fill X Density of sludge
	=	7.4 X 0.9 X 90 lbs
	=	600 lbs
For Min moisture content (0%)		600 lbs is solid 0 lbs is water
For Average moisture content (20%)		480 lbs is solid 120 lbs is water
Mass of grout to be added	=	Mass of Solid content of sludge
	=	570 lbs for Min moisture content
	=	480 lbs for Average moisture content
Mass of grout to be added	=	Mass of OPC/PFA + Mass of Water Added + Mass of Water in Sludge
Hence		
Mass of Water Added	=	Mass of Grout - Mass of OPC/PFA - Mass of Water in Sludge
Mass of Water for Minimum Moisture content	=	600 - (1/1.35)X600 - 0
	=	156 lbs
Maximum Volume of Water	=	156/62.5
	=	2.50 ft^3
Mass of Water for Average Moisture content	=	480 - (1/1.35)X480 - 120
	=	4.0 lbs
Average Volume of Water	=	4.0/62.5
	=	0.06 ft^3

b. The quantity of water which might have to be added to the sludge in the pug mill is hence estimated to be in the range 0 - 2.5 ft^3. If all the water is added to the sludge in the pug mill and not in the grout area then on average 0.06 ft^3 of water will have to be added to each batch of sludge.

2. Addition of Absorbent to Waste to Allow Encapsulation in Polymer

a. It is recognized that any free water that is present in the waste, will have to be removed to allow it to be immobilized in a polymer matrix. Discussions with vendors[6] indicate that products are available that have an absorption efficiency in the order of 400% (i.e. 1 lb of absorbent will absorb 4 lbs of water). If it is assumed that as a worst case, 15% of the volume of a drum will be free water requiring removal, then:

Mass of water requiring absorption
= 0.15 X 7.4 X 62.5 = 69 lbs

Mass of Absorption material required
= 69/4 = 18 lbs

Volume of Absorbent material @ 5 lbs/ft ^{3}
= 18/5 = 3.6 ft ^{3}

b. If in a worst case the absorption efficiency of the absorbent was only 100% (i.e. 1 lb of absorbent will absorb 1 lb of water) then;

Mass of absorption material required
= 69 lbs

Volume of absorption material @ 5 lbs/ft^3
= 69/5 = 13.8 ft^3

c. The quantity of absorbent material which might have to be added to absorb free water in a drum is hence estimated to be in the range 0-13.8 ft^3

8.0 REFERENCES

1. WRAP 2A ACDR Work Plan, 26 January 1993.

2. WRAP 2A Conceptual Design Report, Prepared by UE&C for US-DOE, July 1992.

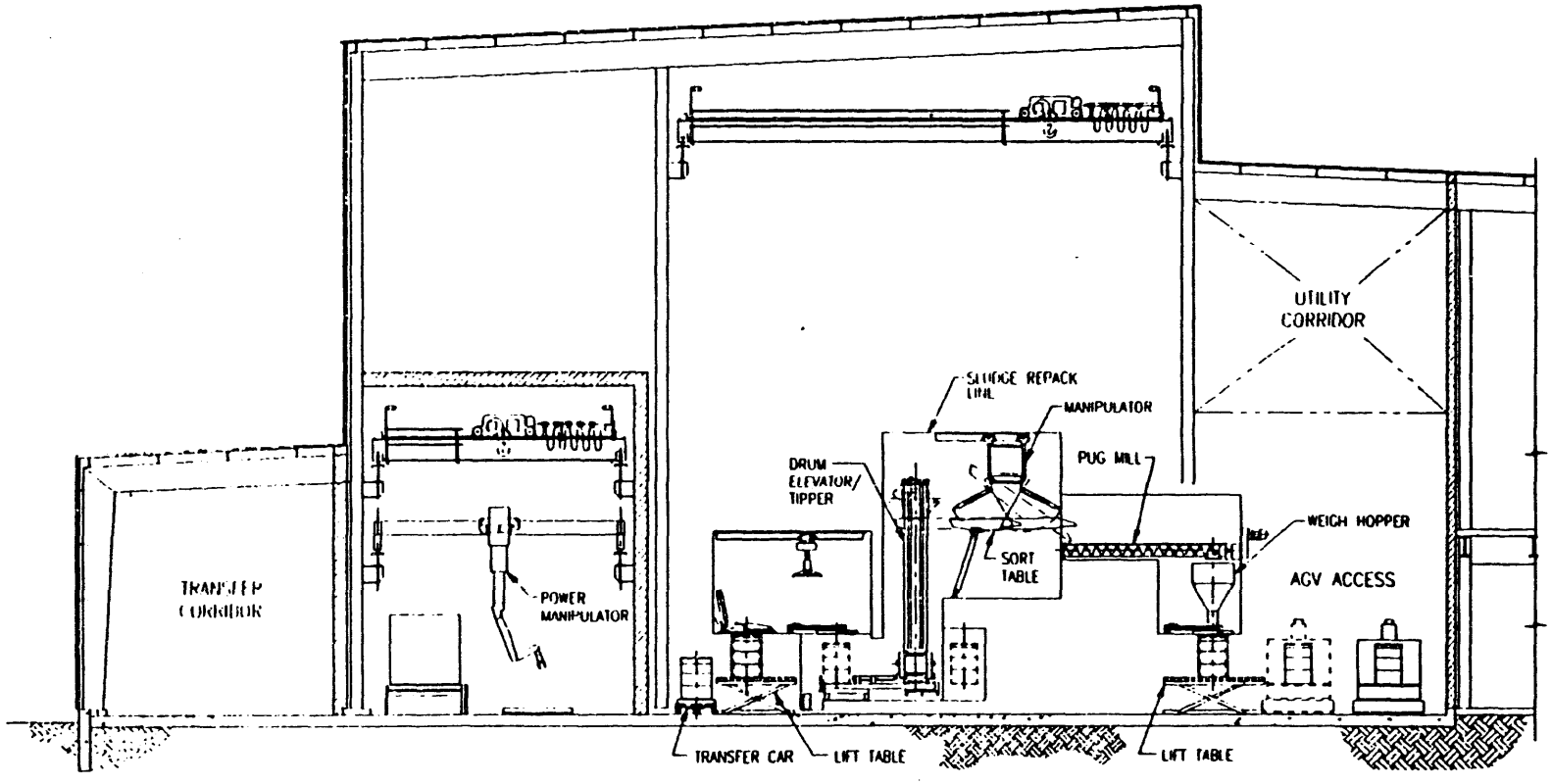
3. WRAP 2A Advanced Conceptual Design Report Study, 1605-5, Open Sort and Size Reduction Evaluation, Prepared by UE&C for US-DOE May 1993.

4. WRAP 2A Functional Design Criteria Revision 1, J Westcott WHC, 14 December 1992.

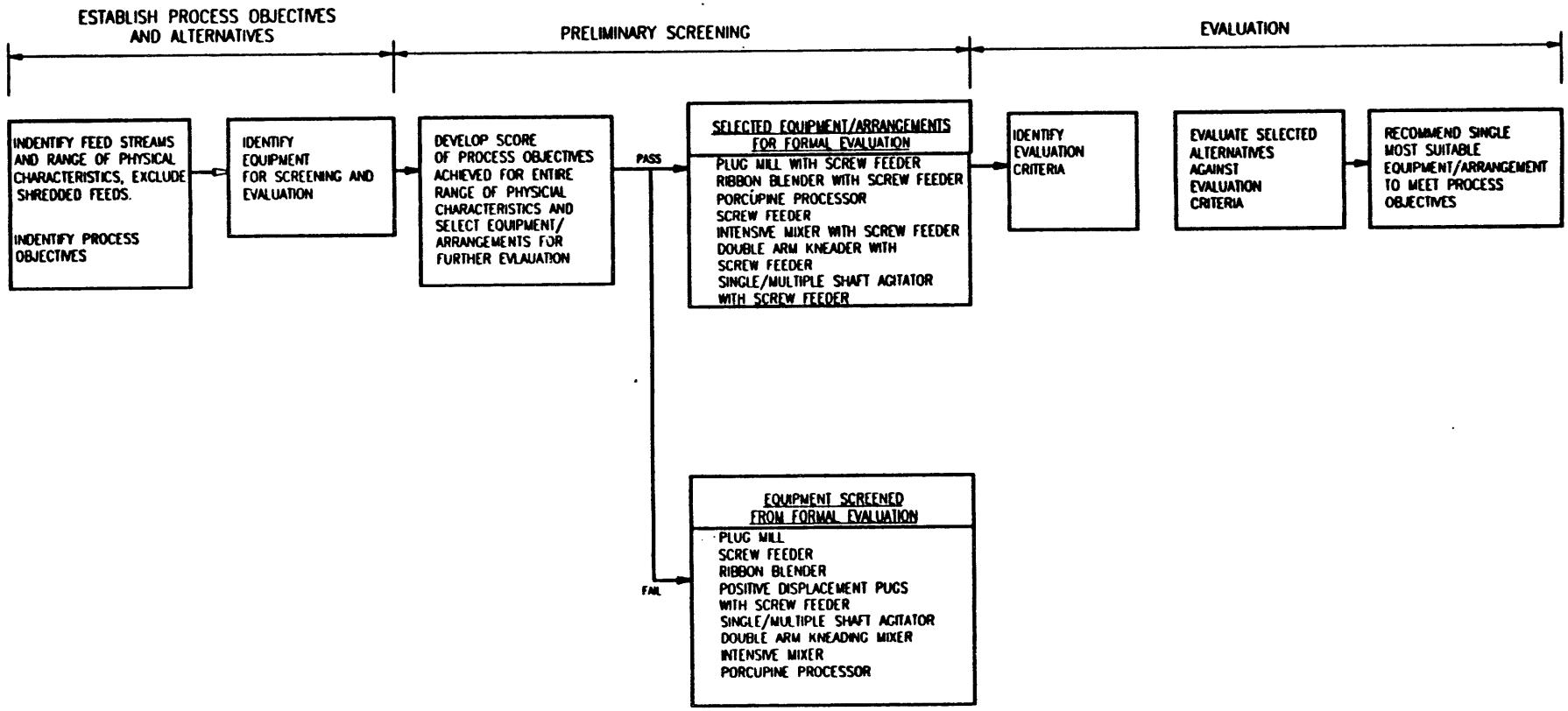
5. Perry's Chemical Engineering Handbook, Sixth Edition, Perry & Green, 1984.

6. Telecon Note TC93035.008: S.A. Sharpe - J. Larson, 10 June 1993.

APPENDIX A
FIGURES

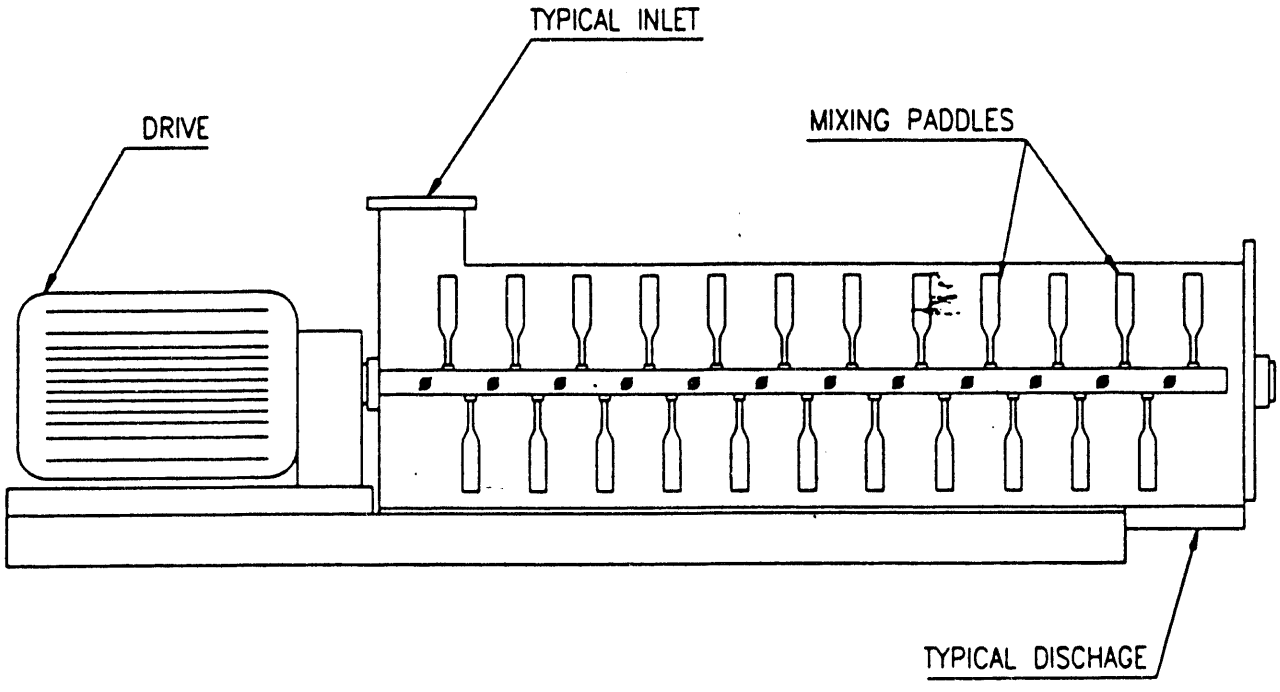


CONCEPTUAL DESIGN
CDR BASELINE DESIGN
SLUDGE REPACK ENCLOSURE
FIGURE 1-1



SLUDGE REPACK STUDY EQUIPMENT SCREENING LOGIC DIAGRAM

FIGURE 5-1



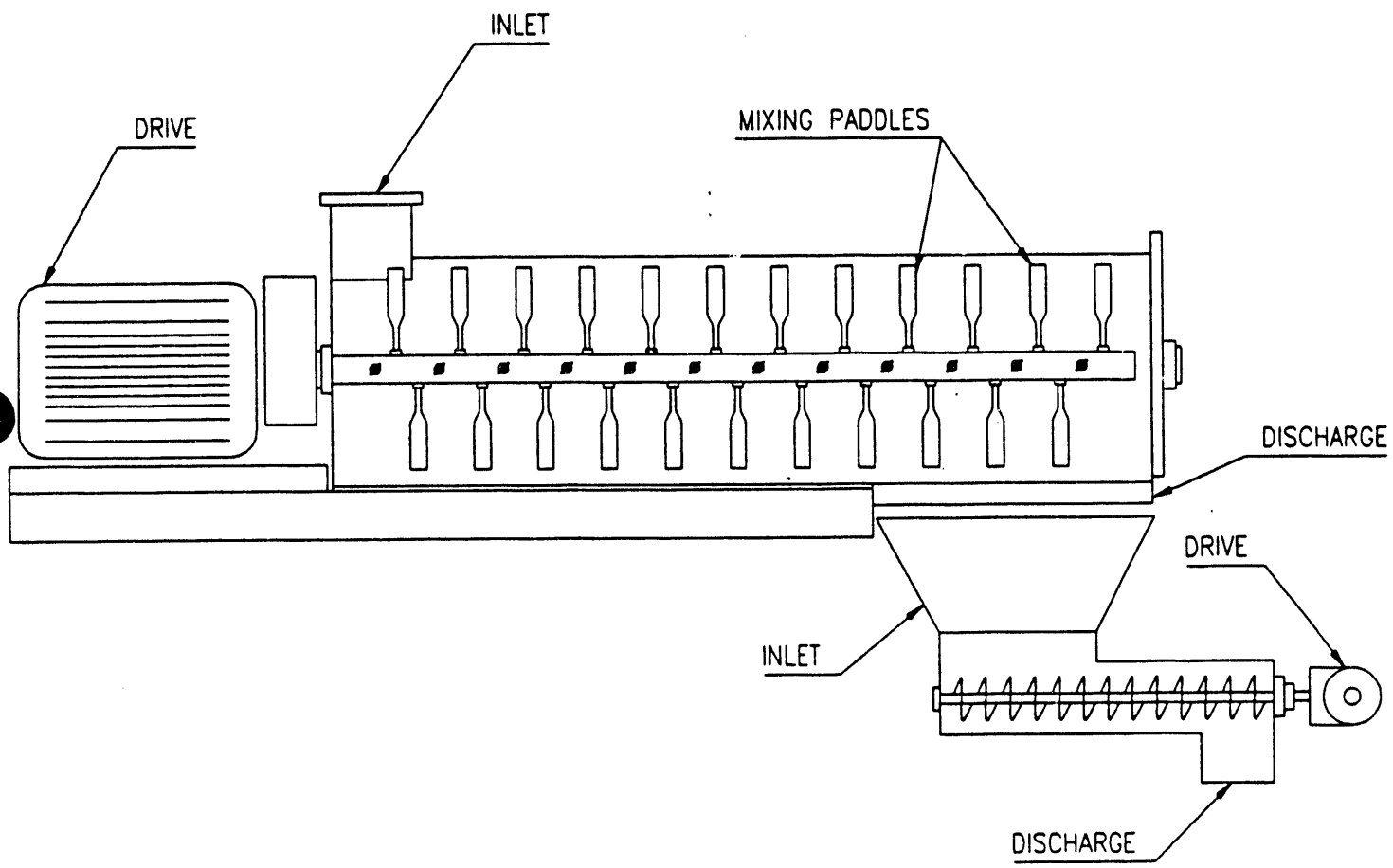
ALTERNATIVE A1-PUG MILL

FIGURE 6-1

NOTES

MIXING BODY IS AN ENCLOSED CYLINDER WITH FLIP OPEN TOP FOR CLEANING

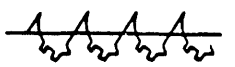
CADFILE : JC_7610



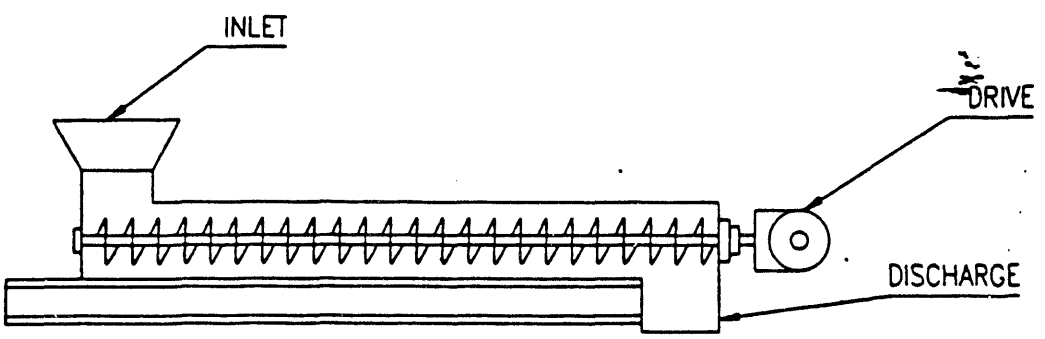
ALTERNATIVE A2-PUG MILL AND SCREW FEEDER COMBINATION

FIGURE 6-2

OPTION SCREW FLIGHT
CONFIGURATION

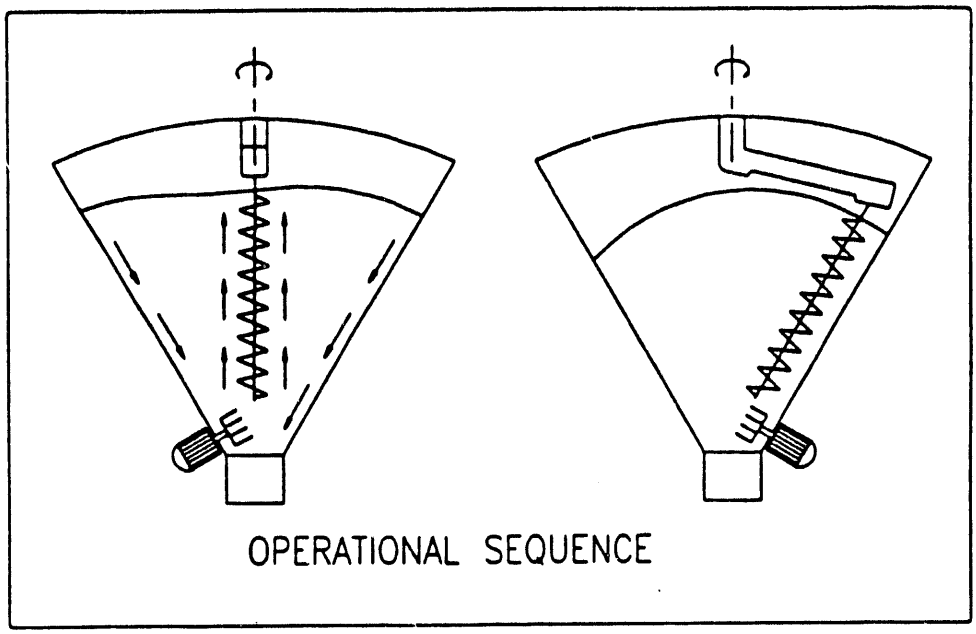


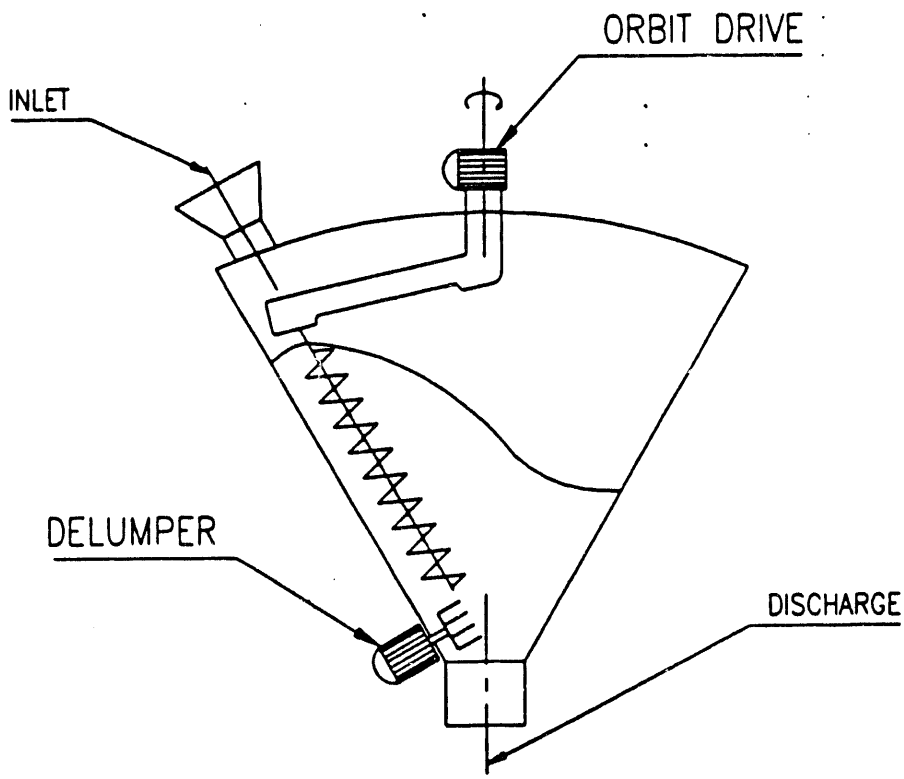
CUT FLIGHT TO IMPROVE MIXING



ALTERNATIVE A3 – SCREW AND TROUGH MIXER (CONTINUOUS MIXING)

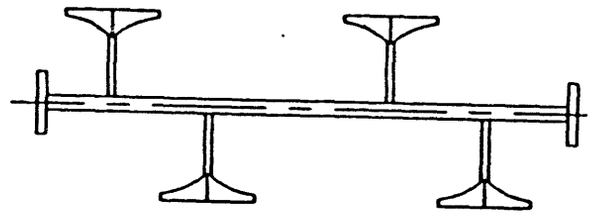
FIGURE 6-3



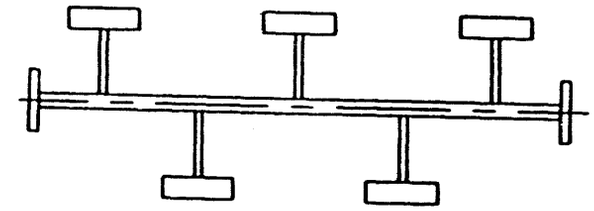


ALTERNATIVE A3 – CONE AND SCREW VERTICAL MIXER (BATCH MIXING)

FIGURE 6-4

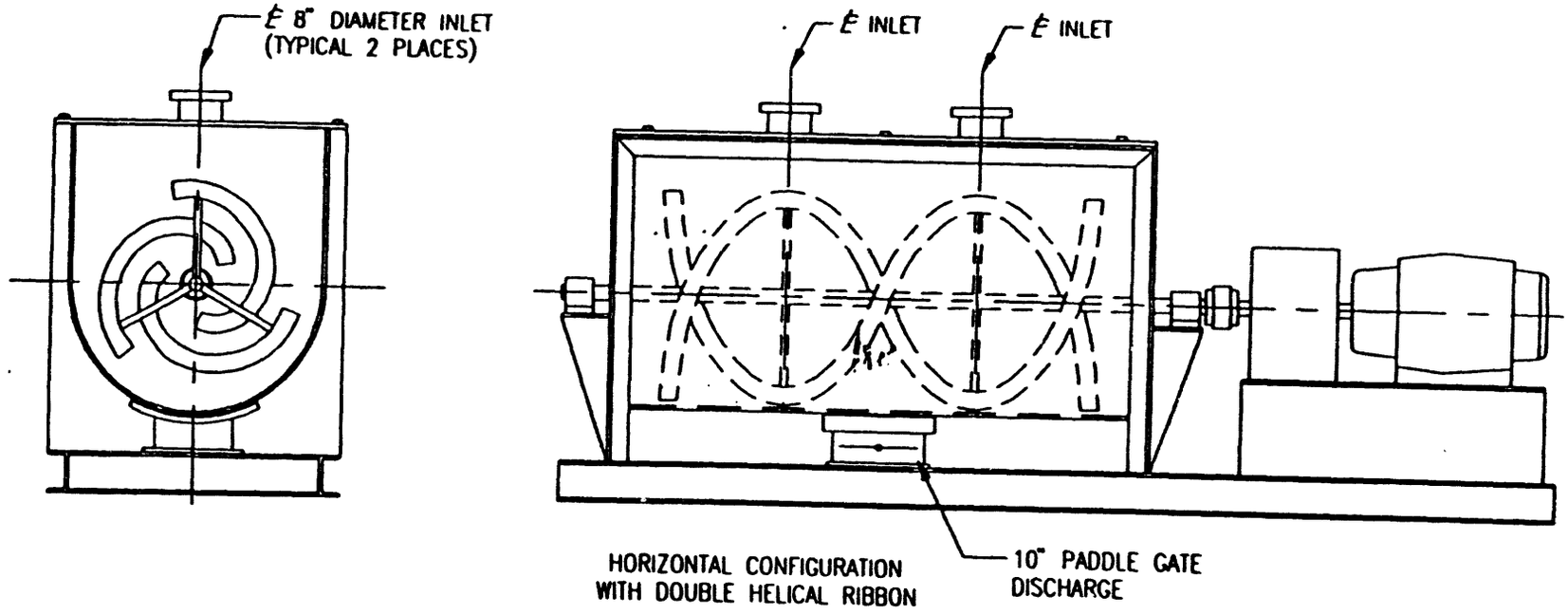


PLOW STYLE



PADDLE STYLE

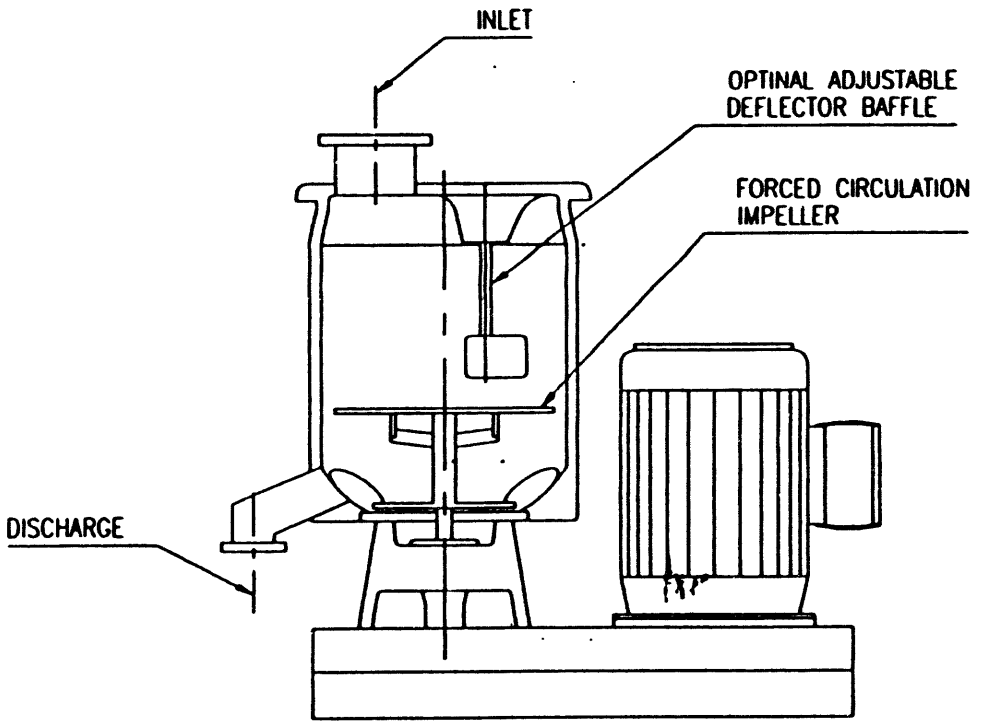
OPTIONAL AGITATOR CONFIGURATIONS



ALTERNATIVE A4 - RIBBON BLENDER

NOTES :
1. TYPICAL OPERATING SPEEDS
25 - 50 RPM.

FIGURE 6-5

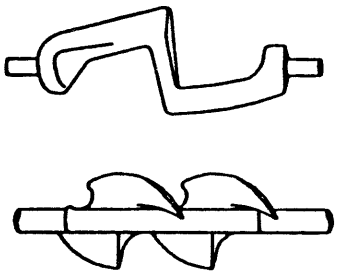


ALTERNATIVE A6 – SINGLE SHAFT AGITATION FOR SOLIDS

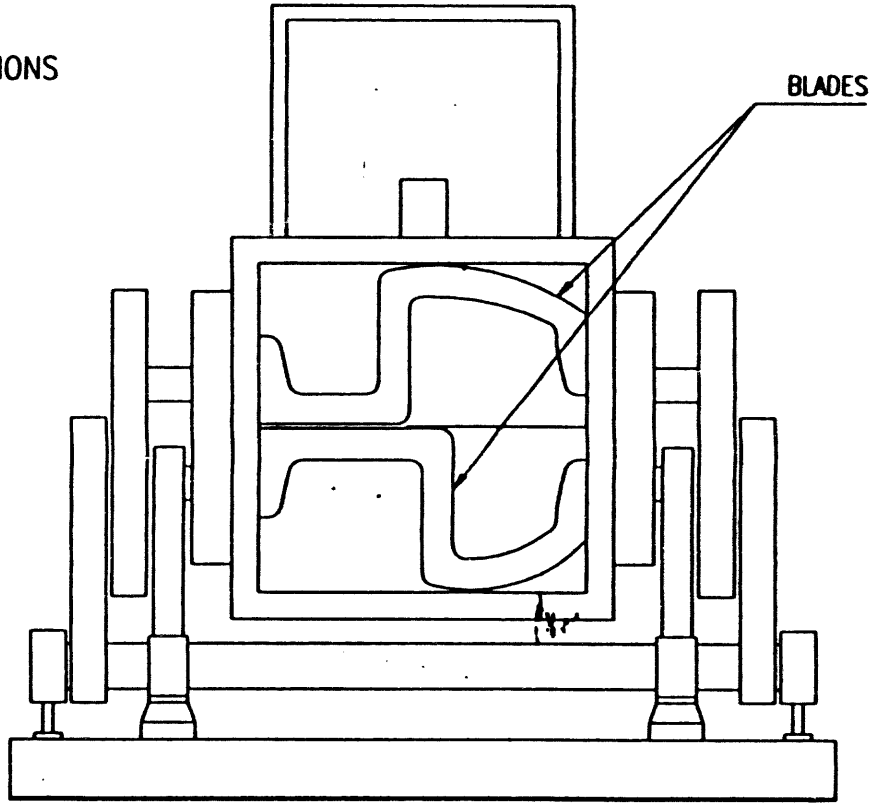
FIGURE 6-6

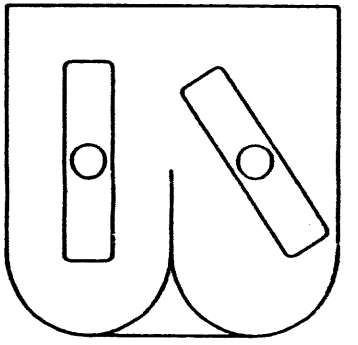
NOTES :
CONFIGURATION IS SHOWN WITH
BOTTON DRIVE

DOCNT ID.FRIC



POTENTIAL BLADE CONFIGURATIONS





MIXING CHAMBER
AND BLADE CONFIGURATION

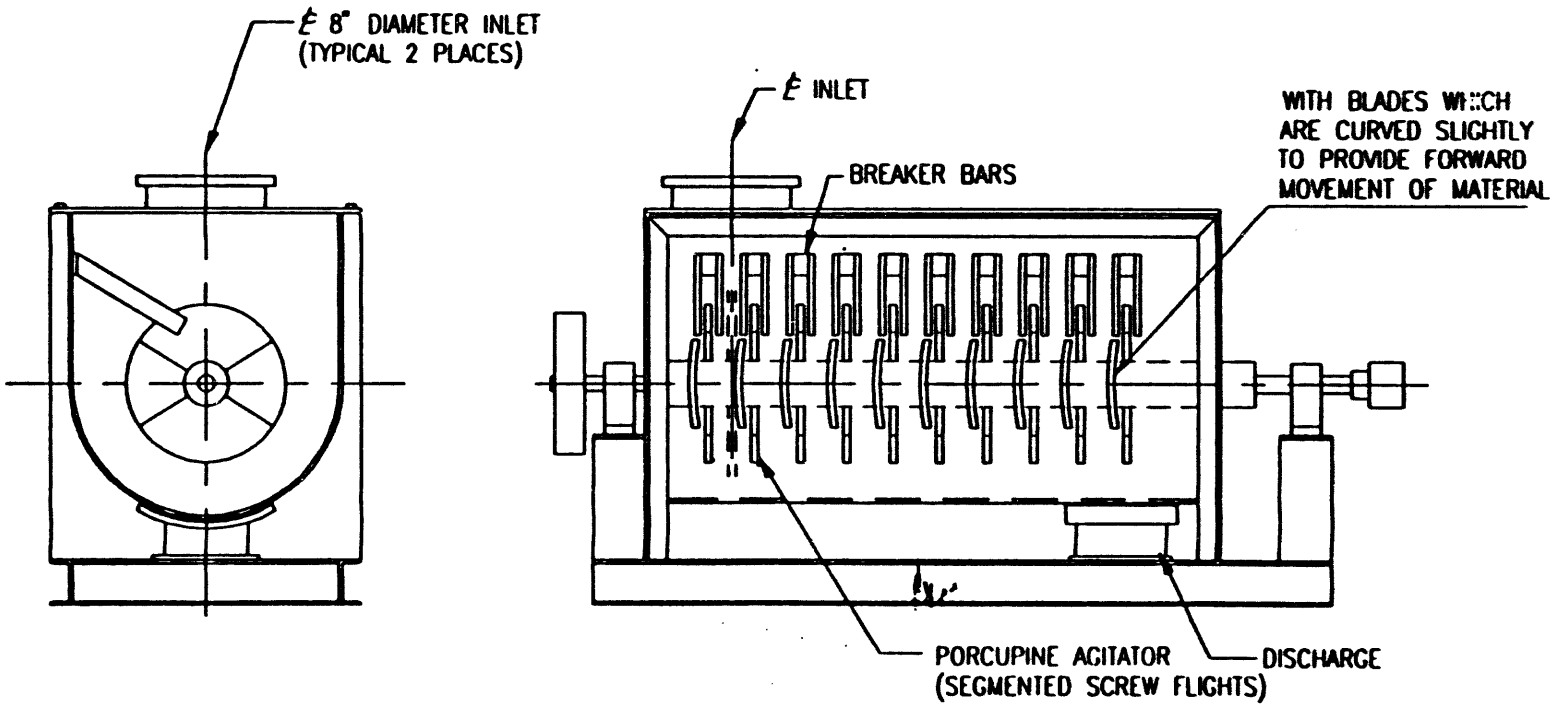
ALTERNATIVE A8 – DOUBLE-ARM KNEADER MIXER

FIGURE 6-7

NOTES :

1. TYPICAL OPERATING SPEEDS 25 - 50 RPM.
2. VESSEL IS SHOWN ROTATED AND OPEN FOR DISCHARGE

CADFILE : 02_FIG10



ALTERNATIVE A12 - PORCUPINE PROCESSOR

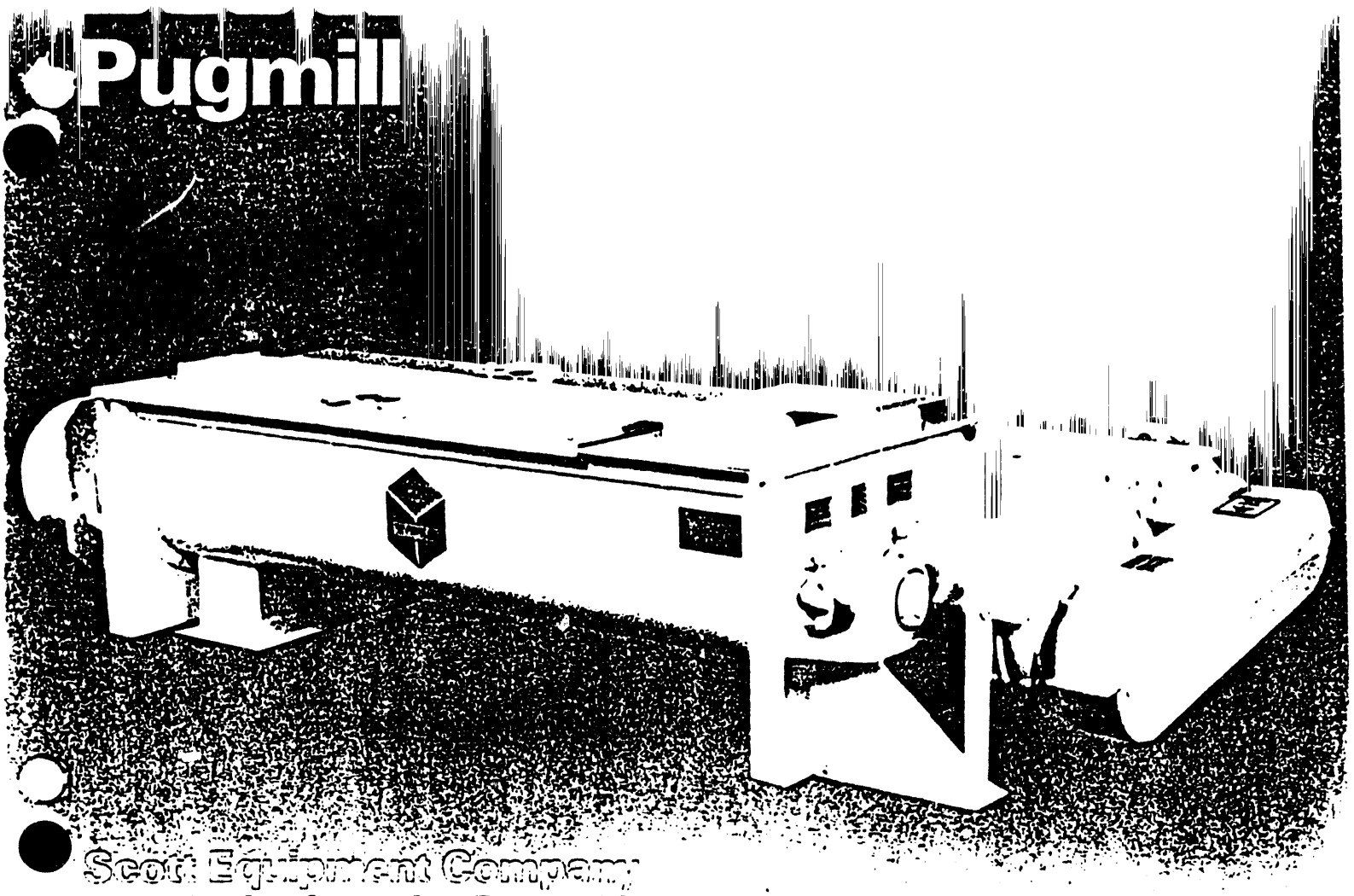
FIGURE 6-8

CADFILE : 3TLOG

APPENDIX B
VENDOR CONTACTS

WRAP 2A ACDR STUDY 1604-6	EQUIPMENT CONTACTS	6237008 05/07/93
VENDOR/SUPPLIER	**EQUIPMENT TYPE**	**TELEPHONE CONTACT**
1 SCOTT NEW PRAGUE, MN	PUG MILLS/HIGH SPEED BLENDERS	DAVID GRIMES 800-264-9519
2 J.C. STEELE STATESVILLE, NC	PUG MILLS/EVEN FEEDERS	RICHARD STEELE 216-362-1177
3 ACRODYNE DENVER, CO	PUG MILLS/SCREW FEEDERS	AL PETERSON 303-458-5024
4 HAYES & STOLZ INDUSTRIAL FT WORTH, TX	HORIZONTAL BLENDER - RIBBON TYPE	KEITH HOLT 800-725-7272 BILL HASKINS 303-220-9151
5 KTRON PITMAN, NJ	SCREW FEEDERS	JOE LAWRENCE 609-589-0500
6 CHARLES ROSS & SON 10 HAUPPAUGE, NY	DOUBLE ARM KNEADER VERTICAL CONE BLENDER MULTIPLE SHAFT AGITATOR (POWER MIX)	TOM O'SHAUGHNESSY 516-234-0500
7 MUNSON MACHINERY UTICA, NY	HORIZONTAL BLENDER RIBBON/PADDLE TYPE	TOM BASHANT 315-797-0090
8 TECHNA-FLO, INC. LITTLETON, CO	SCREW FEEDERS HORIZONTAL BLENDERS	BILL HASKINS 303-220-9151
9 PAUL O. ABBE' INC.	RIBBON BLENDERS KNEADERS	J.R. HOFFMANN 201-256-4242

Pugmill



Scott Equipment Company Revolutionizes the Pugmill with Counter-Flow Mixing

Problems mixing hard-to-handle materials are easily solved with Scott Equipment Company's Pugmill Mixer. Scott's unique design features twin counter rotating shafts with four rows of adjustable paddles on each shaft to vary retention time. Every other paddle on the shaft is slightly smaller and reversed in direction of the product flow to increase agitation and retention time in the mixer. Every Scott Pugmill is designed for a specific application with consideration given to corrosion, abrasion and maintenance.

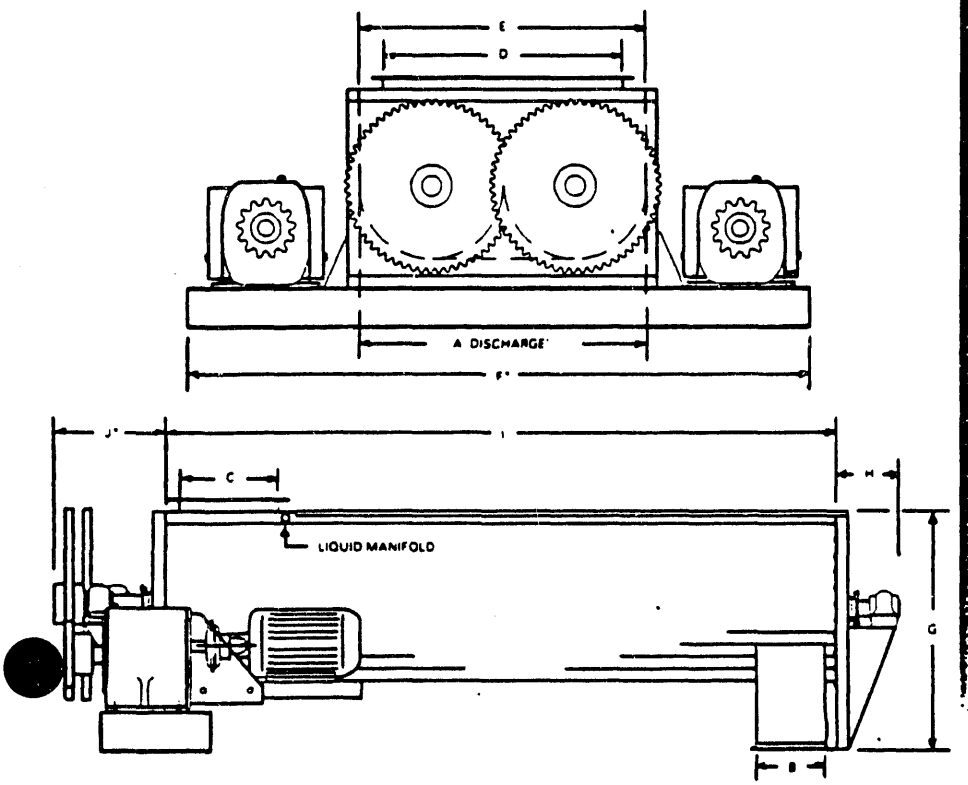
Scott Pugmill's are constructed of carbon steel, stainless steel and abrasion resistant steel for years of durable and dependable operation. In highly abrasive or corrosive situations, liners are available for the mixer tub. Designed for easy maintenance, each Scott Pugmill is equipped with full length doors over the agitators, outboard pillow block bearings and easily replaceable shaft seals.

With the capacity to handle anywhere from 1 ton to 250 tons of product per hour, the Scott Pugmill Mixer provides heavy-duty mixing action for materials such as sand, soil, cement, hazardous waste, fly ash, sludge with lime, and bag house dust.

When it comes to revolutionizing the industry, Scott Equipment is a leader. Even when you're mixing the most difficult materials, Scott has the mixer to perform the job.

Scott Equipment...innovators in the industry

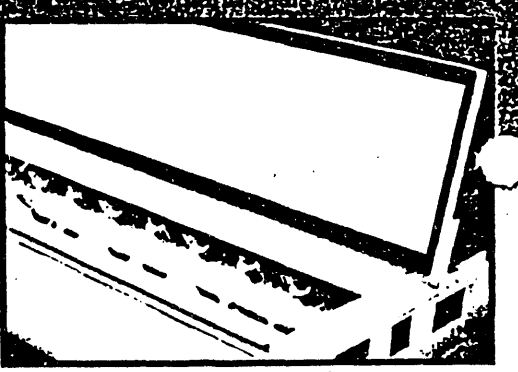
Scott Equipment has established durability in mixers, blenders, bulk material bins and size reduction equipment. Still, we've continued to innovate the industry by perfecting our equipment for over twenty-six years. Scott places special emphasis on quality workmanship to ensure low maintenance and dependable performance from every product we manufacture.



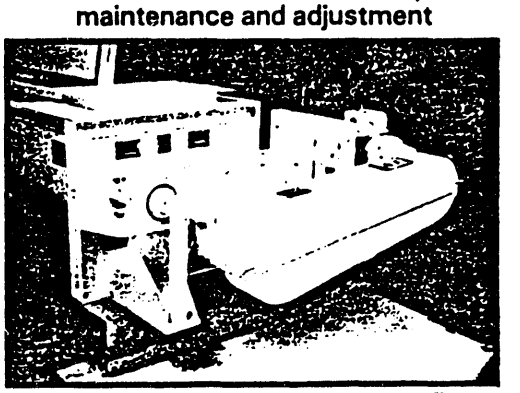
MODEL	SIZE	TON HR	A	B	C	D	E	F	G	H	I	J
PM246	24 x 72	2 3	24	8	8	20	24	96	48	8	72	20
PM248	24 x 96	5 10	24	8	8	20	24	96	48	8	96	20
PM2410	24 x 120	10-18	24	8	8	20	24	96	48	8	120	20
PM368	36 x 96	18 20	36	10	10	34	36	96	48	10	96	20
PM3610	36 x 120	20 25	36	10	10	34	36	96	48	10	120	20
PM3612	36 x 144	25 35	36	10	10	34	36	96	48	10	144	20
PM488	48 x 96	30-40	48	12	12	44	48	120	50	12	96	24
PM4810	48 x 120	35-45	48	12	12	44	48	120	50	12	120	24
PM4812	48 x 144	45-50	48	12	12	44	48	120	50	12	144	24
PM4813	48 x 156	50-60	48	12	12	44	48	120	50	12	156	24
PM6010	60 x 120	45-60	60	14	14	56	60	144	58	14	120	26
PM6012	60 x 144	60-65	60	14	14	56	60	144	58	14	144	26
PM6013	60 x 156	65 70	60	14	14	56	60	144	58	14	156	26
PM6014	60 x 168	70-80	60	14	14	56	60	144	58	14	168	26
PM7212	72 x 144	65 80	72	16	16	68	72	156	64	16	144	32
PM7213	72 x 156	80-90	72	16	16	68	72	156	64	16	156	32
PM7214	72 x 168	90-120	72	16	16	68	72	156	64	16	168	32
PM7215	72 x 180	120-200	72	16	16	68	72	156	64	16	180	32

BASED ON PRODUCT BULK DENSITY OF 60# FT^3
*DIMENSIONS VARIES DEPENDING ON HORSEPOWER REQUIREMENTS

Counter rotating shafts with back mixing adjustable paddles



Quick access doors for easy maintenance and adjustment

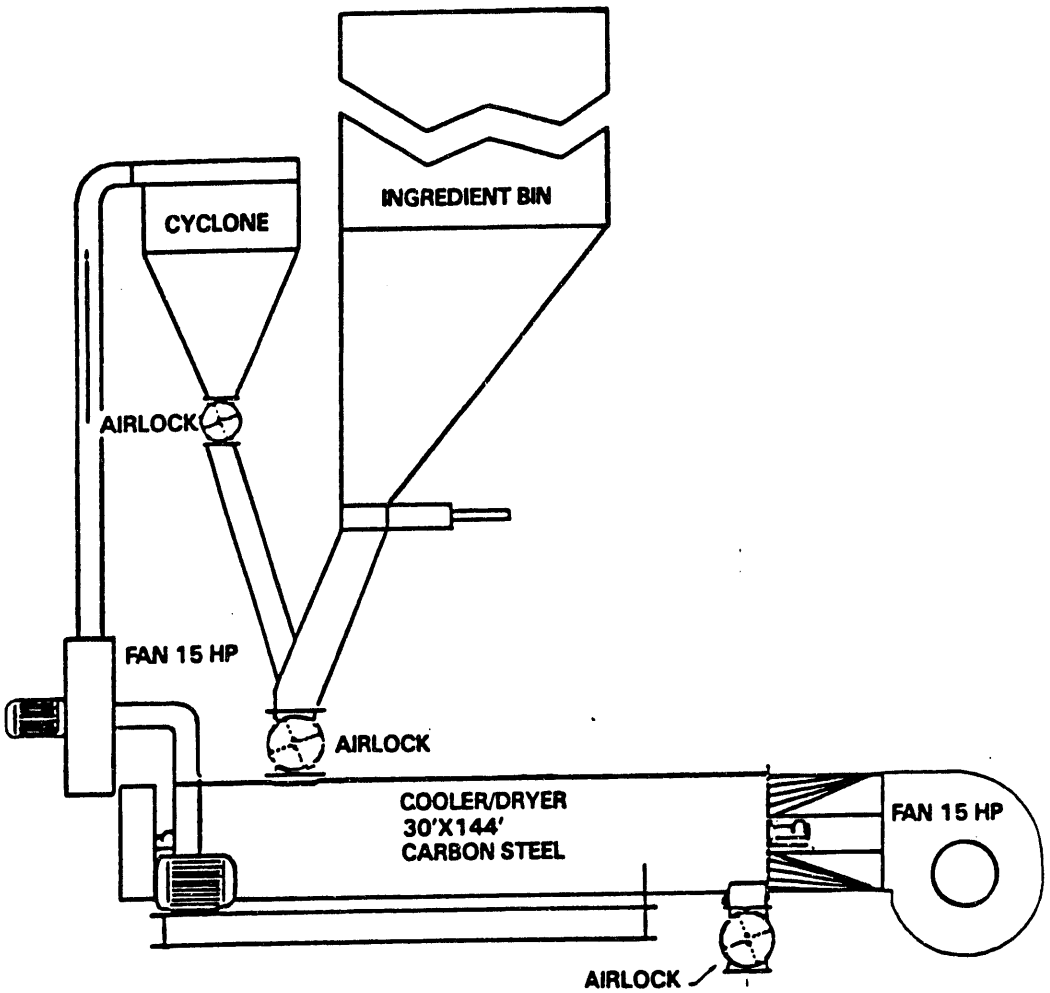


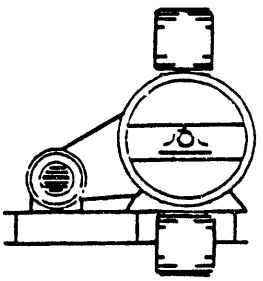
Shaft mount drive with torque flex belt drive

Call toll free 1-800-264-9519

After all, you wouldn't want to mix us up with anyone else.

SCOTT
EQUIPMENT COMPAN..
605 Fourth Avenue Northwest
New Prague, MN 56071
612-758-2591
612-758-4377 Fax





SCOTT
EQUIPMENT COMPANY

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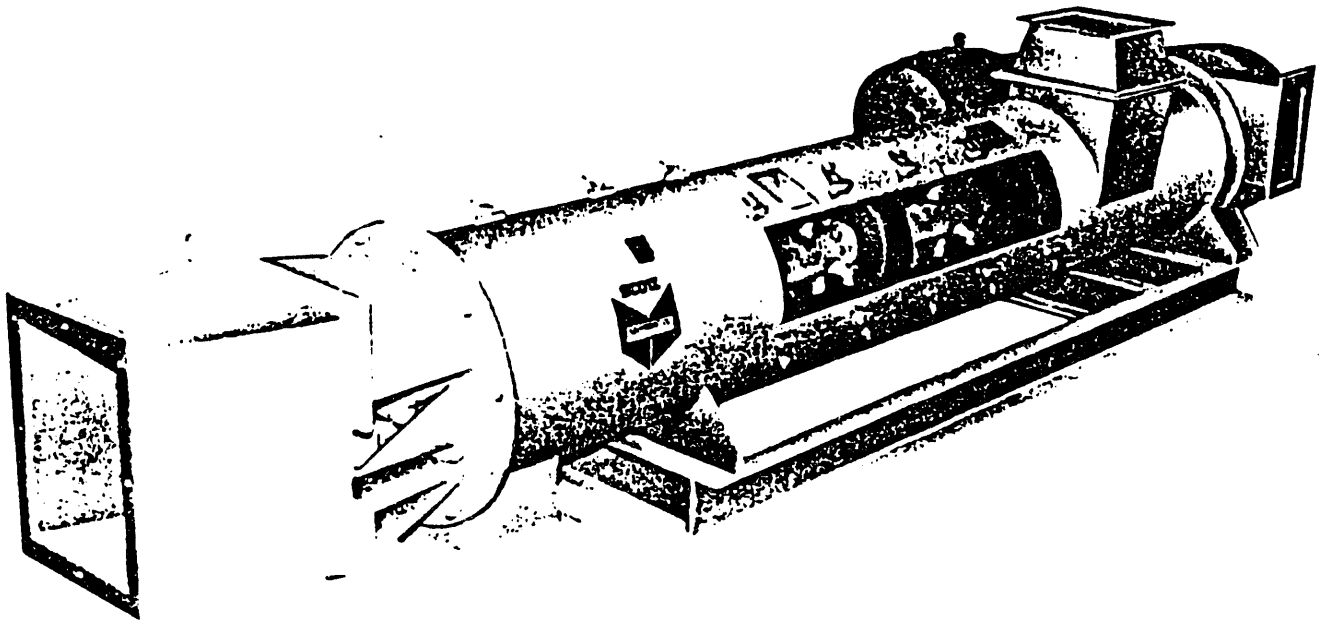
New Prague, MN 56071
612-758-2591
612-758-4377 FAX

SCOTT'S NEW COOLER/DRYER



FOR MORE CONSISTENT HIGH-TEMPERATURE MEAL

If cooling and moisture problems are keeping you from getting the consistent processed meal you need for proper packaging and storing, you now have a solution. It's the new Scott Cooler/Dryer, and it's just the equipment to ensure better handling of meal or powder products that have been heated to temperatures of 160-220 degrees F.

If you have a hot product, you are probably experiencing condensation and difficulty in unloading your bins and your bulk trucks. You may even be inviting salmonella problems if you have condensation caused by hot meal.

That's why you'll like this. The Scott Cooler/Dryer will not only cool your product, it will enable you to add moisture when necessary.

The uncomplicated design of the Scott Cooler/Dryer makes it inexpensive every way you look at it. A unique but simple cylinder totally encloses the product, so you experience little product loss into the air stream. It uses ambient air, so it's cost-effective to operate. And maintenance costs are predictably low.

The Scott Cooler/Dryer is ideal for cooling and drying your linseed meal, cottonseed meal, rape seed meal and numerous other products.

And with a production rate of up to 30 tons per hour, you'll find the new Scott Cooler/Dryer a valuable addition to your meal processing operation.

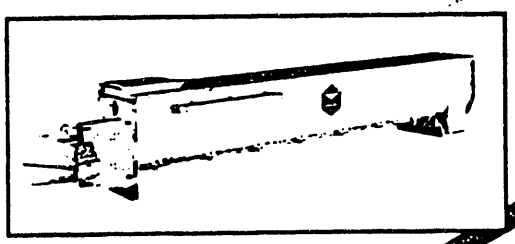
For more information on making that happen, just contact your Scott representative.

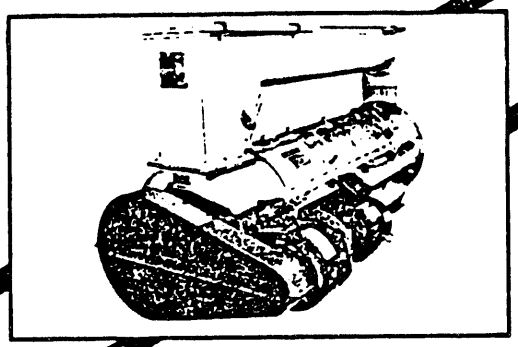
Call . . .

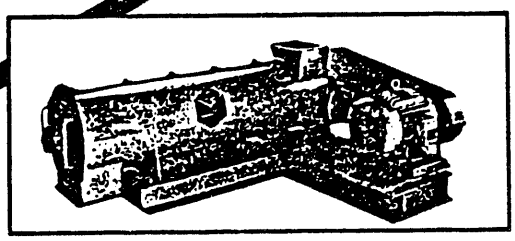
scott
EQUIPMENT COMPANY

IF IT'S NEW
YOU KNOW IT'S
FROM SCOTT!!!

1-800-333-9519

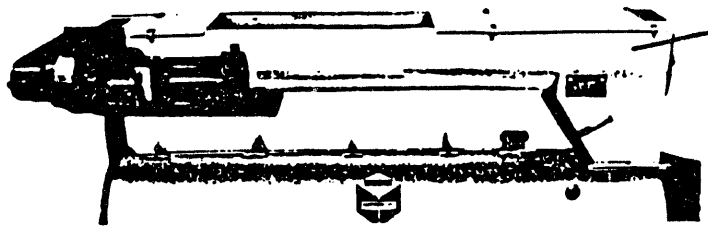






SCOTT

Continuous Process Equipment



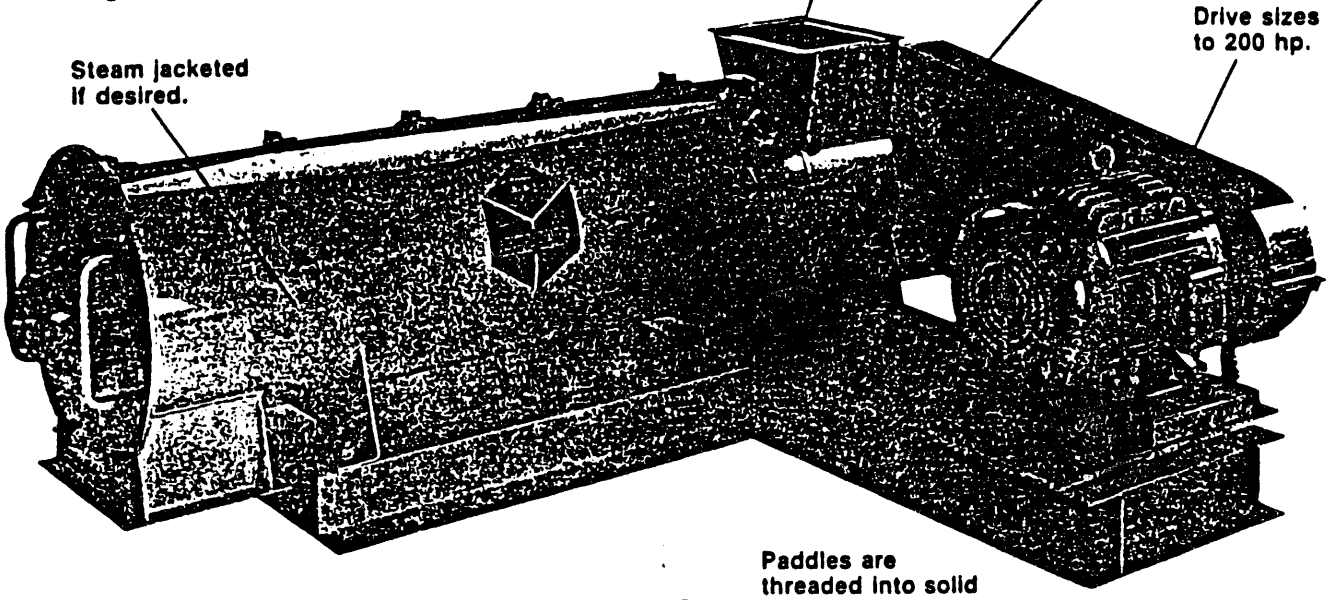
Feeder is available to control flow to blender.

Production range 1 ton to 250 ton per hour.

Rpm up to 1200 rpm's.

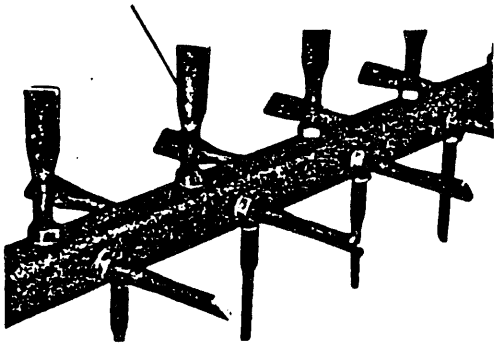
Drive sizes to 200 hp.

Steam jacketed if desired.



High Production/High Speed Continuous Blenders

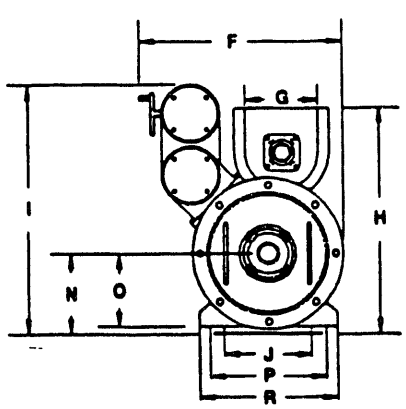
Paddles are threaded into solid shaft. Can be adjusted and replaced. Available in mild steel or stainless steel.

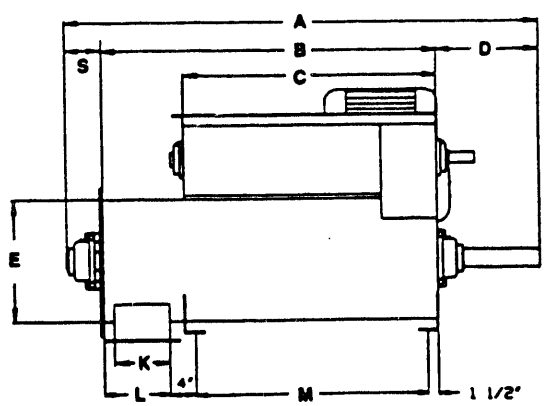


This machine will combine dry materials together. It will also add liquids to powder without lumps being formed. By varying the speed, the Scott High Speed Blender can agglomerate powders such as dried skim milk powder. Scott has used this machine to mix liquids with bag house dust and other potentially hazardous waste products for disposal purposes. It will mix and produce a product dry, one that is only slightly moistened, a smooth paste or a lump free slurry. It can be jacketed to heat or cool. The wear parts are adjustable and replaceable and made of various materials to accomodate the product.

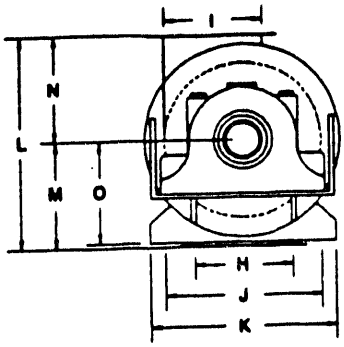
High Speed Blender Dimensions (Inches)

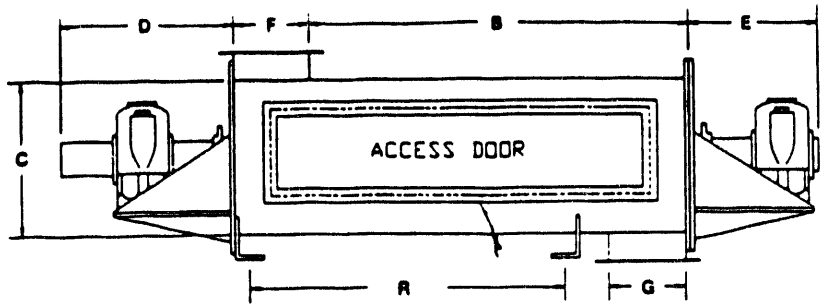
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	HP
1648	60	48	36	8	16	28	10	31	34	12	8	9½	33	11	10	16	19	5	5-15
1660	76	60	48	12	16	28	10	31	34	12	8	9½	45	11	10	16	19	5	15-30
2072	92	72	54	14½	20	30	13	39	39	16	10	11½	55	14	12½	22	24	6	30-60
2090	111	91	60	14½	20	30	13	39	39	16	10	11½	74	14	12½	22	24	6	50-100





SCOTT



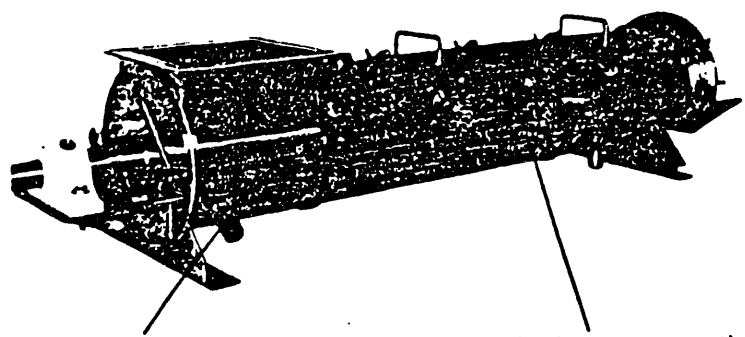


RIGHT SIDE VIEW

Turbo Blender Dimensions (Inches)																	
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	R	HP
1042	73	36	10	15	10	6	7	9	8	12	15	16½	8½	8	7	32	10
1442	73	36	14	16½	12½	7	7	9	8	14	17	20	10	10	9	29	20
1648	80	40	16	19	13	8	8	10	10	16	19	22	11	11	10	33	40
2060	94	50	20	20	14	10	10	14	14	22	24	27	14	13	12½	44	60

Ultra High Speed Continuous Turbo Blender

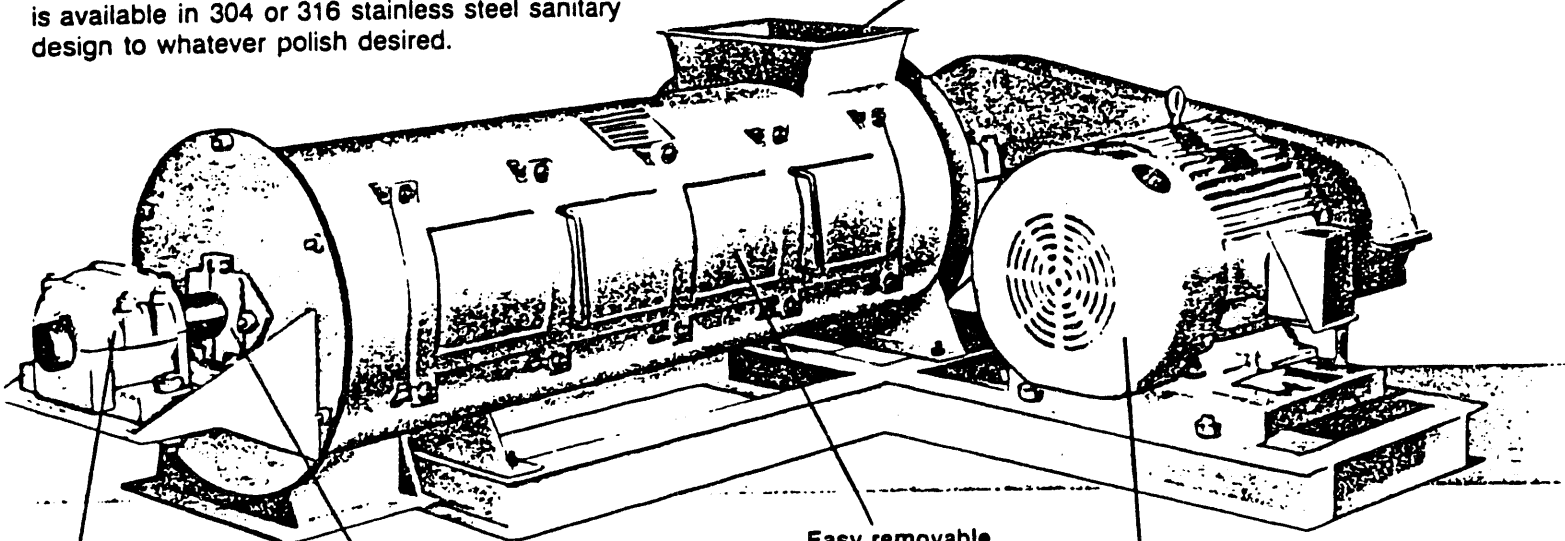
This continuous machine is similar to the Scott High Speed Blender in many respects. It will operate at higher speeds up to 2500 rpm. It has the mixing blades closer together. It is made in smaller sizes down to a 10" cylinder and equipped with special duty outboard bearings and is carefully balanced to run at extra high speed. We can equip this machine with a variety of removable panels for easy cleaning and it is available in 304 or 316 stainless steel sanitary design to whatever polish desired.



Steam manifold.

Production up to 75 ton per hour.

Sanitary construction up to 3a dairy finish.



Outboard pillow block bearings.

Separate repackable seals.

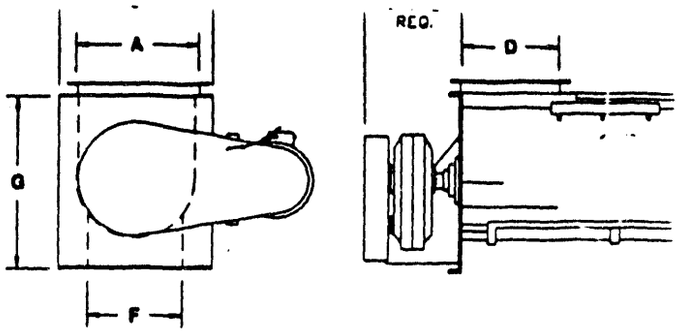
Easy removable clean out door.

Horsepower up to 100 hp.

We will be pleased to quote on any of these items of equipment.

SCOTT EQUIPMENT COMPANY 605 Fourth Ave. NW., New Prague, MN 56071
(612) 758-2591
Fax (612) 758-4377

Tender Blender Dimensions (Inches)							
Model	A	B	C	D	E	F	G
16" x 120"	17	120	21½	17	8	17	22⅝
18" x 132"	19	132	24½	19	8	19	25½
20" x 144"	21	144	26½	21	10	21	28½
24" x 156"	25	156	30½	25	10	25	34⅝



Scott Continuous Process Equi

There are many applications where the continuous process works better than the batch system. When the following conditions exist continuous mixing may be the best system.

- *The number of ingredients are limited. Two to six ingredients usually work very well.*
- *The product is produced in fairly long runs without ingredient changes.*
- *The ingredients used in the product are in reasonably large amounts. Micro ingredients may need to be diluted to increase the volume used in the total mix.*
- *If the total process in the plant is continuous then the mixing process should be evaluated.*
- *Because the continuous mixer is small and holds a small amount of material at one time, clean up is much easier.*

When the above conditions apply the following will be accomplished:

1. *Large production*
2. *Low production cost*
3. *Quality product*

High Production/Low Speed Tender Blend Continuous Machine

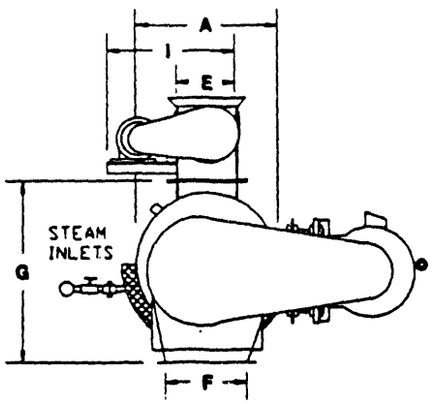
Tender Blend, a continuous machine, is designed to mix products with larger particle sizes, pelleted products, flakes and whole grains. Ideal for combining liquids with coarse products. Used for coating particles with a liquid, syrup or color if desired. Tender Blend is available in carbon or stainless steel with special sanitary design finishes available as an option.

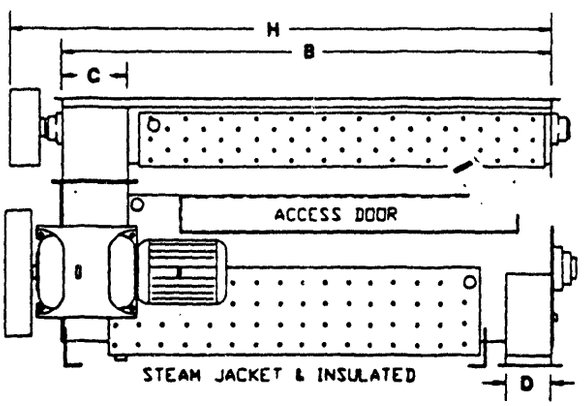
The Scott Tender Blend also performs as a continous blender. In many cases it will replace a batch mixer where the process is better suited to a continuous mix.

Scott can work with you to design a system for your product. We have the experience to assist you.

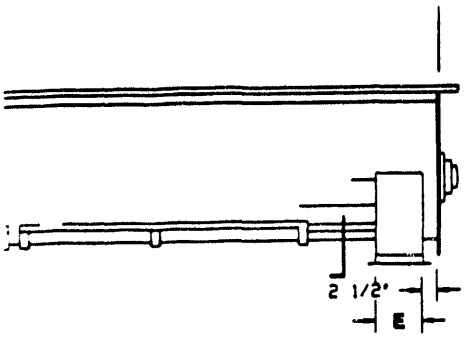
This machine will produce the rate you require from a few hundred pounds per hour up to 400 tons per hour.

The Scott Ultimate Mix 400 The pellet mill conditioner that the industry has



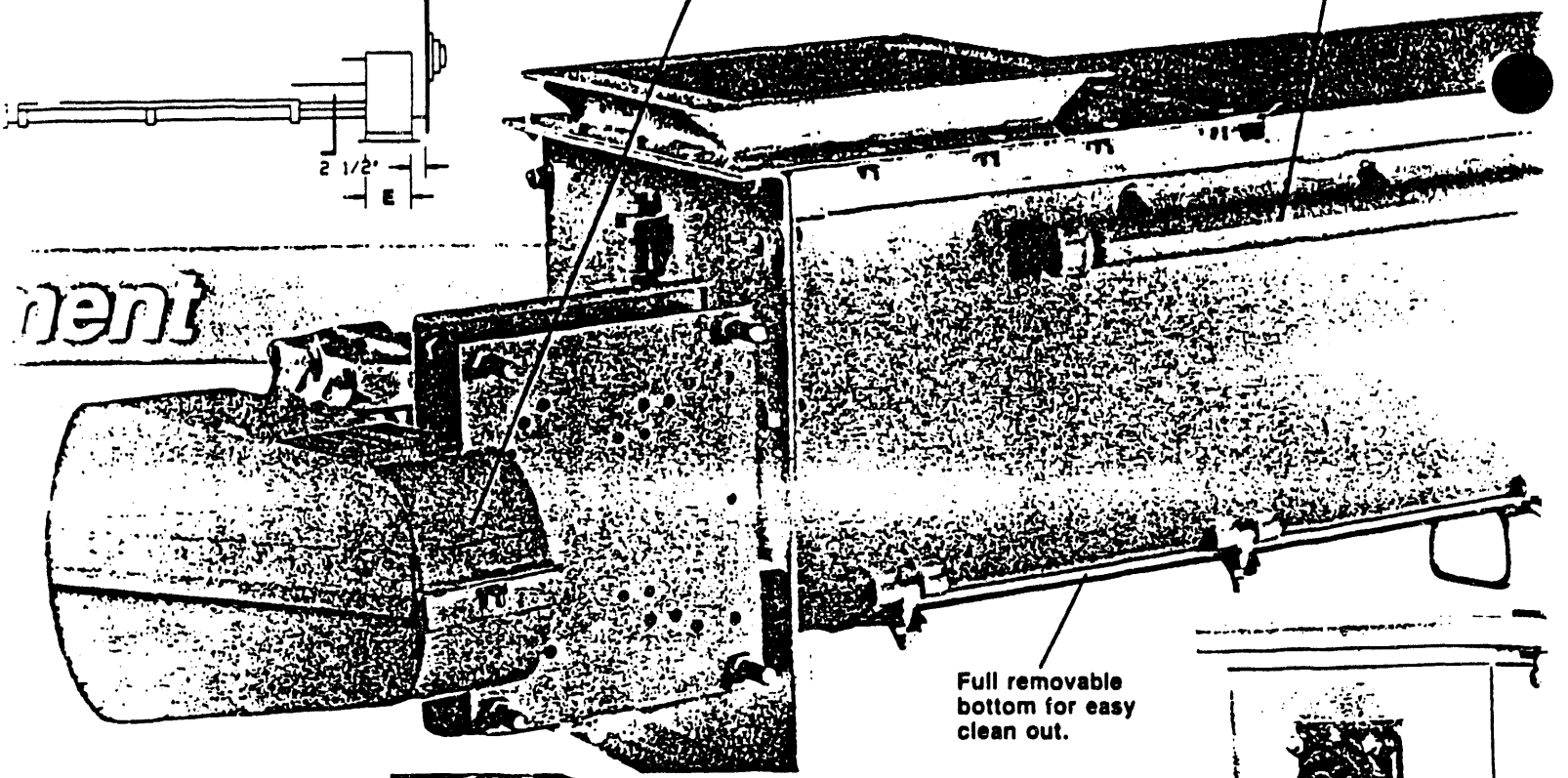


SCOTT



Drive may be variable to improve performance when a wide range of products are being mixed.

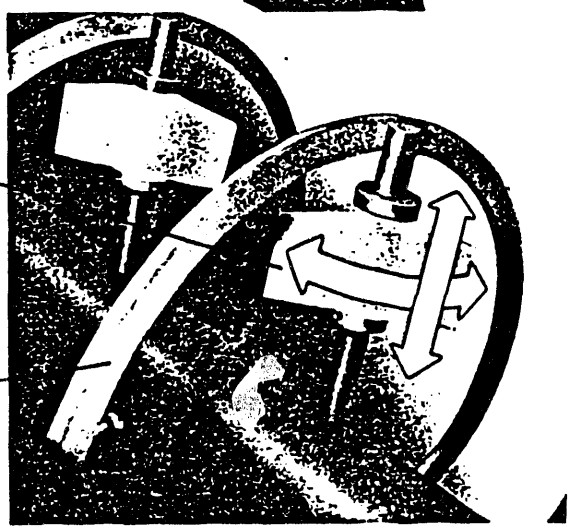
Liquid manifold can be externally mounted or in a spray assembly in the inlet.



Full removable bottom for easy clean out.

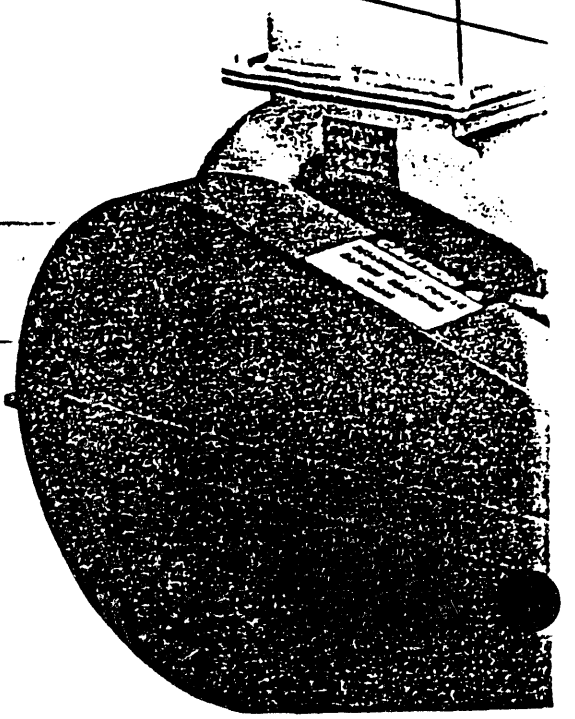
The paddles are adjustable to increase or decrease the intensity of the mix. Adjusting the paddles will also adjust the fill height in the mixer.

Ribbon minimum of 1/2" thick by 1" wide, and can be produced thicker and wider on larger sized machines.

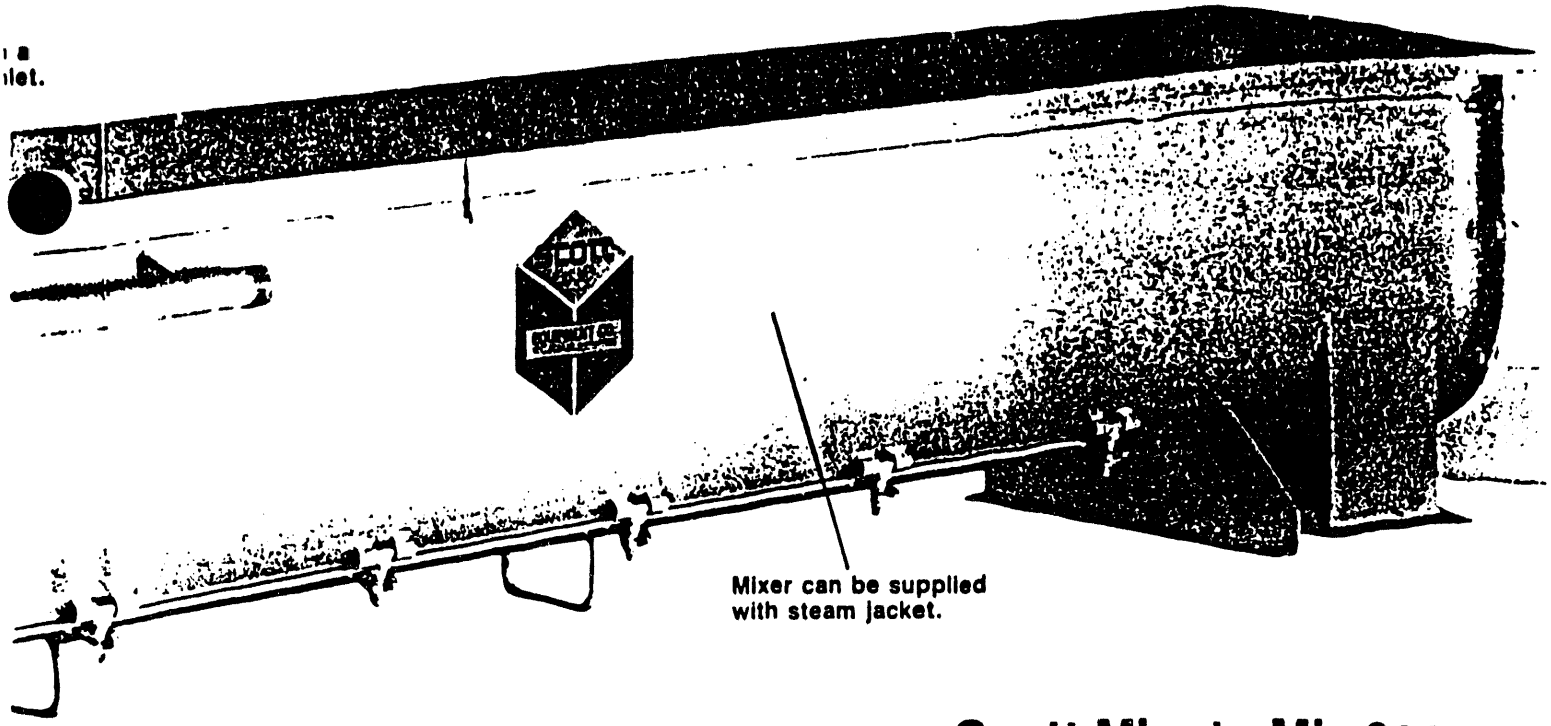


Hinged magnet location.

Removable cover for cleaning and adjusting paddles.



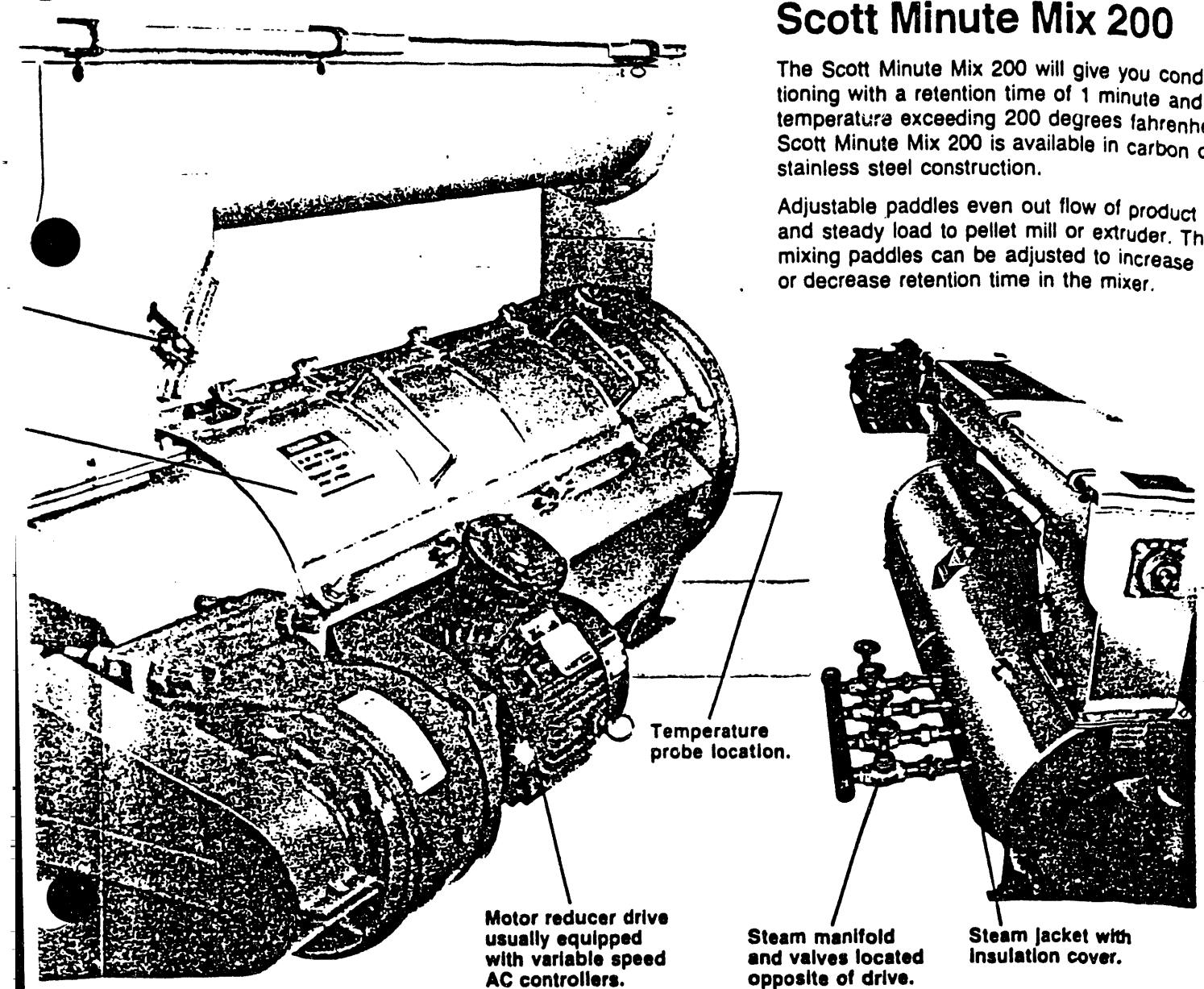
Scott Minute Mix 200 Dimensions (Inches)											
Model	TPH	CF	A	B	C	D	E	F	G	H	I
24" x 96"	25	25	24	96	10	8	10	20	31	106	34
24" x 120"	32	31	24	120	10	8	10	20	31	132	34
30" x 96"	41	39	30	96	13	10	13	26	36	108	38
30" x 120"	51	49	30	120	13	10	13	26	36	132	38

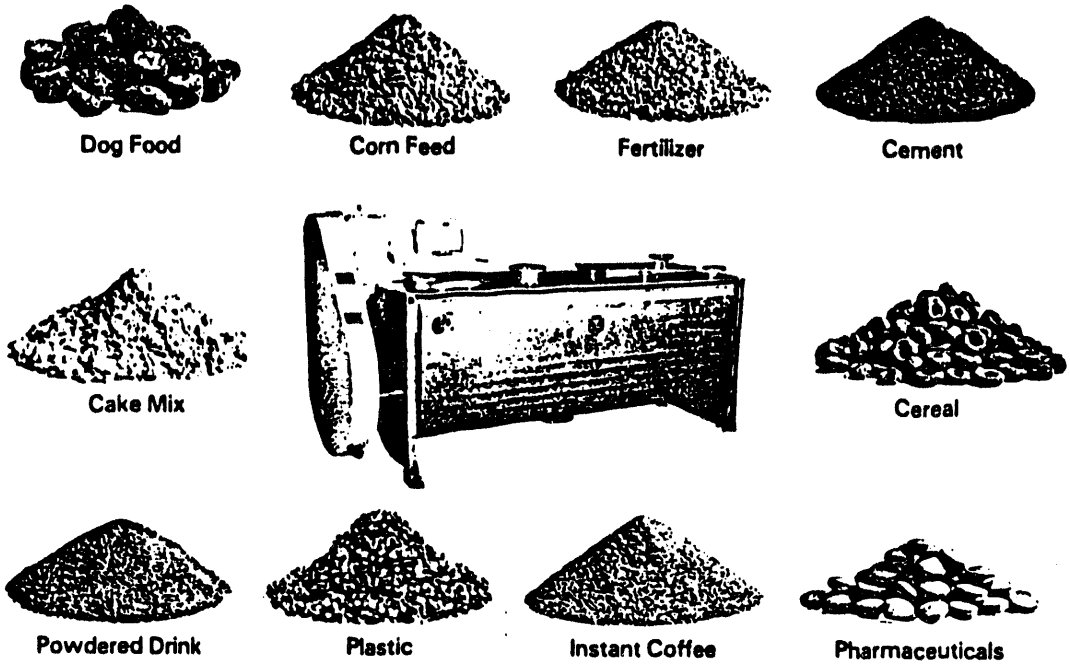


Scott Minute Mix 200

The Scott Minute Mix 200 will give you conditioning with a retention time of 1 minute and temperature exceeding 200 degrees fahrenheit. Scott Minute Mix 200 is available in carbon or stainless steel construction.

Adjustable paddles even out flow of product and steady load to pellet mill or extruder. The mixing paddles can be adjusted to increase or decrease retention time in the mixer.

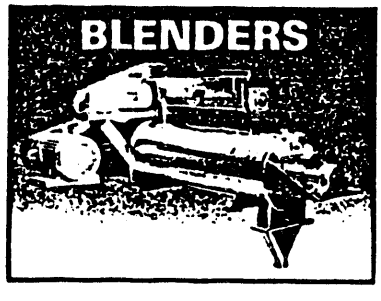




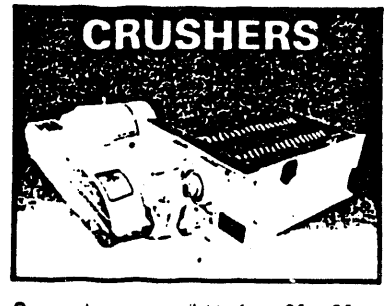
The Perfect Mix.

Once again, Scott Equipment has created the perfect recipe. It starts with the perfect mix. Whether it be plastics, cake mix or powdered drinks, our Heavy Duty Stainless Steel Horizontal Mixers handle complete mix cycles in under four minutes. Our Mixer will accurately mix many textures, from fine powders to coarse ingredients.

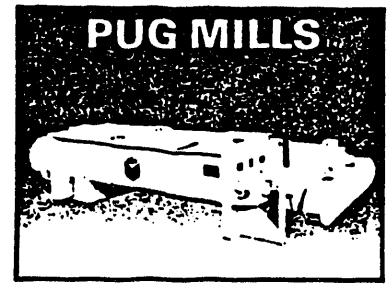
Scott Equipment also makes other durable machines to help with your material processing. So to perfect your recipe, start with the perfect mix. Start with Scott Equipment. After all, you wouldn't want to mix us up with anyone else.



Our blenders continuously blend from 1 to 250 tons per hour with up to 200 hp and 2,000 rpm's. The wear parts can be adjusted and replaced, and they're made of various materials. The blenders will make a consistent blend from fine powders to a slurry without lumps.



Our crushers are available from 9" x 9" to 48" x 72" with various tooth configurations. They come in many finishes and can also be supplied with a sizing screen. They can delump agglomerations and crush a variety of materials including plastics, food and chemicals.



Our Pugmill Mixer provides heavy-duty mixing action for hard to handle materials such as fly ash, sludge with lime and bag house dust. It's equipped with counter rotating solid steel shafts and alternating adjustable paddle settings. Special liners offer abrasive resistance, and oil bath spur gears provide maximum performance with minimum noise.

IF IT'S NEW
YOU KNOW IT'S
FROM SCOTT!!!

SCOTT
EQUIPMENT COMPANY

605 Fourth Avenue NW
New Prague, MN 56071
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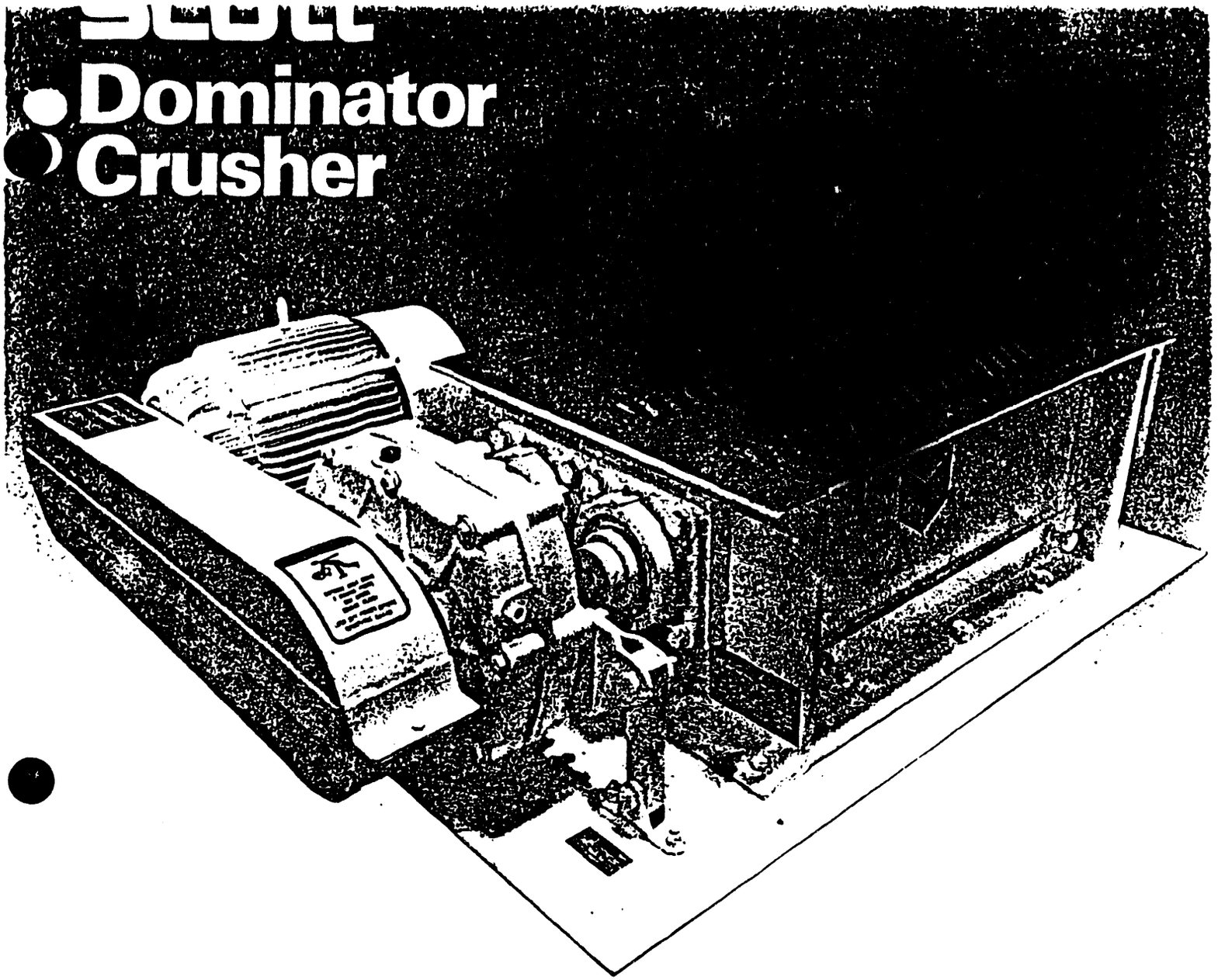
Mixers • Blenders • Bulk Material Bins • Particle size Reduction • Feeders • Pit Eliminators

Dominator Crusher

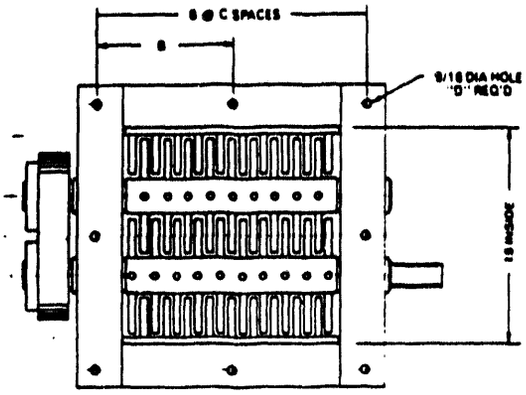


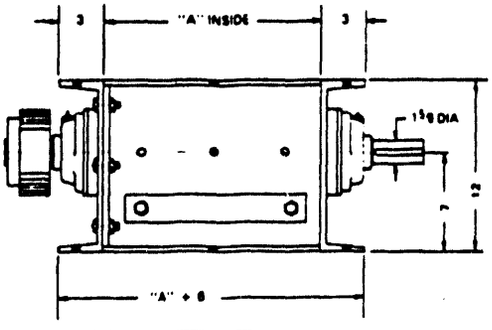
Scott designs and manufactures a superior size reduction machine, the Dominator Crusher. This equipment breaks up and crushes a variety of materials including bones, chemicals, food, salt, and fertilizer. The Crusher also delumps virtually all agglomerations and chunks.

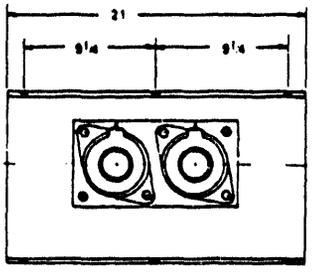
The Dominator Crusher has six different tooth configurations, a unique feature which makes it more efficient. This unparalleled design allows a greater variety of products to be broken up. Because the teeth can be moved close together or far apart, a wide range of materials can be crushed and different end-product sizes can be achieved.

Our Crusher is available in carbon steel, stainless steel, standard, and special food grade finishes. It ranges from 9"x9" to 48"x48" to accommodate your changing needs and can be operated with or without a sizing screen.

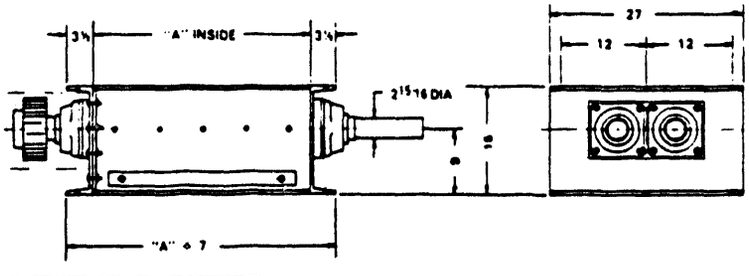
We've established durability in mixers, blenders, bulk material bins, and now size reduction equipment. Our company has been perfecting products in this industry for over twenty-five years with special emphasis on quality workmanship. Because of this, our implements are notorious for low maintenance and consistent performance.



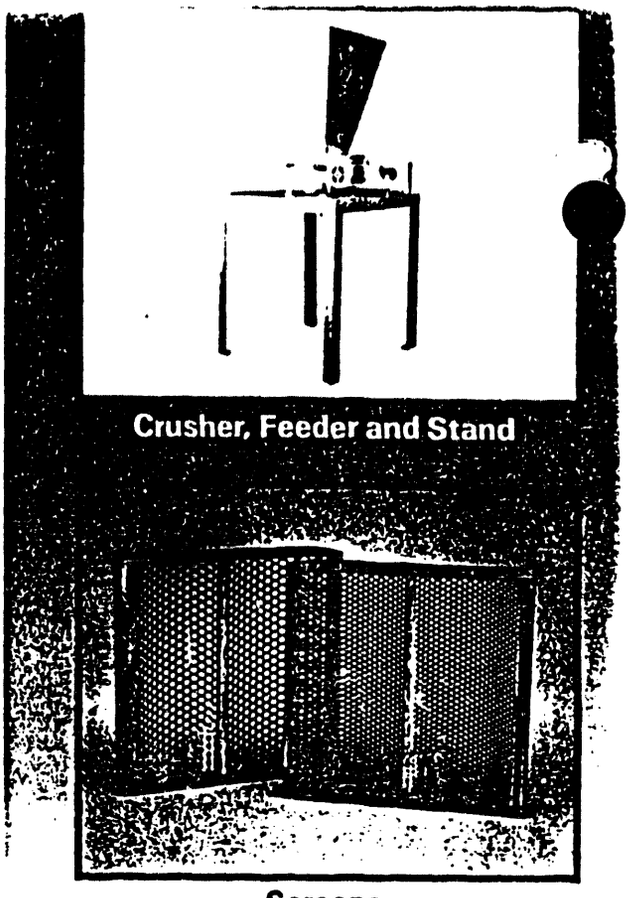




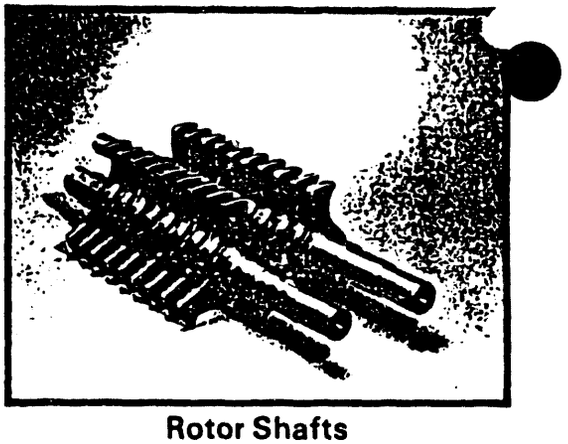
SPECIFICATIONS					
MACHINE TYPE	SIZE	A	B	C	D
CR15-18	15 x 15	15	9 1/4	2	8
CR15-20	15 x 20	20	11 1/4	2	8
CR15-25	15 x 25	25	9 1/4	3	10
CR15-30	15 x 30	30	8 3/4	4	12



SPECIFICATIONS					
MACHINE TYPE	SIZE	A	B	C	D
CR20-18	20 x 18	18	11	2	8
CR20-24	20 x 24	24	8	3	10
CR20-30	20 x 30	30	8 1/4	4	12
CR20-36	20 x 36	36	10	4	12
CR20-42	20 x 42	42	11 1/4	4	12
CR20-48	20 x 48	48	13	4	12



Screens



Rotor Shafts

Call toll free 1-800-333-9514

After all, you wouldn't want to mix us up with anyone else.

SCOTT
EQUIPMENT COMPANY
605 Fourth Avenue Northwest
New Prague, MN 56071
612-758-2591
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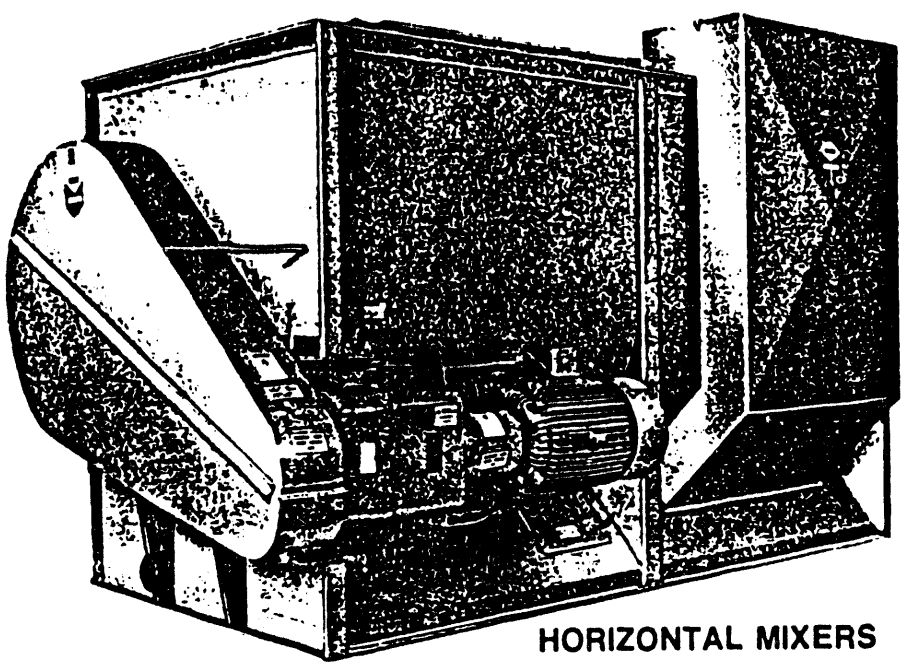
SCOTT

HEAVY-DUTY MIXERS

QUALITY ENGINEERED
TO MEET TODAY'S INDUSTRIAL NEEDS

For Smoother,
More Dependable Mixing
of All Types of Dry Ingredients



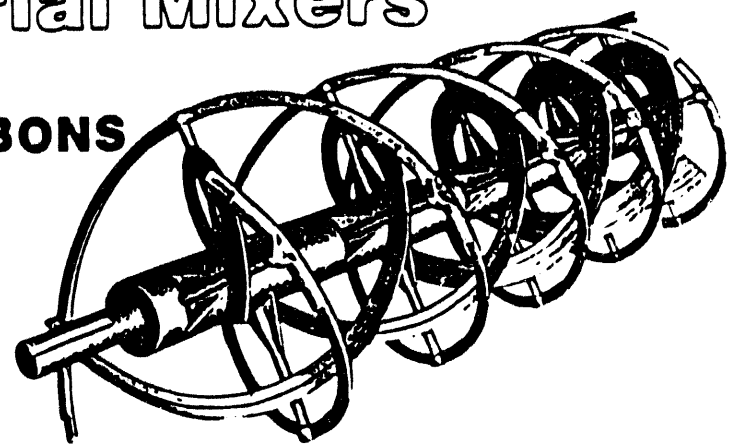
HORIZONTAL MIXERS
HORIZONTAL DROP-BOTTOM MIXERS
FAST, EFFICIENT PRE-MIXERS
MIXER AND SURGE-HOPPER COMBINATIONS
MIXERS WITH SCALE HOPPERS

BUILT FOR TODAY
TO LAST FOR TOMORROW

SCOTT
EQUIPMENT COMPANY

SCOTT Quality-Engineered Industrial Mixers

SCOTT HEAVY-DUTY RIBBONS

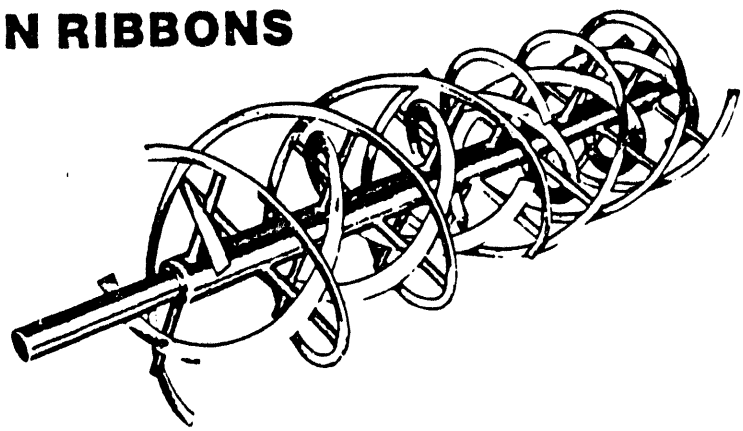


Constructed in close-wrapped, balanced design.

Triple-mixing action insures smoother, more efficient blending of ingredients.

Available in either mild or stainless steel.

SCOTT SANITARY DESIGN RIBBONS



Same triple-action mixing as with standard ribbon assembly.

Polished sanitary design to help eliminate cross contamination between mixing runs.

Optional air-purge design through main shaft to give complete cleanout when use of drop-bottom is not appropriate.

Also available in either mild or stainless steel.

SCOTT POLISHED SANITARY INTERIORS

Generous radius of rounded inside corners helps eliminate contamination between mixer runs.

All mixers can be furnished in either mild or stainless steel.

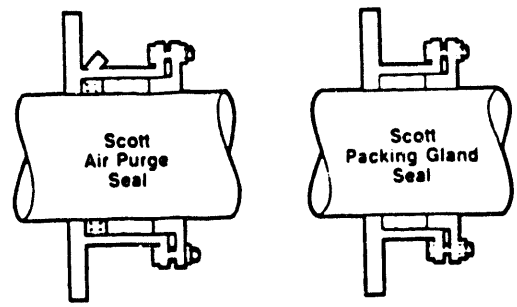
SCOTT SPECIAL SEALS

The Standard Scott Seal is a reservoir-type stuffing box.

Air Purge and plain Packing Gland-type seals are for special applications.

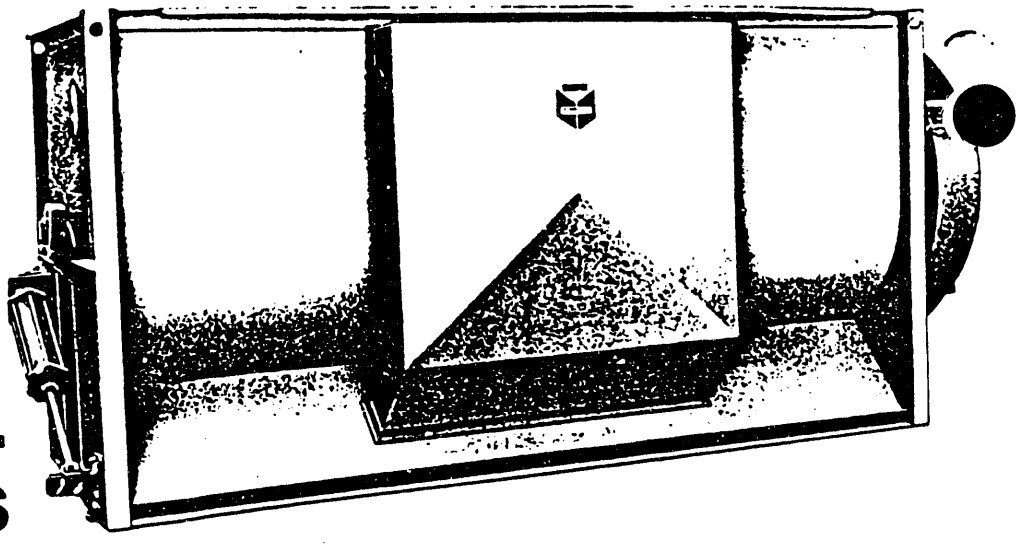
Air Purge seals prevent leakage of fine materials.

Air or sanitary seals . . . or any other types that may be required . . . also are provided.



BUILT FOR TODAY
TO LAST FOR TOMORROW

SCOTT



SCOTT HORIZONTAL MIXERS

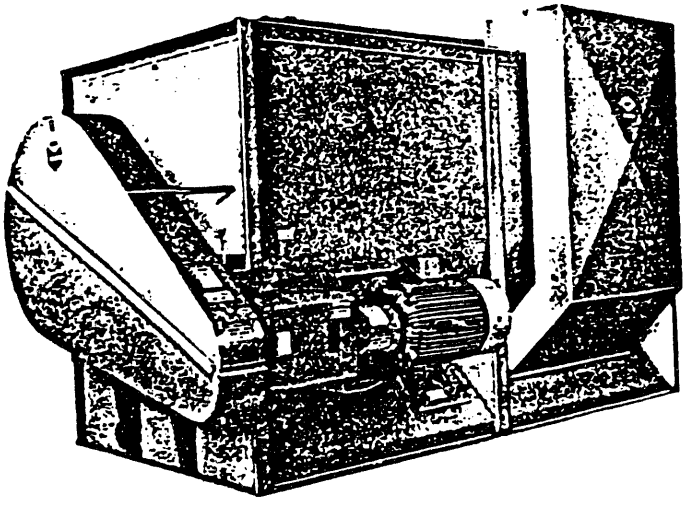
Insure accurate mixing of all types of products from fine, powdered materials to coarse-ground ingredients

- Sanitary construction in either mild or stainless steel.
- Ribbon or paddle design.
- With slide-gate or full drop-bottom discharge.
- Drop-bottom provides greater protection against contamination.
- Complete mix cycles of under four minutes.
- In 60 to 500 cubic-foot capacities.

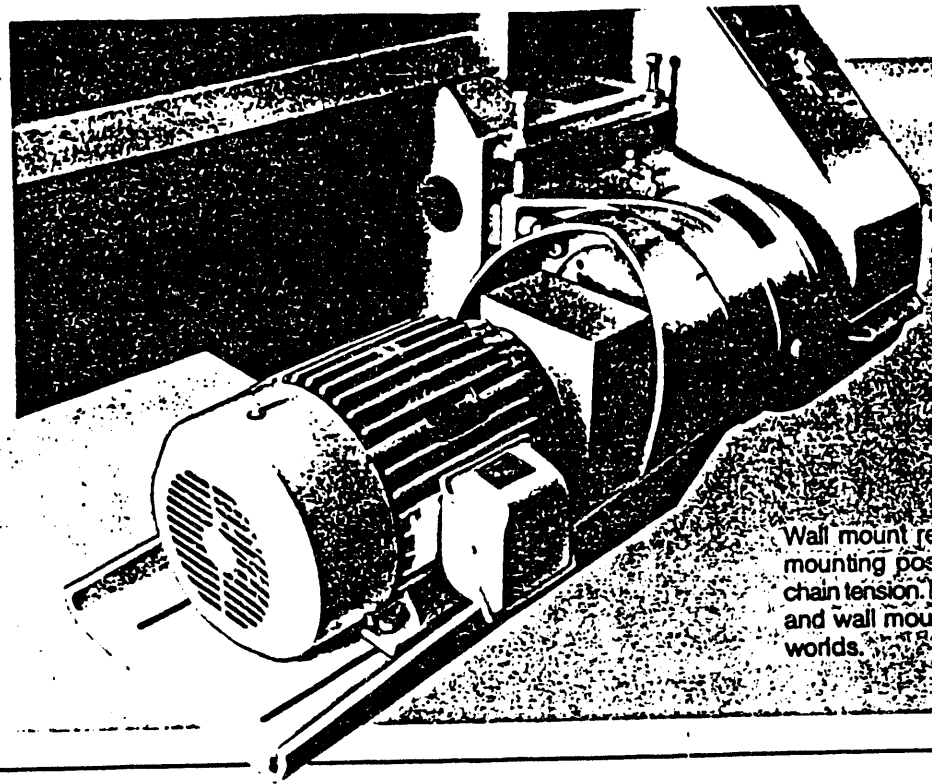
SCOTT BUILT FOR TODAY TO LAST FOR TOMORROW

RUGGEDLY-BUILT

For Long Years of Trouble-Free Operation



- Heavy-plate tub bottom and end plates.
- An oil bath guard gives the chain drive continuous lubrication.
- Special seals to fit individual requirements.
- A wide range of liquid manifolds is available for varied liquid applications.
- Can be equipped with large air vent to equalize pressure from surge to mixer in drop-bottom models.
- Jacketed mixers for heating and cooling the product also available.

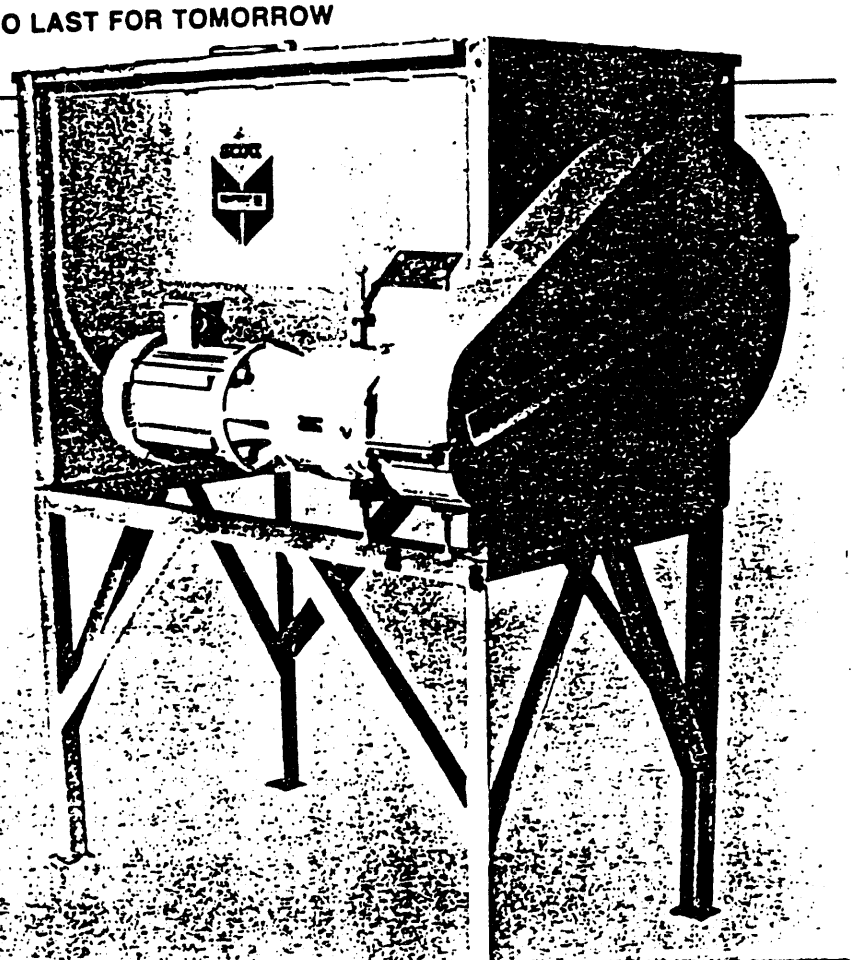


IF IT'S NEW, IT'S FROM SCOTT

Wall mount reducer for the strongest mounting possible to retain constant chain tension. Note base mounted motor and wall mount reducer. Best of both worlds.

SCOTT

BUILT FOR TODAY TO LAST FOR TOMORROW



Scott slide gate mixer with gear head motor reducer drive and mixer on legs. Hinged top cover for manual charging of mixer.

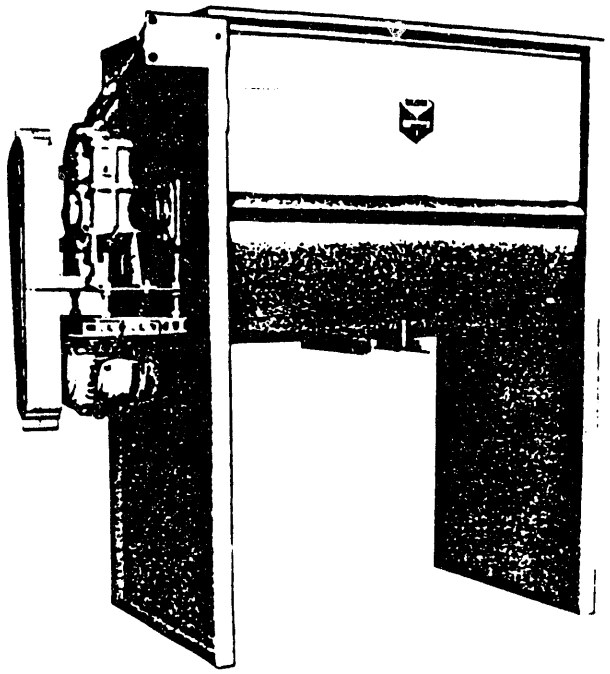
SCOTT

PROVIDES QUALITY

SCOTT EQUIPMENT IS A LEADING PROVIDER OF MIXING EQUIPMENT TO THE MATERIALS PROCESSING INDUSTRY. EACH MIXER IS BUILT TO MEET OUR CUSTOMER'S SPECIAL REQUIREMENTS. SCOTT BUILDS THE HIGHEST QUALITY EQUIPMENT AT COMPETITIVE PRICES.

SCOTT

HIGH-PERFORMANCE PRE-MIXERS

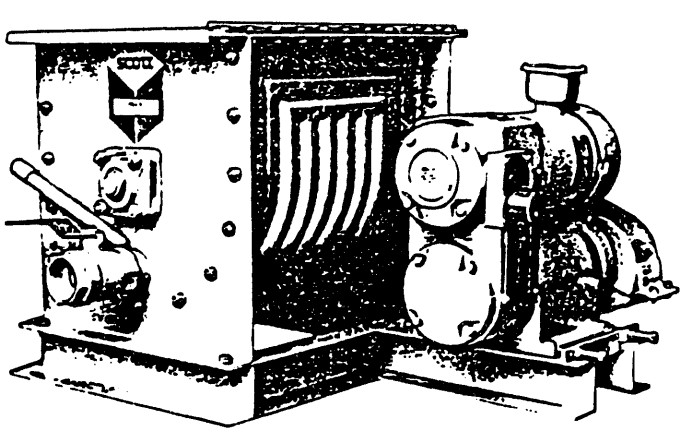


Capacities from one cubic foot to 50 cubic feet

- Heavy-duty construction in either mild or stainless steel.
- Ribbon or paddle design.
- Slide-gate or full drop-bottom discharge.
- All pre-mix units can be epoxy-coated for special applications.
- Jackets also available for heating and cooling of product.
- Also can be furnished with surge hopper or bagging hopper beneath the mixer.

SCOTT JACKETED LABORATORY MIXER

- Complete sanitary design.
- Jackets can be supplied for steam heat, hot water heat or cold water for cooling.
- In either mild or stainless steel.



What is your Mixing Problem?

All Scott Industrial Mixers are custom built to meet specific production requirements. So if you have a mixing problem . . . call Scott. There's no obligation. And our engineers will be glad to help you work it out.

SCOTT

BUILT FOR TODAY

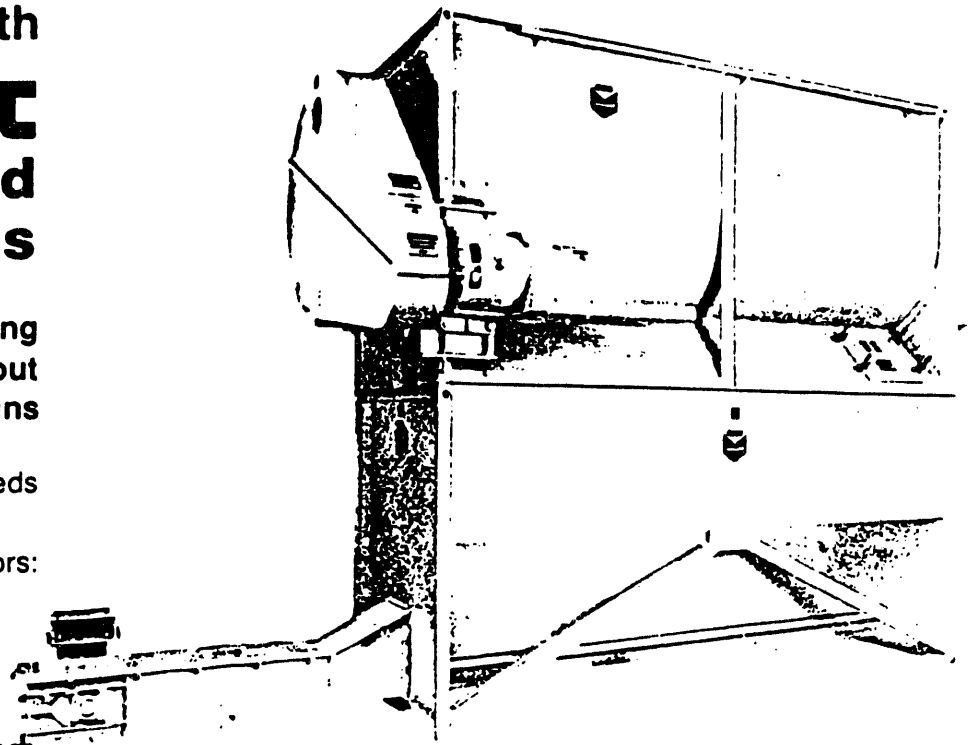
TO LAST FOR TOMORROW

SCOTT DROP-BOTTOM MIXERS

For Use With

SCOTT Specially Designed Surge Hoppers

For easy unloading and fast, efficient cleanout between mixing runs



Mixer-Surge Hopper combination speeds up production.

Available with several types of conveyors: screw, paddle-drag and flat-bottom bar.

Can be furnished with different lengths of conveyor extensions.

Surge conveyor can be equipped with curved section that inclines up to 30°.

SCOTT

BUILT FOR TODAY TO LAST FOR TOMORROW

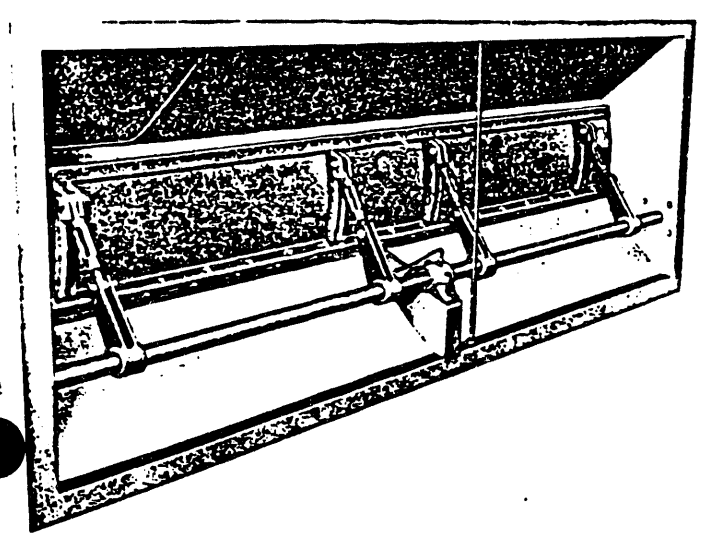
SCOTT DROP-BOTTOM GATE

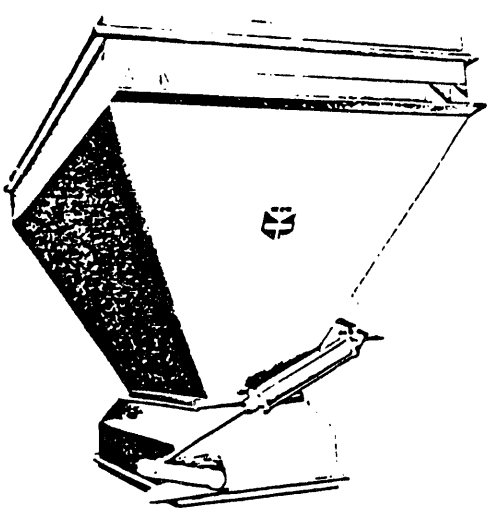
- Rugged, single drop-bottom gate is leak-proof and gives complete discharge.
- Requires minimal servicing or adjusting.
- No felt, rubber or other sealing materials are used yet a positively tight seal is obtained.

SCOTT SCALE HOPPER

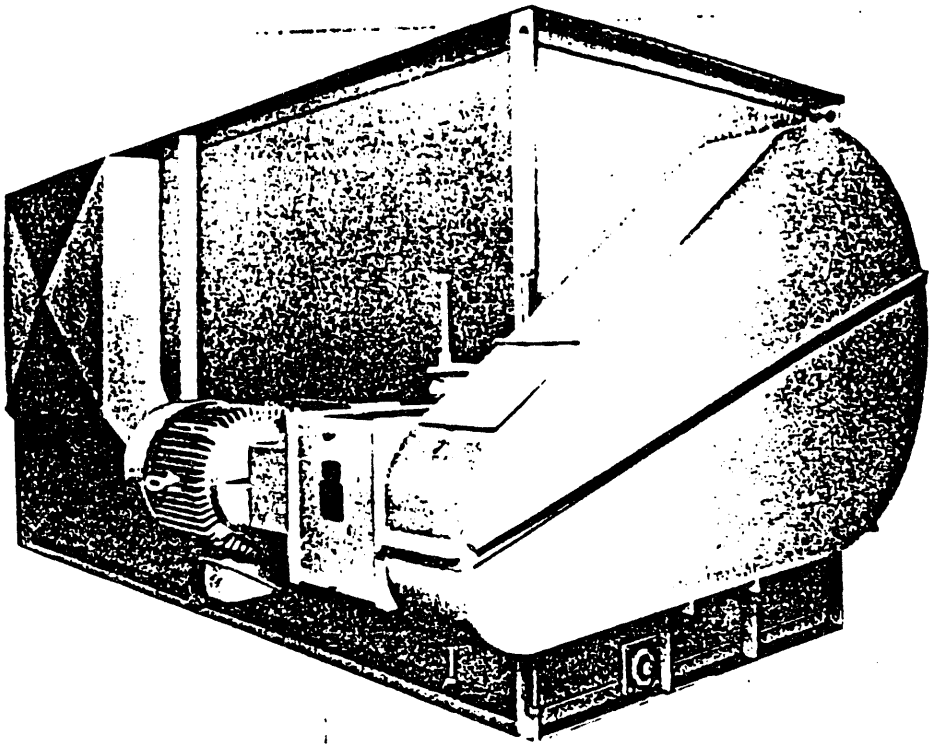
For more accurate measurement of all ingredients

- Drop-gate or slide-gate discharge.
- Adaptable to either load-cell or lever scales.
- Built to customer's specifications.

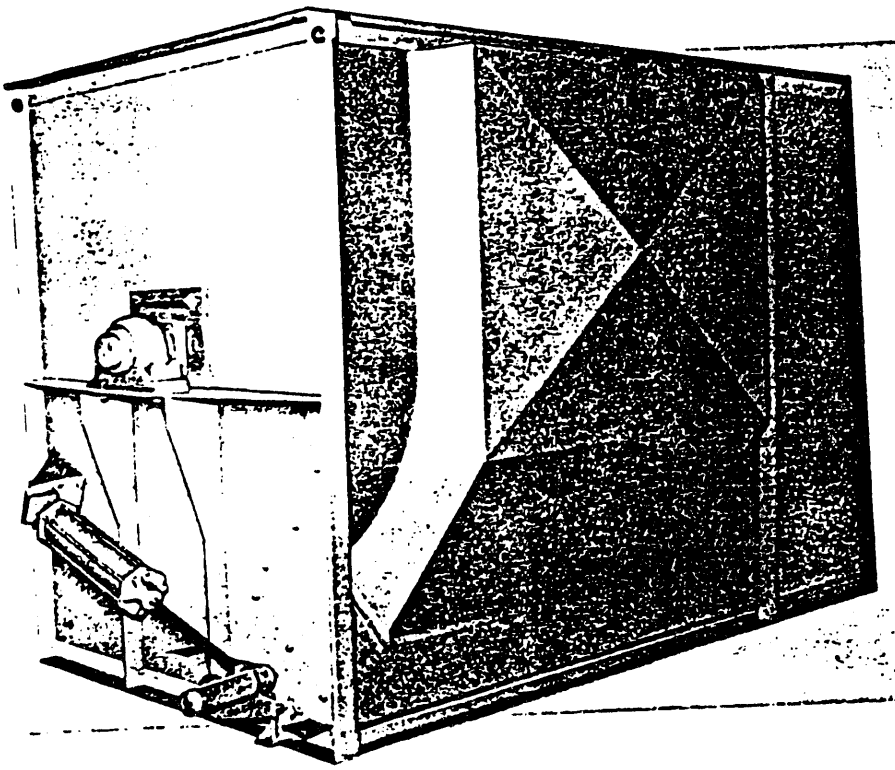




Scott drop bottom mixer with the large air intervent to eliminate dust. Scoop mount motor reducer and oil bath guard for type III lubrication and long chain life... The oil bath guard is standard equipment on all Scott Horizontal Mixers that are equipped with chain drives. The oil lubrication extends chain and sprocket life by up to three times.



SCOTT DROP BOTTOM MIXERS

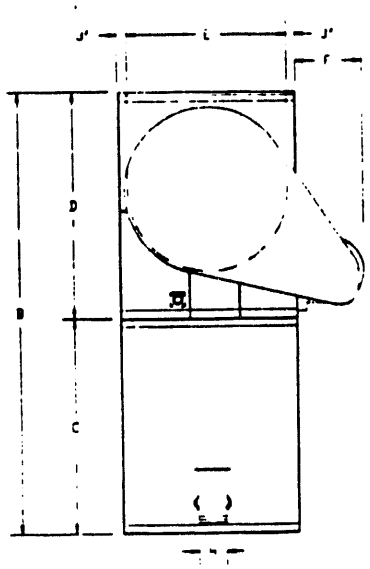


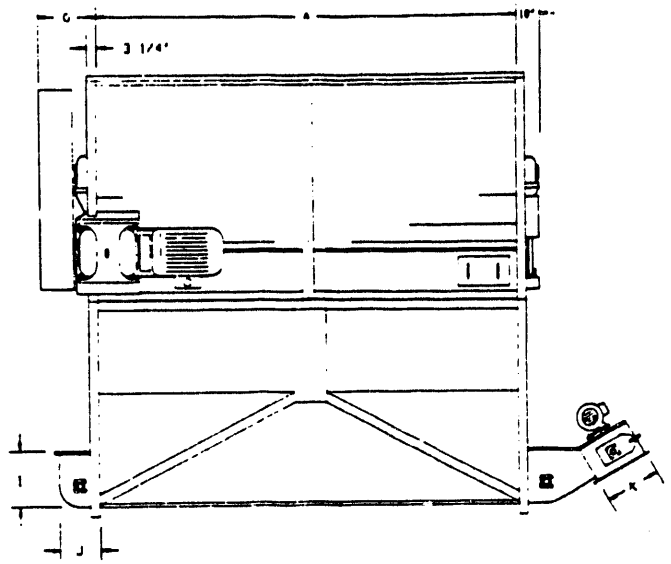
Scott drop bottom mixer with large air vent and air cylinder to operate gate. The oversized intervent on Scott drop bottom mixers allows air exchange between the mixer and surge bin to occur which helps eliminate dust contamination. This is standard equipment on all Scott drop bottom mixers. Vent air capacity ranges from 288 square inches on the small mixers to 840 square inches on the large mixers.

Air restrictors are provided on all Scott drop bottom air cylinders to regulate the speed of the gate for dust control and product discharge control.

SPECIFICATIONS

SCOTT
HEAVY-DUTY MIXERS





MIXER DIMENSIONS														
MODEL	SIZE	MIXING CAPACITY VOLUME CUFT (CUM)	SURGE HOPPER CAPACITY CUFT (CUM)	A Inches (MM)	B Inches (MM)	C Inches (MM)	D Inches (MM)	E Inches (MM)	F* Inches (MM)	G Inches (MM)	H Inches (MM)	I Inches (MM)	J Inches (MM)	K Inches (MM)
HHA485	48 x 60	60 (1.7)	70 (2.0)	60 (1524)	134 (3403.6)	64 (1625.6)	70 (1778)	48 (1219.2)	22 (558.8)	16 (406.4)	8 (203.2)	22 (558.8)	16 (406.4)	18 (457.2)
HHA486	48 x 72	75 (2.1)	88 (2.5)	72 (1828.8)	134 (3403.6)	64 (1625.6)	70 (1778)	48 (1219.2)	22 (558.8)	16 (406.4)	8 (203.2)	22 (558.8)	16 (406.4)	18 (457.2)
HHA488	48 x 96	99 (2.8)	116 (3.2)	96 (2438.4)	134 (3403.6)	64 (1625.6)	70 (1778)	48 (1219.2)	22 (558.8)	16 (406.4)	8 (203.2)	22 (558.8)	16 (406.4)	18 (457.2)
HHA489	48 x 108	113 (3.2)	133 (3.7)	108 (2743.2)	134 (3403.6)	64 (1625.6)	70 (1778)	48 (1219.2)	22 (558.8)	16 (406.4)	8 (203.2)	22 (558.8)	16 (406.4)	18 (457.2)
HHA4810	48 x 120	126 (3.5)	148 (4.2)	120 (3048)	134 (3403.6)	64 (1625.6)	70 (1778)	48 (1219.2)	22 (558.8)	16 (406.4)	8 (203.2)	22 (558.8)	16 (406.4)	18 (457.2)
HHA4812	48 x 144	151 (4.2)	177 (5.0)	144 (3657.6)	134 (3403.6)	64 (1625.6)	70 (1778)	48 (1219.2)	22 (558.8)	16 (406.4)	8 (203.2)	22 (558.8)	16 (406.4)	18 (457.2)
HHA5410	54 x 120	159 (4.5)	187 (5.2)	120 (3048)	148 (3759.2)	72 (1828.8)	76 (1778)	54 (1938.4)	22 (558.8)	16 (406.4)	10 (254.0)	22 (558.8)	16 (406.4)	18 (457.2)
HHA5412	54 x 144	200 (5.6)	235 (6.6)	144 (3657.6)	148 (3759.2)	72 (1828.8)	76 (1778)	54 (1938.4)	22 (558.8)	16 (406.4)	10 (254.0)	22 (558.8)	16 (406.4)	18 (457.2)
HHA5414	54 x 168	223 (6.2)	261 (7.3)	168 (4267.2)	148 (3759.2)	72 (1828.8)	76 (1778)	54 (1938.4)	22 (558.8)	16 (406.4)	10 (254.0)	22 (558.8)	16 (406.4)	18 (457.2)
HHA6012	60 x 144	235 (6.6)	275 (7.7)	144 (3657.6)	162 (4114.8)	80 (2032)	82 (2082.8)	60 (1524)	24 (609.6)	19 (482.6)	12 (304.8)	22 (558.8)	16 (406.4)	22 (558.8)
HHA6013	60 x 156	255 (7.2)	298 (8.3)	156 (3962.4)	162 (4114.8)	80 (2032)	82 (2082.8)	60 (1524)	24 (609.6)	19 (482.6)	12 (304.8)	22 (558.8)	16 (406.4)	22 (558.8)
HHA6014	60 x 168	275 (7.7)	322 (9.0)	168 (4267.2)	162 (4114.8)	80 (2032)	82 (2082.8)	60 (1524)	24 (609.6)	19 (482.6)	12 (304.8)	22 (558.8)	16 (406.4)	22 (558.8)
HHA6615	66 x 180	350 (9.8)	410 (11.5)	180 (4572)	176 (4470.4)	88 (2235.2)	88 (2235.2)	66 (1676.4)	30 (762)	20 (508)	12 (304.8)	22 (558.8)	16 (406.4)	22 (558.8)
HHA7214	72 x 168	395 (11.2)	462 (13)	168 (4267.2)	190 (4826)	96 (2438.4)	94 (2387.6)	72 (1828.8)	30 (762)	24 (609.6)	18 (457.2)	36 (914.4)	24 (609.6)	24 (609.6)
HHA7815	78 x 180	497 (14)	581 (16.4)	180 (4572)	204 (5181.6)	104 (2641.6)	100 (2540)	78 (1981.2)	30 (762)	24 (609.6)	18 (457.2)	36 (914.4)	24 (609.6)	24 (609.6)

* APPROXIMATE DIM VARIES DEPENDING ON HORSE POWER REQUIREMENTS

- **Also available in intermediate sizes.**
- **All mixing capacities based on 30 pounds per cubic-foot material.**

All Scott Equipment products can be custom built to fit user requirements.

SCOTT

EQUIPMENT COMPANY

605 Fourth Avenue N.W., New Prague, MN 56071, Phone: 612-758-2591
FAX #: 758-4377

Optional Features

Seals

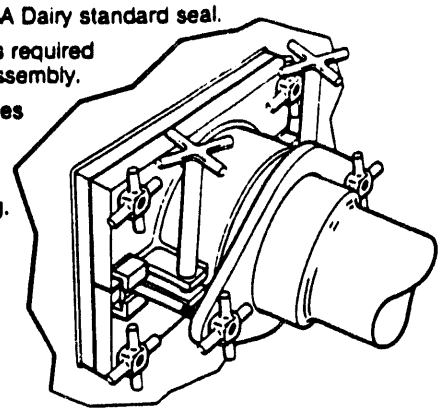
The seals shown are the basic seal designs offered on the Scott Horizontal Mixer. These seals will meet most of the requirements for today's mixing industry. If you have a particular problem with your product, Scott will be happy to custom design a seal to fill your need.

Ultra Sanitary Seal

USDA 3A Dairy standard seal.

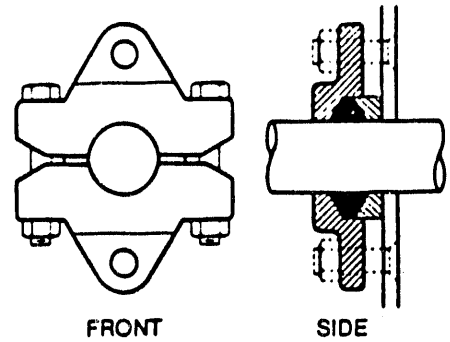
No tools required for disassembly.

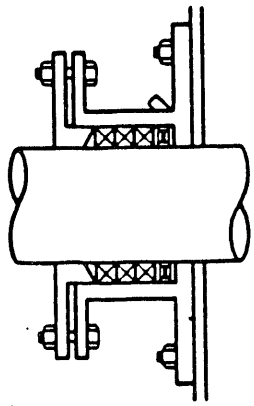
All flanges split to remove for washing.



Split Packing Gland Seal

Graphite or nylon packing.

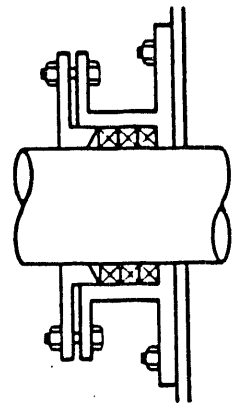




Air Purge Seal

Air purge packing gland seals are available for special applications.

Air purge seals prevent leakage of fine materials.



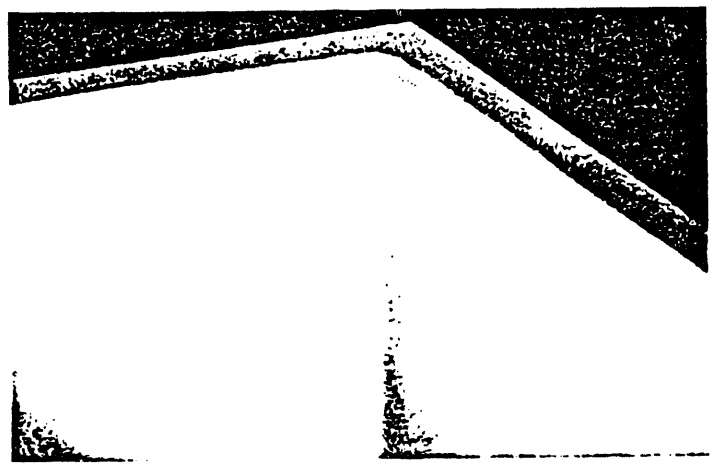
Packing Gland Seal

3 or more rings of packing available.

Polished Sanitary Interior

Generous radius of rounded inside corners helps eliminate contamination between mixer runs.

All mixers can be furnished in either mild or stainless steel.



What is Your Mixing Problem?

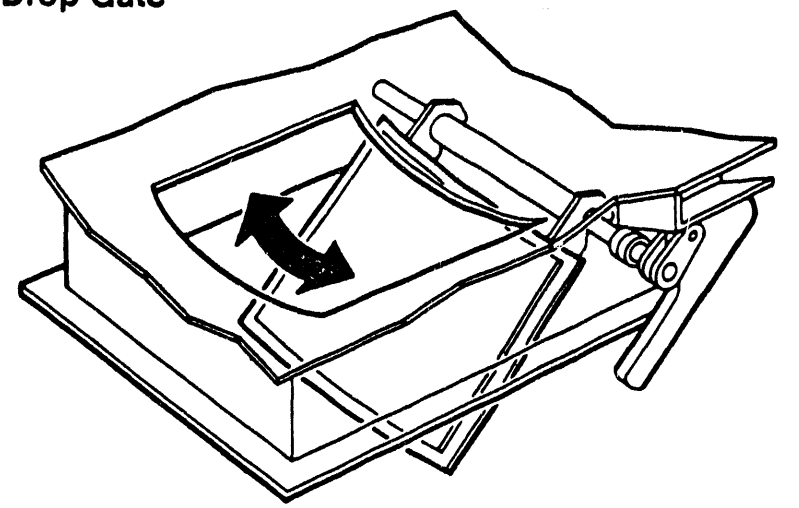
All Scott Industrial Mixers are custom built to meet specific production requirements. So if you have a mixing problem... call Scott. There's no obligation. And our engineers will be glad to help you work it out.

Optional Features

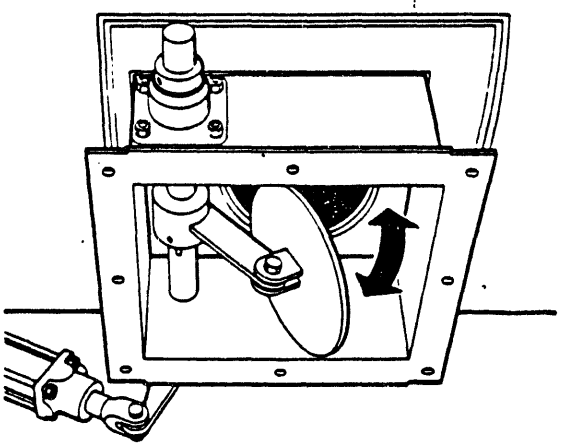
Discharge Gates

Scott Equipment offers a wide variety of discharge gates. These gates are available in sizes ranging from 2" diameter to 36" diameter. With the ribbon design agitator, the discharge gate can be located on either end of the mixer or in the center of the mixer. The paddle design agitator must have the discharge located in the center of the mixer. The different discharge gates available from Scott Equipment Company will meet your needs. Custom designed discharges are also available.

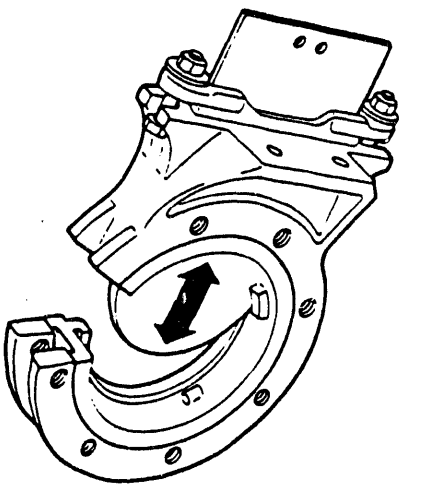
Hinged Drop Gate



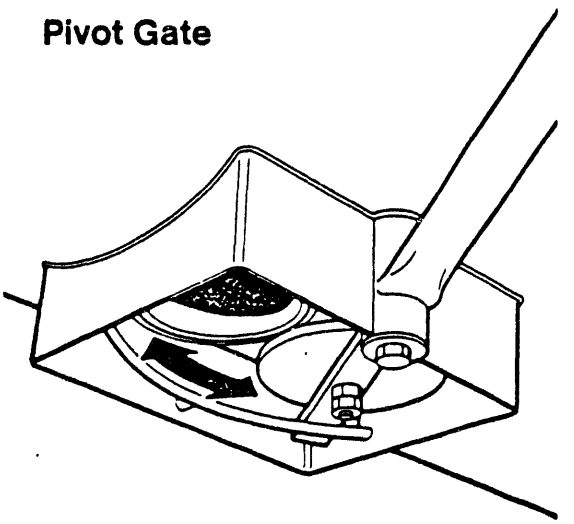
Hinged Plug Gate



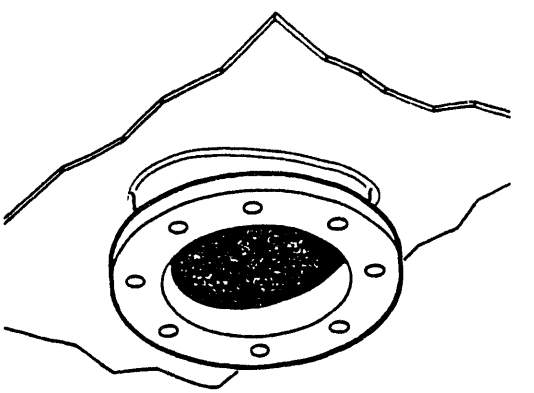
Sanitary Knife Gate



Pivot Gate



Pipe Flange Adapter

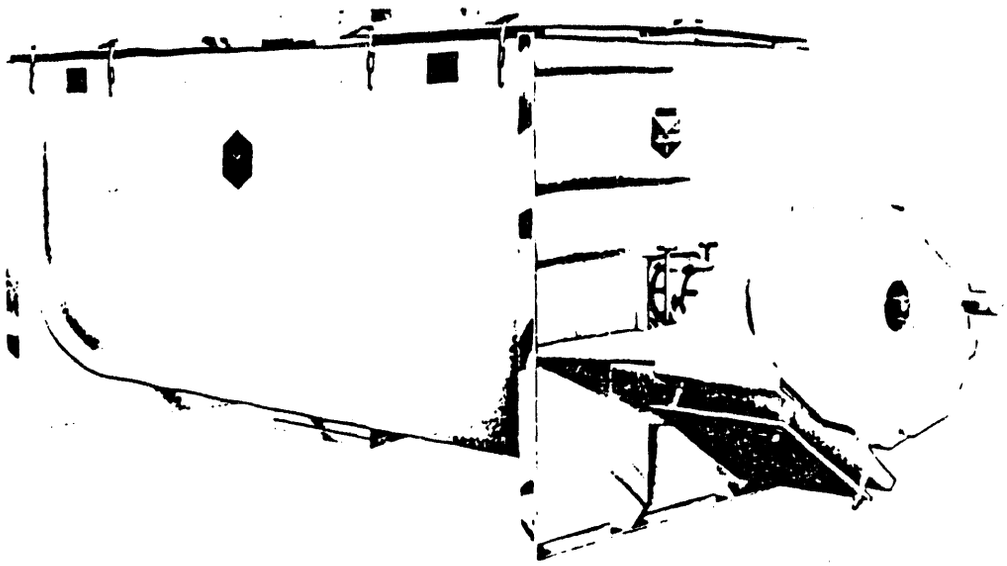


SCOTT

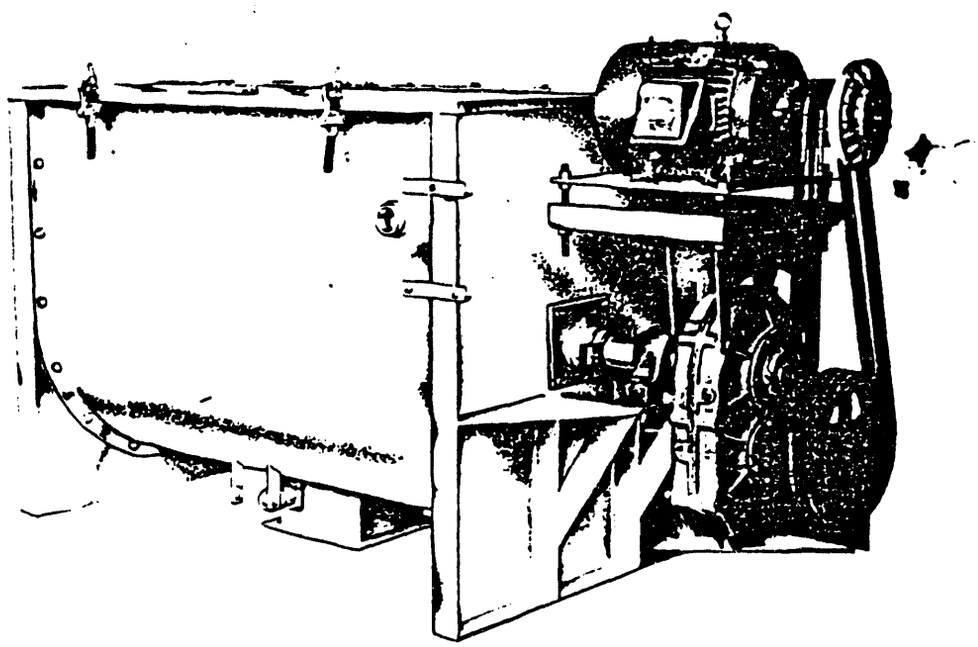
Horizontal Mixers

Insure accurate mixing of all types of products from fine powdered materials to coarse ground ingredients.

Ruggedly-built for long years of trouble-free operation



A



B

A. Sanitary construction in either mild or stainless steel.

Ribbon or paddle design. Wide variety of dischargers available.

Complete mix cycles of under four minutes.

Available in 1 to 500 cubic foot capacities.

B. Heavy-plate tub bottom and end plates.

Oil bath guard gives the chain drive continuous lubrication.

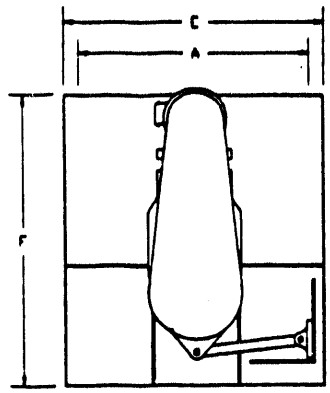
Special seals to fit individual requirements.

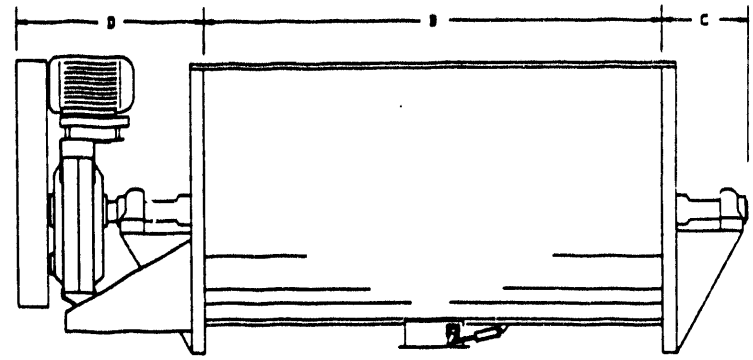
Wide range of liquid manifolds is available for varied liquid applications.

Jacketed mixers for heating and cooling the product also available in mild or stainless steel.

SCOTT

Built For Today... To Last For Tomorrow





MODEL #	SIZE	CAPACITY CUFT. (CU.M.)	DIMENSIONS IN. (MM)					
			A	B	C	D*	E	F
HM243	24X36	10 (.28)	24 (610)	36 (914)	10 (254)	23 (584)	28 (711)	32 (813)
HM304	30X48	20 (.56)	30 (762)	48 (1219)	10 (254)	23 (584)	34 (864)	38 (965)
HM404	40X48	35 (.99)	40 (1016)	48 (1219)	10 (254)	23 (584)	44 (1118)	48 (1219)
HM405	40X60	44 (1.24)	40 (1016)	60 (1524)	10 (254)	23 (584)	44 (1118)	48 (1219)
HM445	44X60	53 (1.5)	44 (1118)	60 (1524)	10 (254)	23 (584)	50 (1270)	56 (1422)
HM485	48X60	63 (1.78)	48 (1219)	60 (1524)	10 (254)	25 (635)	54 (1372)	60 (1524)
HM486	48X72	75 (2.12)	48 (1219)	72 (1829)	10 (254)	25 (635)	54 (1372)	60 (1524)
HM488	48X96	101 (2.86)	48 (1219)	96 (2438)	12 (305)	28 (711)	54 (1372)	60 (1524)
HM489	48X108	113 (3.19)	48 (1219)	108 (2743)	12 (305)	28 (711)	54 (1372)	60 (1524)
HM4810	48X120	126 (3.56)	48 (1219)	120 (3048)	14 (356)	30 (762)	54 (1372)	60 (1524)
HM4812	48X144	151 (4.27)	48 (1219)	144 (3658)	14 (356)	30 (762)	54 (1372)	60 (1524)
HM5410	54X120	159 (4.5)	54 (1372)	120 (3048)	14 (356)	30 (762)	60 (1524)	66 (1676)
HM5412	54X144	191 (5.4)	54 (1372)	144 (3658)	14 (356)	30 (762)	60 (1524)	66 (1676)
HM5414	54X168	223 (6.31)	54 (1372)	168 (4267)	14 (356)	30 (762)	60 (1524)	66 (1676)
HM6012	60X144	236 (6.68)	60 (1524)	144 (3658)	14 (356)	34 (864)	66 (1676)	72 (1829)
HM6013	60X156	255 (7.22)	60 (1524)	156 (3962)	14 (356)	34 (864)	66 (1676)	72 (1829)
HM6014	60X168	275 (7.78)	60 (1524)	168 (4267)	14 (356)	34 (864)	66 (1676)	72 (1829)
HM6615	66X180	350 (9.91)	66 (1676)	180 (4572)	14 (356)	34 (864)	72 (1829)	78 (1981)

*APPROXIMATE DIM. VARIES DEPENDING ON HORSE POWER REQUIREMENTS.

DIFFERENT SIZE MACHINES AVAILABLE UPON REQUEST.

Scott Equipment Company

605
Fourth Ave. N.W.
New Prague
Minnesota
56071

(612) 758-2591
x (612) 758-4377

Sanitary Design Ribbons

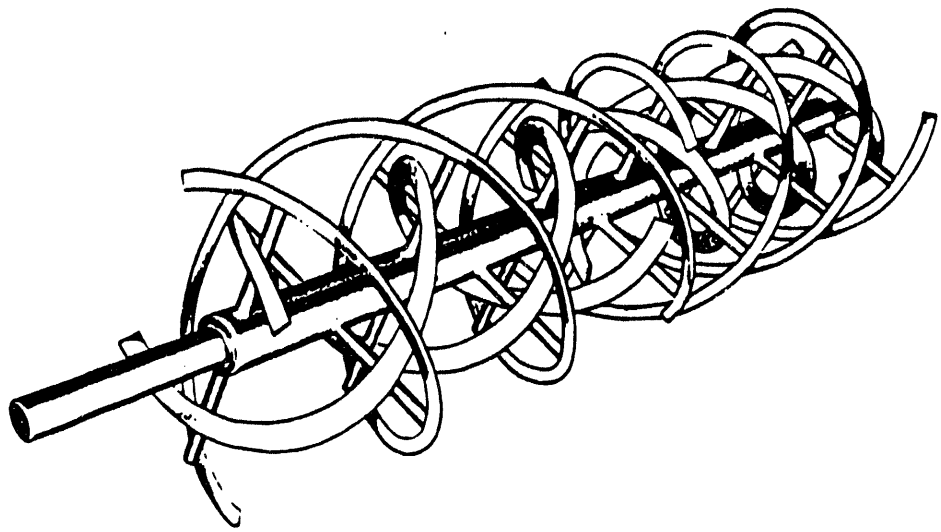
Constructed in close-wrapped balanced design.

Triple-mixing action insures smoother, more efficient blending of ingredients.

Polished sanitary design to help eliminate cross contamination between mixing runs.

Optional air-purge design through main shaft to give complete cleanout.

Available in either mild or stainless steel.



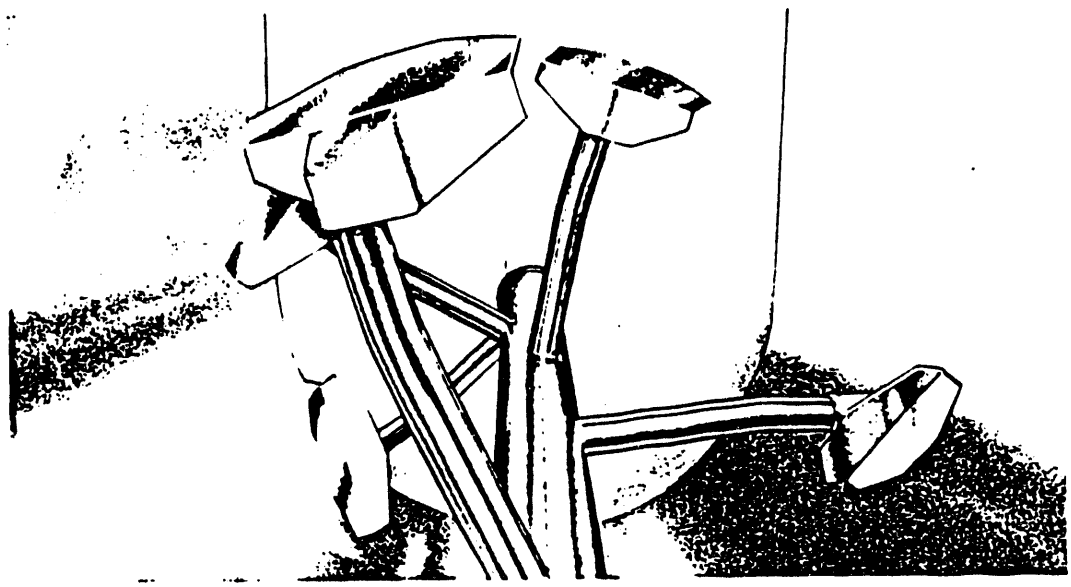
Paddle Agitator Assembly

Allows for easy cleaning of agitator assembly.

Available in polished sanitary design up to 3A Dairy Standard if desired.

Available in mild or stainless steel construction.

Paddle blades are adjustable and replaceable to maintain close tolerance to mixer bottom in non-sanitary models.

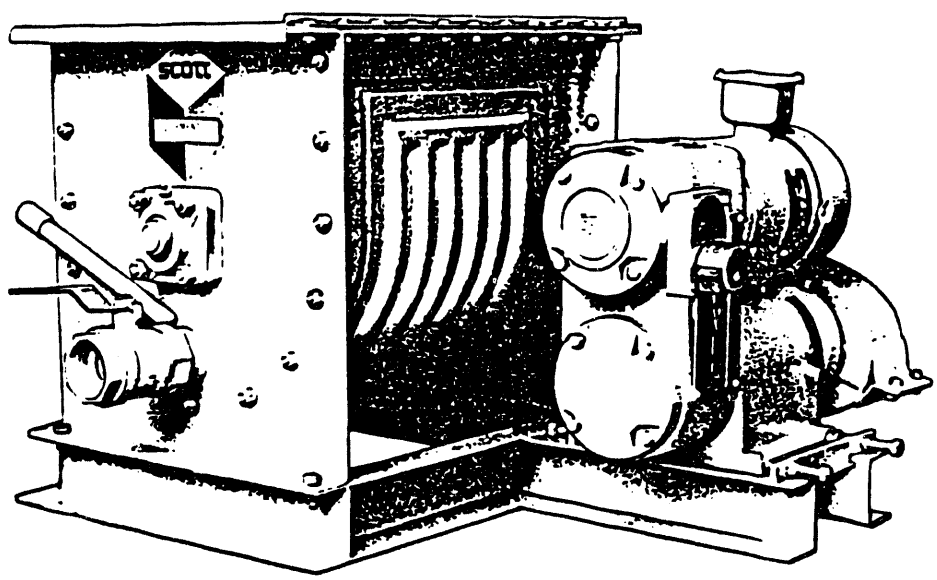


Jacketed Laboratory Mixer

Complete sanitary design.

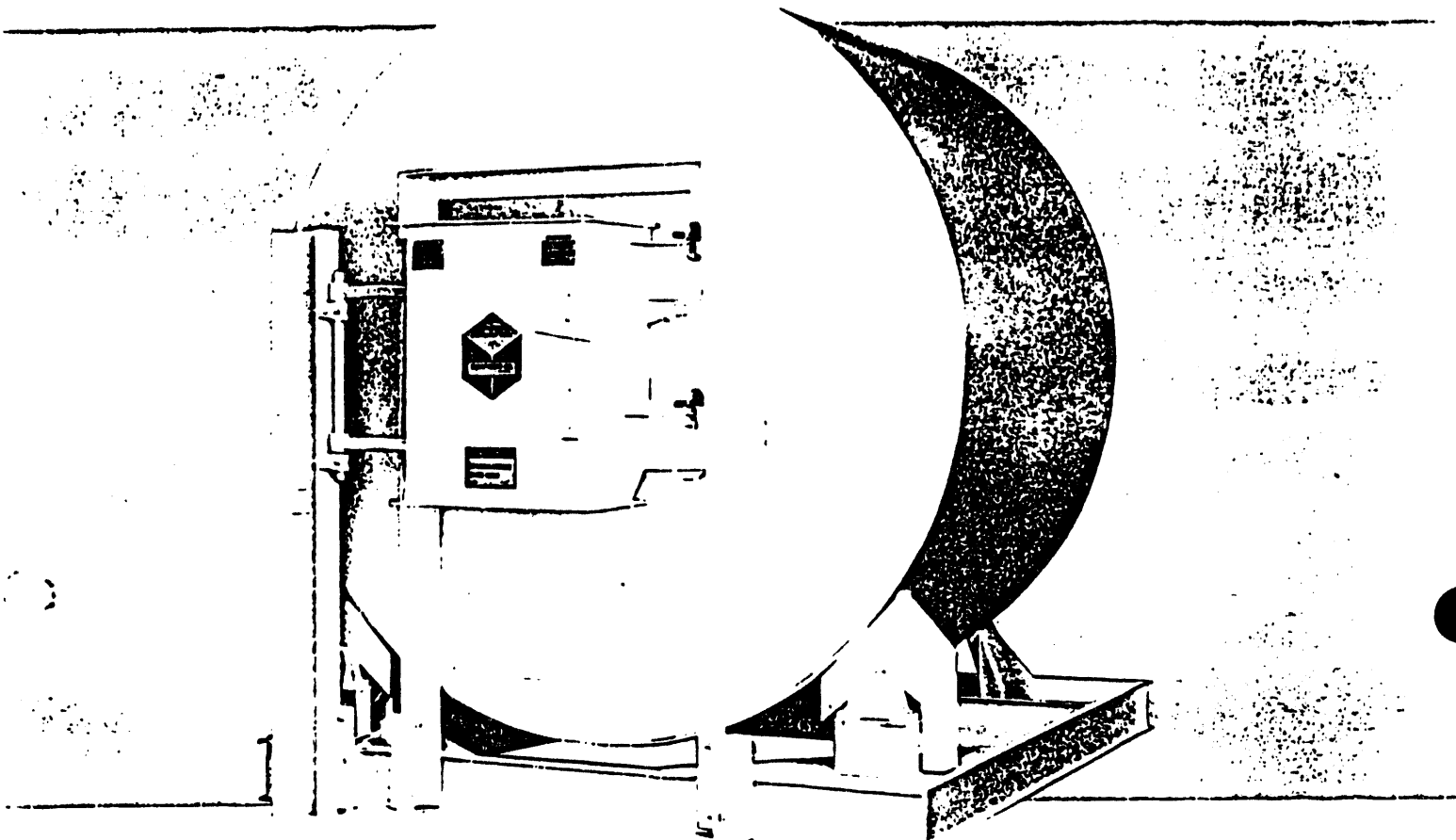
Jackets can be supplied for steam heat, hot water heat or cold water for cooling.

Available in either mild or stainless steel.



SCOTT

HIGH-CAPACITY ROTARY DRUM MIXER



- Stainless or mild steel construction.
- No augers or ribbons.
- Low in cost.
- Minimum service and maintenance.
- 2-ton size discharges completely in 30 seconds.

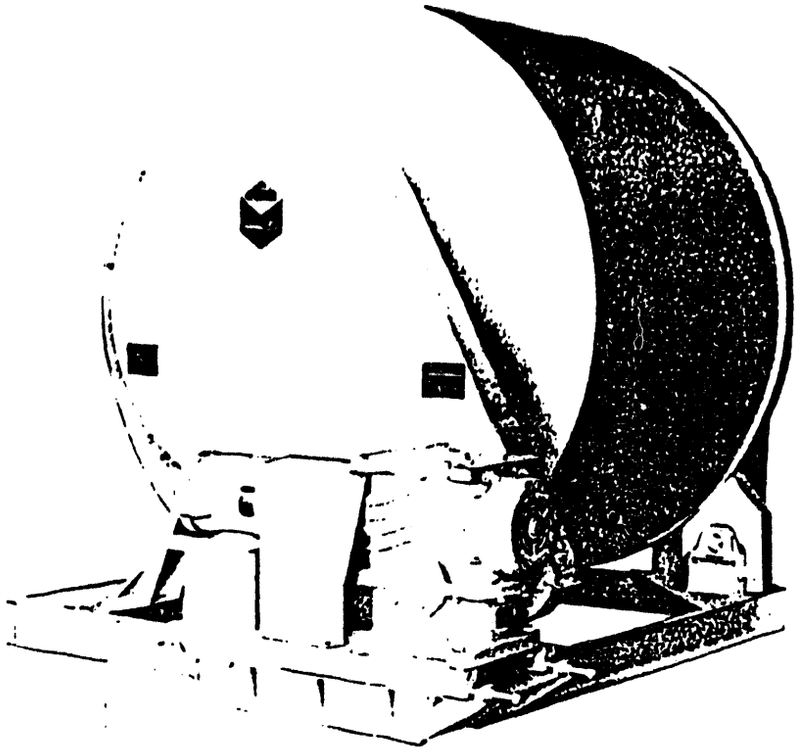
For Fast, Efficient Mixing of Heavy Free-Flowing Materials

IF IT'S NEW YOU KNOW IT'S FROM SCOTT

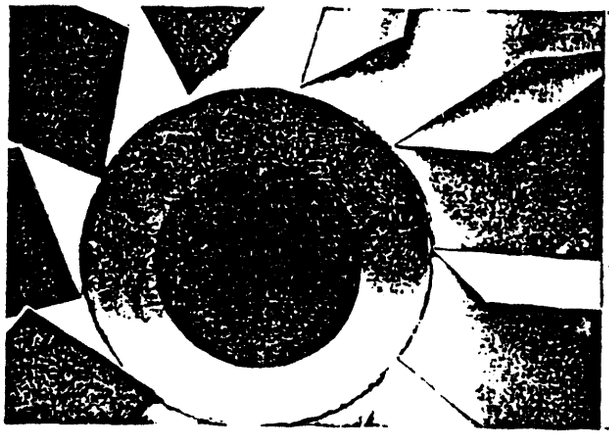
SCOTT EQUIPMENT CO.
605 Fourth Ave. N.W., New Prague, Minn. 56071 612/758-2591
FAX #: 758-4377

ROVIDE

SERVICE



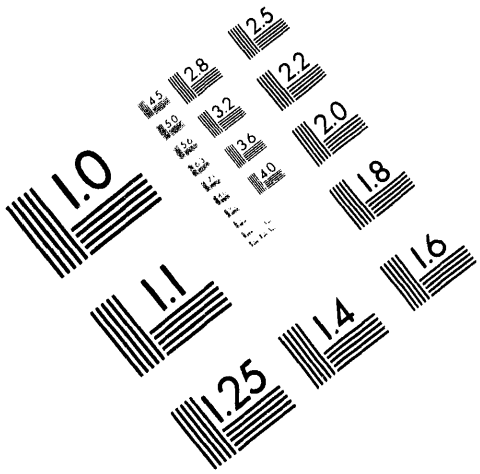
- All shafts and bearings are extremely easy to replace.
- The front trunnion wheels are standard items that we stock and can be easily replaced by removal of only four bolts.
- Power supplies range from 7½ HP for the 2-ton mixer to 20 HP for the 4-ton unit.
- With proper loading and unloading, it is possible to achieve production of 90 tons per hour with our 2-ton, high-capacity mixer.



IF IT'S NEW
YOU KNOW
IT'S FROM
SCOTT

NO AUGERS OR RIBBONS to become coated and bind as a result of condensation or sweating inside the mixer. The forward/reverse rotation of the drum and heavy, angled stainless or mild steel baffle plates assure virtually a 100 percent discharge.

You'll Increase Production and Cut Mixing Costs with the SCOTT High-Capacity Rotary Drum Mixer



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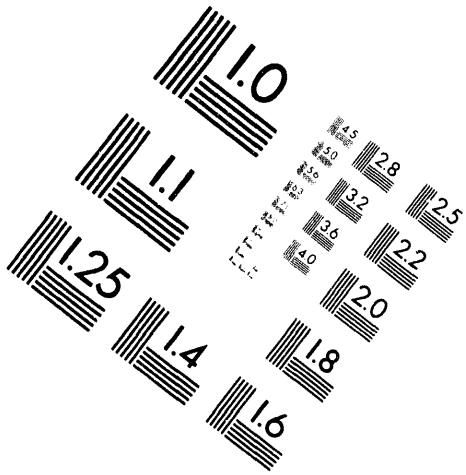
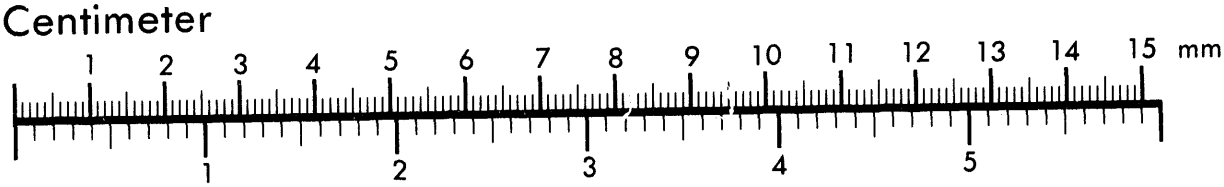
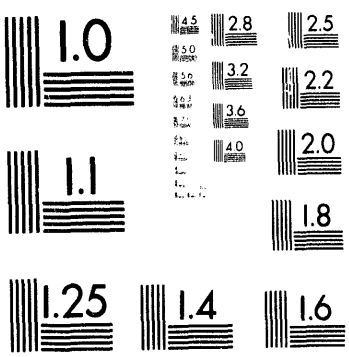
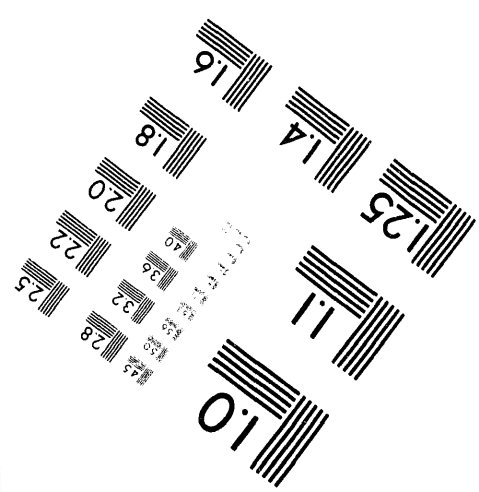


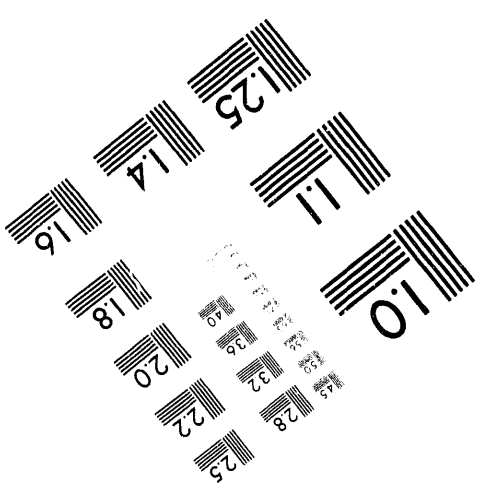
Centimeter



Inches

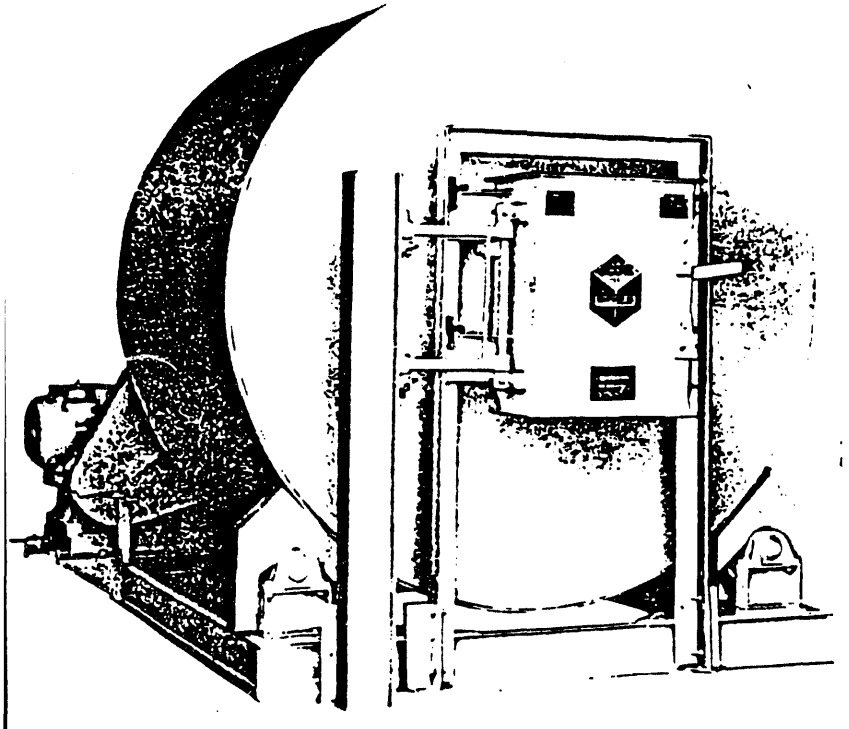




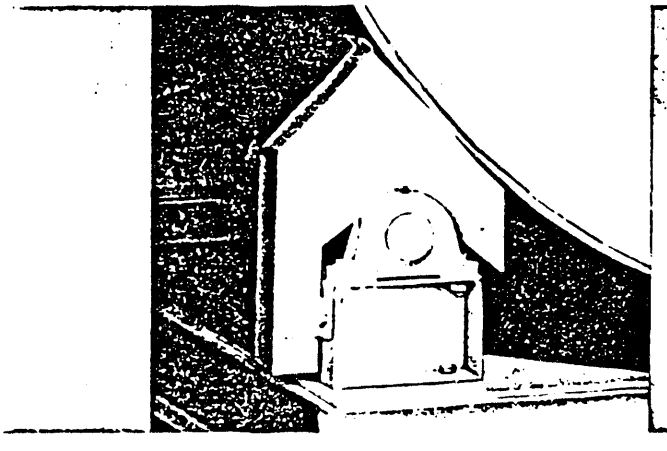


MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

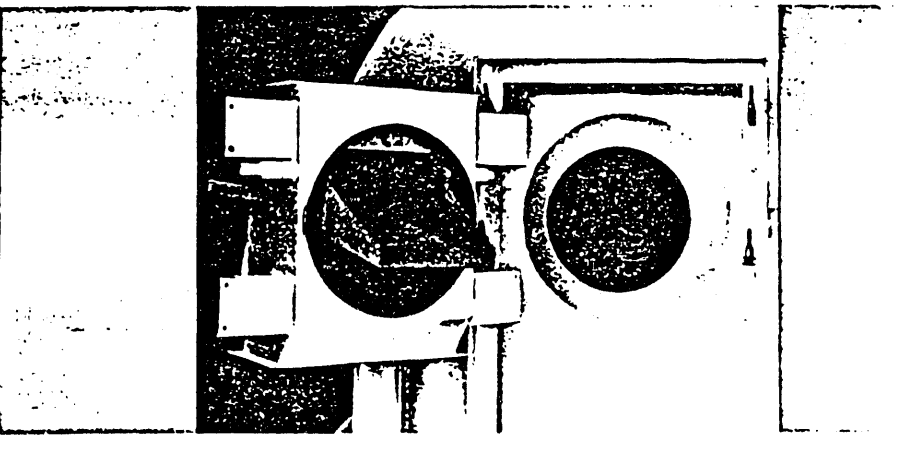
QUALITY ENGINEERED TO LONG YEARS OF TROUBLE-



- Sturdy, all-welded construction.
- Mixing and discharging is done by heavy stationary paddles welded inside the mixer drum.
- Bearings and seals do not come in direct contact with the material.
- Because there are no ledges and no seals inside the mixer, it is easier to clean.
- Complete cleanout eliminates contamination.
- A full 2-ton mixing cycle, including charging, mixing and discharging, can be completed in 90 seconds.



SPECIAL GUARDS OVER TRUNNION WHEELS insure greater safety when mixer is in operation. The stress and strain on these wheels is critical since the entire drum rotates on them.

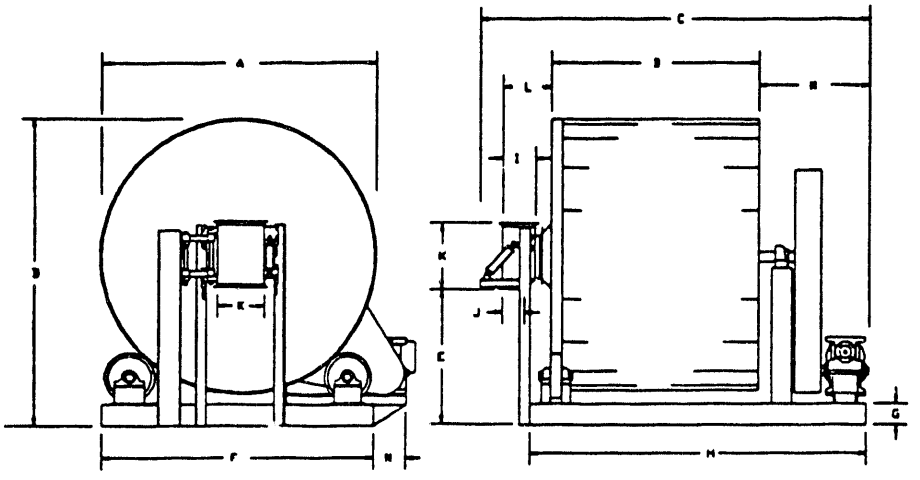


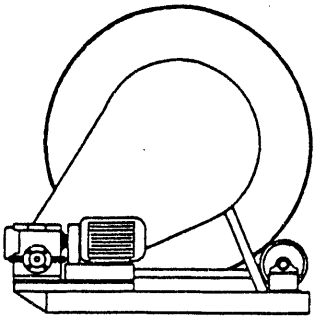
OPTIONAL SWING INLET-DISCHARGE DOOR provides easier access to the interior of the drum. This allows faster, more efficient cleanout after mixing runs and gives greater protection against contamination.

SCOTT

HIGH-CAPACITY ROTARY DRUM MIXER

SPECIFICATIONS





MIXER DIMENSIONS (in.)																	
SIZE	CAP cu.ft.	H.P	A	B	C	D	E	F	G	H	I	J	K	L	M	N
RD20	20	3-5	73.5	24	59	81.5	35.25	72	6	61	10	7	19	16	30	15
RD30	30	5-7.5	73.5	48	107	81.5	35.25	72	6	85	10	7	19	16	30	15
RD60	60	5-7.5	73.5	60	122	81.5	35.25	72	6	99	10	7	19	16	32	16
RD75	75	7.5-10	79.5	60	122	87.5	38.25	78	6	99	10	7	19	16	32	16
RD80	80	10-15	83.5	60	125	91.5	40.25	84	6	102	10	7	19	16	35	18
RD100	100	15-20	94.5	60	130	104.5	47.75	94	8	107	10	7	19	16	40	20
RD140	140	20-30	86.5	96	166	96.5	43.75	86	8	143	10	7	19	16	40	20
RD170	170	30	85.5	120	174	97.5	45.25	86	10	167	10	7	19	16	40	20
RD225	225	50	97.5	120	174	109.5	51.25	98	10	167	10	7	19	16	40	20
RD275	275	75	107.5	120	174	119.5	56.25	108	10	167	10	7	19	16	40	20

NOTE: DIMENSIONS BASED ON 12" INLET-DISCHARGE CHUTE & WORM-GEAR DRIVE.

Other Precision Engineered Products also available from **SCOTT**

- HIGH SPEED LIQUID BLENDERS
- HORIZONTAL MIXERS
- LIQUID CONDITIONING FEEDERS
- EXTERNAL FAT APPLICATION REELS
- HEAVY-DUTY BATCH MIXERS
- HIGH-SPEED CONTINUOUS MIXERS
- HORIZONTAL WEIGH BLENDER SYSTEMS
- COMPLETE BATCH MAKE-UP SYSTEMS
- MODULAR STEEL PANELS

We will be pleased to quote on any of these items of equipment.

All SCOTT EQUIPMENT Products Can Be Custom-Built to Fit Users' Requirements

IF IT'S NEW YOU KNOW IT'S FROM SCOTT

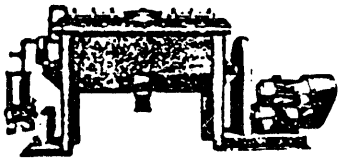
SCOTT EQUIPMENT CO.

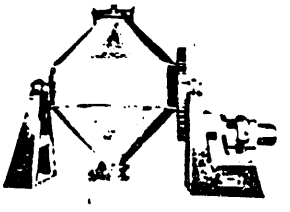
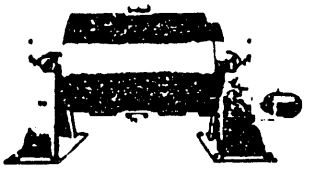
605 Fourth Ave. N.W., New Prague, Minn. 56071 612/758-2591

FAX #: 758-4377

MIXERS

FOR BATCH OR CONTINUOUS MIXING OF DRY POWDERS, PASTES, AND SLURRIES



PAUL O. ABBÉ INC.

RIBBON MIXERS — PAGE 2

SIGMA BLADE MIXERS — PAGE 7

LIGHT DUTY DOUBLE SHAFT MIXERS — PAGE 9

ROTA-CONE DRY BLENDERS — PAGE 10

CYLINDER MIXERS — PAGE 14

DRUM ROLLERS — PAGE 15

LUMP BREAKER — PAGE 15

Ribbon Mixers

Paul O. Abbé Mixers have long been noted for their efficiency in mixing dry powders and granular materials, adding small quantities of liquids to a dry batch, and for flowing pastes. Recent modifications in design, and the addition of auxiliary equipment have, however, greatly increased their field of usefulness. Other operations, which they are efficiently performing in many plants, are: deaerating—drying—chilling—crystallizing—as well as various chemical reactions.

Construction Features

CUSTOM BUILT—Certain features are inherent in the design of our Ribbon Mixers. They are sufficiently flexible, however, to permit any changes that may be necessary to meet a specific operating requirement. This flexibility, combined with our wide experience in the mixing field, enables us to custom build a mixer that will best perform the job for which it is intended.

BOWL and ends are of heavy welded steel construction to assure rugged, leakproof units. Inside corners are fillet welded. Slotted ends can be furnished, when required.

RIBBON AGITATOR for either center or end discharge. Various styles are available to suit specific operating conditions. Those most commonly used are described on page 5.

BEARINGS—Anti-friction spherical bearings suitable for radial and thrust loads are mounted outboard.

SHAFT SEALS—The adjustable gland type seal, described on page 6, is standard. Close tolerance shaft alignment (described in the construction details of our agitators on page 5) assures efficient seal operation. Seals are easily serviced. There are many other types of special seals that can also be adapted to our mixers.

LIQUID SPRAY—Spray nozzles add liquids in controlled amounts for uniformly blending liquids and solids. A practical liquid spraying system is illustrated in fig. 55 on page 12.

TEMPERATURE CONTROL—Jackets are adaptable for cold water, brine and other coolants or hot water, steam, and oil. Suitable baffling insures positive, uniform circulation.

PRESSURES—A.S.M.E. code construction where high pressures are involved.

VACUUM—All sizes can be built for vacuum operation.

COVER—Designed for vacuum, pressure or dustproof construction—all with limit switches.

SANITARY DESIGN for food and pharmaceutical products requiring fast, easy cleaning, in full compliance with government regulations.

SUPPORTS are heavy steel structurals welded to mixer body, providing reasonable working clearance underneath. Changes in the height of these can be easily incorporated to suit any specific operating requirement.

DISCHARGE—Center or end discharge, as desired. The valves most commonly supplied are illustrated on page 6. *with safety grate.*

MOTOR DRIVES—Due to plant space problems and customer preference, we provide a choice of two basic drive arrangements:
1) "Shaft-Pack" drive similar to figures 5 & 6.
2) Roller Chain drive similar to figures 4 & 7.

Either of these drives is mounted on a base which is welded to the mixer stand. The motor can be located beneath the mixer bowl or at the end.

Other special drive arrangements such as V-belt and Silent Chain can also be furnished.

Laboratory Mixers

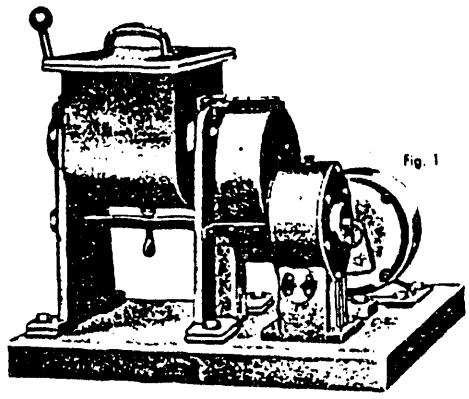


Fig. 1

No. O Ribbon Mixer—bowl tilts for discharge.

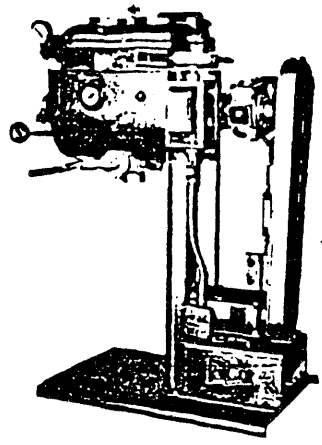


Fig. 2

Jacket for temperature control and vacuum cover permit extensive opportunity for research in this pilot unit. Cantilever mounting and high stands are for convenience in discharging.

Variable speed drive on this pilot mixer provides a method for determining the most practical operating speed. Torque conditions can also be corrected by adjustment in speed if product has any tendency to densify during mixing cycle.

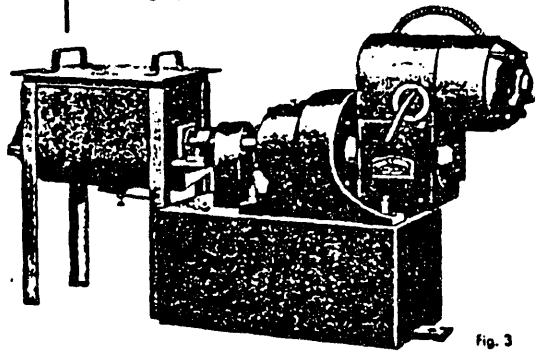


Fig. 3

Production Mixers

set back from end for convenience in discharging. Mixer is driven by means of gearmotor and roller chain.

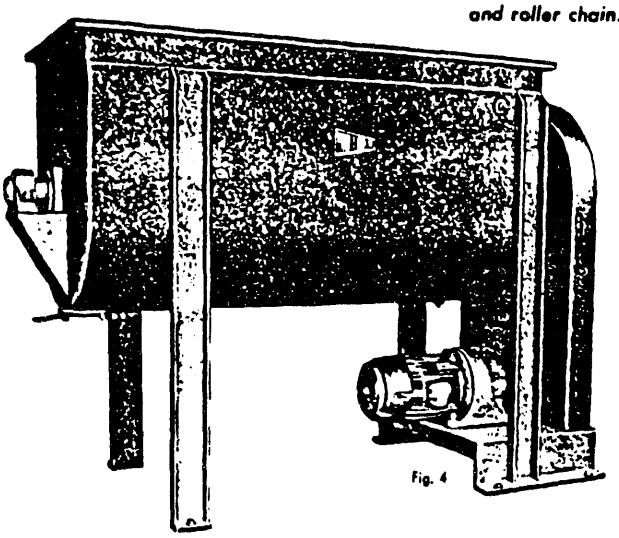


Fig. 4

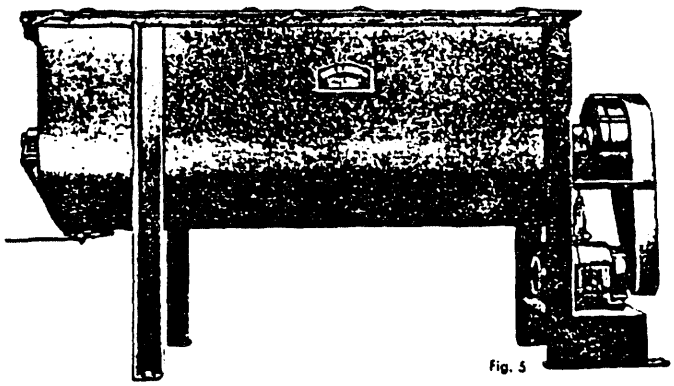


Fig. 5

Supports are set back from end of bowl to provide additional space for discharge. This is optional on any mixer. Mixer is driven by "Shaft-Pack" drive.

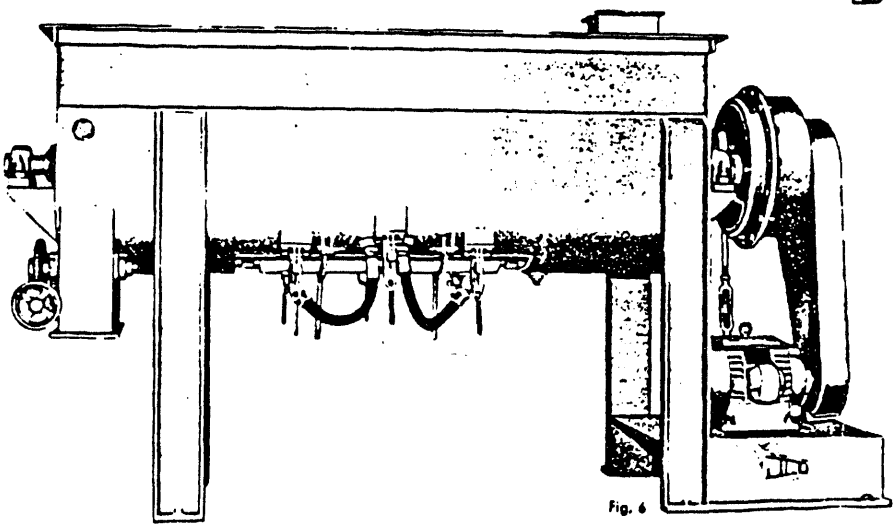


Fig. 6

Jacketed for temperature control. Dump cover on bottom fits flush with the inside of bowl and is jacketed the same as the rest of the bowl. Set back supports provide additional space for discharge. Mixer is driven by "Shaft-Pack" drive.

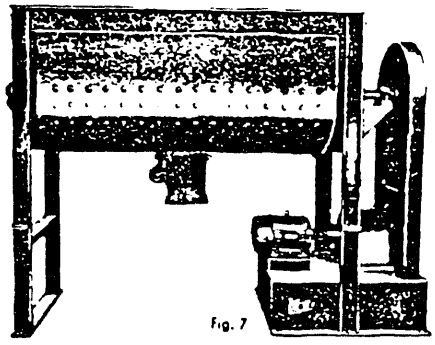


Fig. 7

Code jacket for high working pressures. Split stands can be supplied for any desired height. Mixer is driven by gearmotor and roller chain.

Vacuum Ribbon Mixer with jacket for temperature control—for mixing and deaerating flowing pastes such as plastisols, toothpastes, adhesives, etc. It can also be successfully used for solvent and moisture removal.

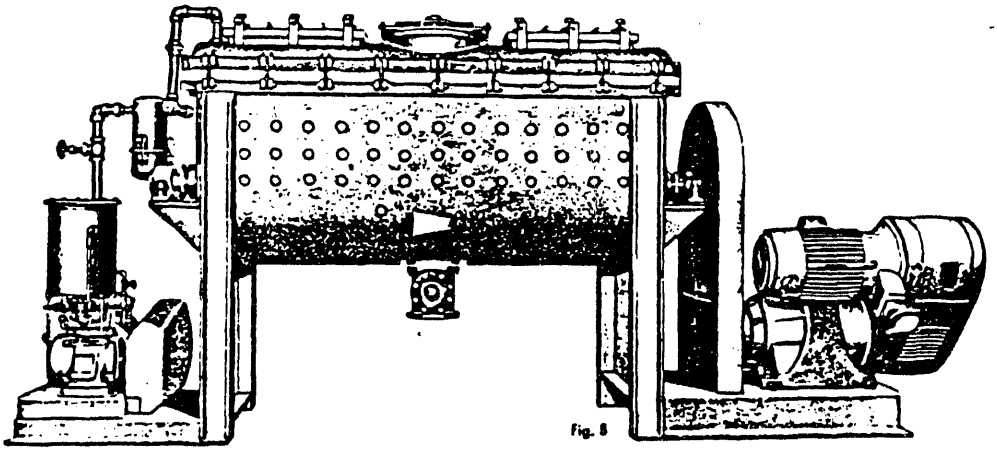


Fig. 8

Continuous Mixers

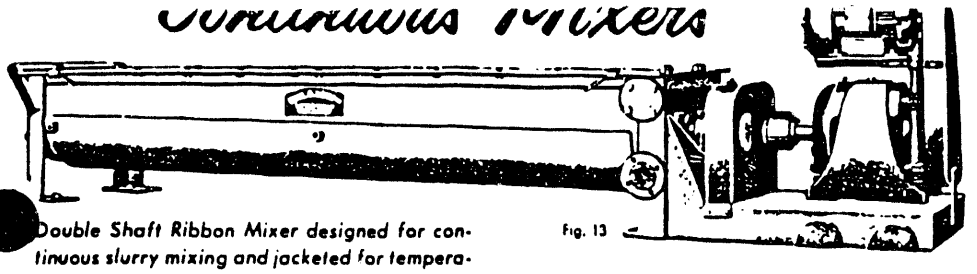


Fig. 13

Double Shaft Ribbon Mixer designed for continuous slurry mixing and jacketed for temperature control. Agitator arrangement combines the conventional ribbons (which slowly move the mass from the feed to the discharge end) and mullers which act as spatulas, wiping out any lumps in the batch. Note unique space-saving drive arrangement.

Single Shaft Continuous Mixer with variable speed motor. Material is fed through flanged feed opening in cover at one end of bowl and discharged at opposite end at a uniform rate by means of an adjustable overflow. Optional equipment includes a series of spray nozzles for feeding liquid at a uniform rate as material passes through the bowl.

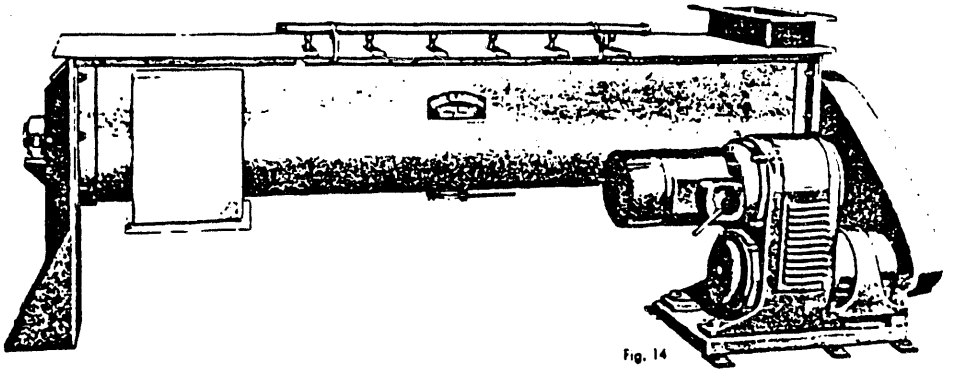


Fig. 14

Agitator Designs

Center, End, and Continuous Discharge

Standard construction consists of extra heavy steel tubing to which are welded steel arms for attaching the ribbons. The ends of the tubing are taper bored to accommodate taper stub shafts which extend through the ends of the bowl and bearings. This design insures perfect alignment of the entire assembly—it provides exceptional strength and rigidity—and also permits easy removal of the blade assembly if this is ever necessary.

All agitators are basically designed to insure a thorough inter-mixing action and are equipped with both inner and outer ribbons, with the exception of the double ribbon split agitator. The outer ribbon tends to move the material in one direction, and the inner ribbon in the reverse direction. The relative proportions in pitch and length of the ribbons are important in producing the most efficient mixing action, as well as quick and thorough discharge.

The agitators illustrated are the types most commonly supplied, and they can be made for either center or end discharge. Supplied in steel, stainless and other materials.

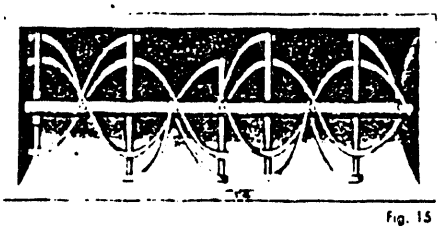


Fig. 15

Double Ribbon Agitator with interrupted outer flight. This arrangement is the most popular of all, as it very evenly distributes the mass of material throughout the entire length of the bowl, thereby insuring a uniform mixing action. It is especially effective on flow-resistant materials.

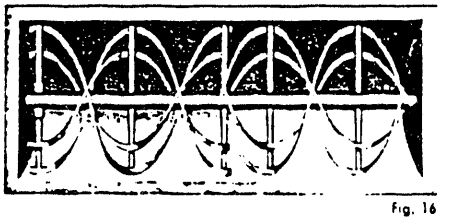


Fig. 16

Double Ribbon Agitator with continuous outer flight. This design provides the same type of action as the interrupted outer flight blade in figure above. It is used where material is free flowing, and for continuous operation.

Fig. 17

Double Ribbon Agitator with mullers. The addition of the mullers provides a spatula-like action which rubs out all lumps whether of dry or pasty material; they also prevent particle reaggregation, especially important when blending small amounts of liquid in a dry base, and intensify the mixing action of fine powders.

Fig. 18

Double Ribbon Agitator with flanged shaft. The flanges on each end are bolted to mating flanges attached to the main shafts. By unbolting these the entire blade assembly can be quickly and easily removed for thorough cleaning, without disturbing bowl ends, seals, bearings or drive. Flanges can be supplied with any blade design.

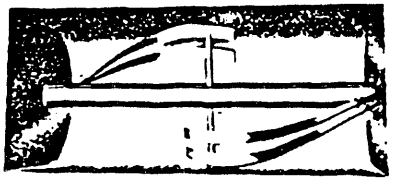


Fig. 19

Double Ribbon Split Agitator. This agitator is excellent for efficiently mixing flowing pastes. It can also be used for dry blending.

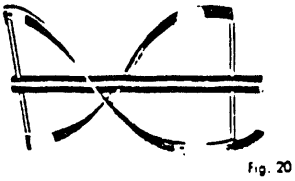


Fig. 20

Wiper strips are supplied in many installations where the blade must be in close contact with the bowl. This illustration shows a section of a single split ribbon agitator equipped with wiper strip. These strips can be supplied in leather, asbestos, Tygon, Teflon, nylon and other materials.

Special mixing blades for Double Shaft Continuous Mixer. Mullers, paddles, and ribbons have been combined for continuously mixing a heat-sensitive chocolate product.

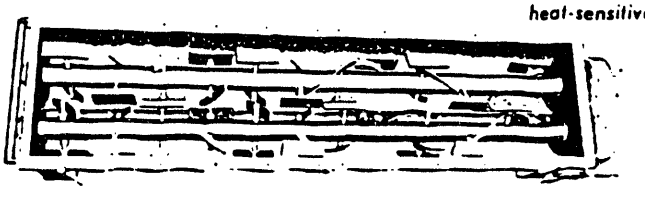


Fig. 21

Construction Features of Double Shaft Mixers

BOWL and ends of heavy steel plate, welded to insure a rugged leakproof unit. Sturdy ribs installed on the ends prevent end deflection. Bowl capacities greatly exceed mixing capacity. This is especially desirable for bulky material and additional thinning prior to discharge. Height of bowl can be extended, when required.

BLADES overlapping or tangential. Tangential blades are usually supplied with differential speeds.

GEARS—Heavy duty machine-cut spur gears completely enclosed in dust-tight gear cases.

BEARINGS—Heavy duty anti-friction spherical bearings suitable for both radial and thrust load, mounted outboard and installed in precision machined housings that are an integral part of the ribs and supports. An additional bearing at the end of the drive shaft provides extra support and prevents any overhung load.

SHAFT SEALS—Gland type—easily accessible for adjustment and maintenance. True alignment of blade shafts helps insure seal efficiency. High vacuum seals, when required. Laboratory mixers are equipped with oil and dust-tight lip seal.

TEMPERATURE CONTROL jackets encircling the bowl are adaptable for cold water, brine and other coolants or hot water, steam, and oil. Suitable baffling insures positive, uniform circulation.

PRESSURES—A.S.M.E. Code construction—where high pressures are involved.

VACUUM—All mixers can be designed for high vacuum operation.

COVERS—Dustproof—or special designs for vacuum and pressure furnished as optional equipment.

DUMP hydraulically operated on all sizes from the No. 1 and larger; manual on No. 1A and smaller.

SANITARY CONSTRUCTION for food and pharmaceutical products requiring fast, easy cleaning in full compliance with government regulations.

MOTOR DRIVES—Size No. 5 and smaller are directly coupled to gear reducer and motor. Larger sizes starting with the No. 7 are driven by means of V-belt and motor. Other drive arrangements can be supplied.

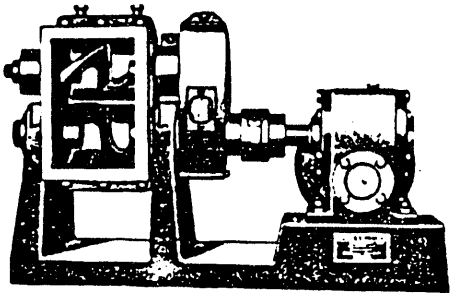
MATERIALS OF CONSTRUCTION—Steel, stainless steel, and other materials. Linings of rubber and plastic are also available.

FINISH—Bowl interiors and blades can be polished, as required.

Sigma Blade Mixers

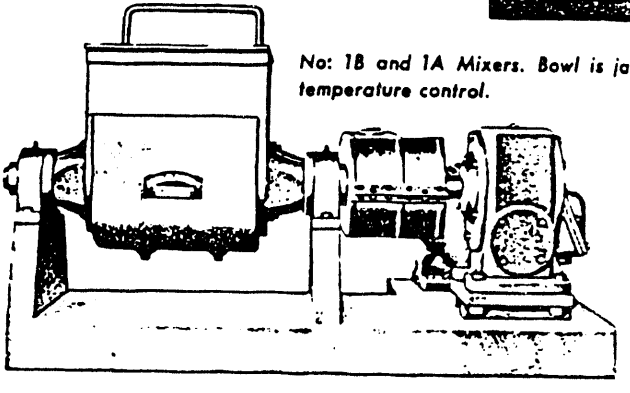
The design and construction of the Paul O. Abbé Double Shaft Mixers are the result of many years' experience in the chemical processing industries. They are truly heavy duty mixers that can be counted on for many years of dependable, uninterrupted service.

Laboratory Mixers



No. OB and OA Laboratory Mixers. Mixer is fitted with jacket for temperature control.

Fig. 27



No: 1B and 1A Mixers. Bowl is jacketed for temperature control.

Fig. 28

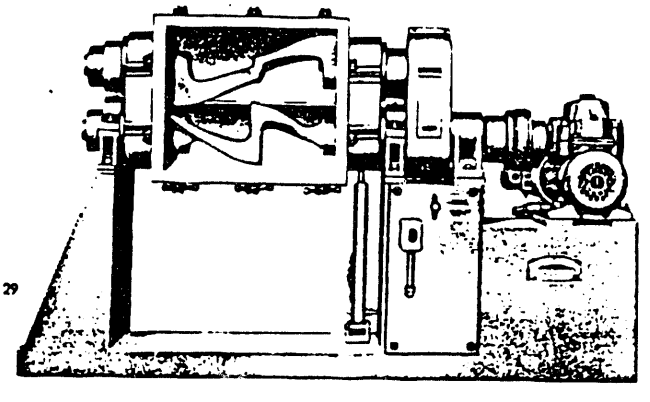


Fig. 29

Tilted view of No. 1 through No. 5 Mixer.

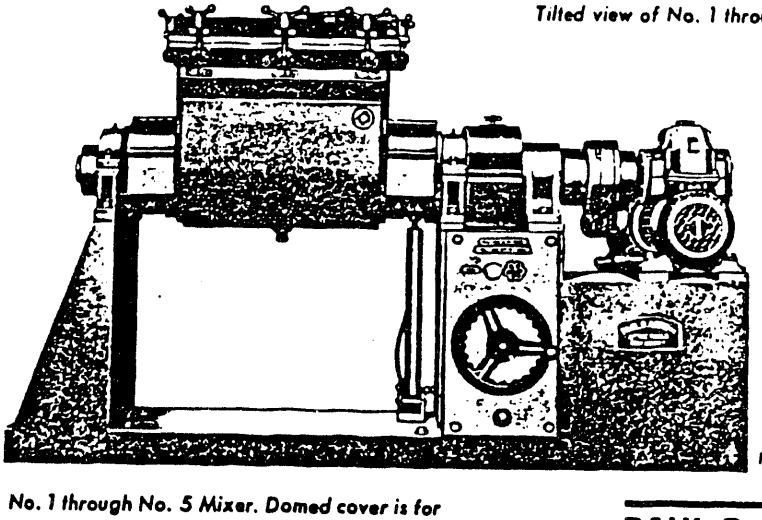


Fig. 30

No. 1 through No. 5 Mixer. Domed cover is for vacuum operation.

Discharge Valves

For discharging the average dry batch, our pivot slide gate or flush plug valve is recommended. These can be operated manually or by remote control, such as air operation. Various types of housing are available to connect to any discharge system.

For discharging light pastes, our flush plug valve, or the conventional types of ball, gate or plug valves are used.

The location of the valve is optional and depends upon the particular application. All discharge openings have safety grate.

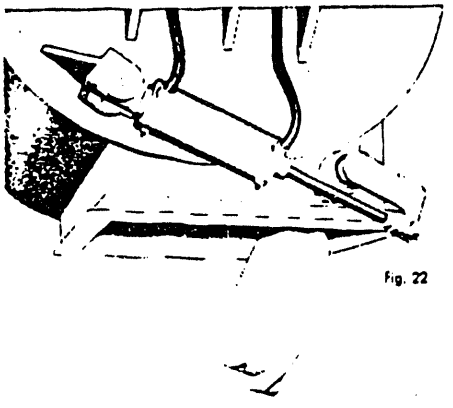


Fig. 22

Air operated flush plug valve.

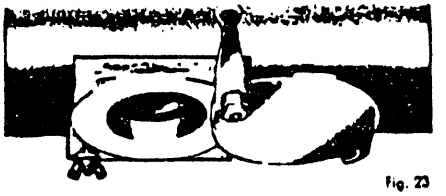


Fig. 23

Pivot slide gate valve.

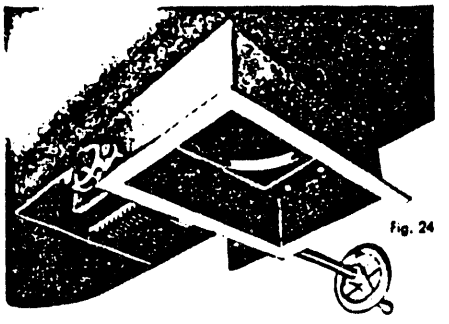


Fig. 24

Rack and pinion slide gate valve, handwheel operated.

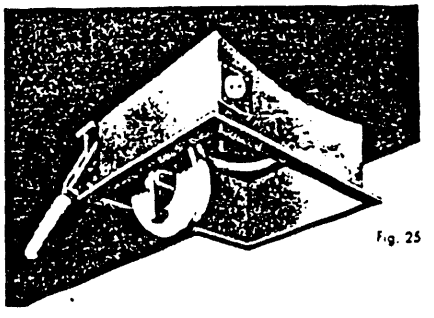


Fig. 25

Flush plug valve.

Shaft Seals

Gland Type Stuffing Box. This is the type of stuffing box most commonly supplied with Paul O. Abbé Ribbon Mixers. The amount of packing used will vary depending upon the application. Gland is easily adjusted for maintaining a tight, dustless seal. Other types of shaft seals are available for special applications.

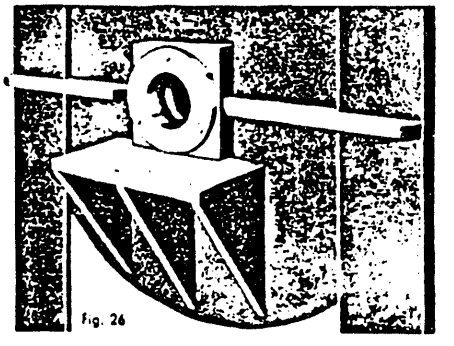


Fig. 26

Ribbon Mixer Details

*** Size	Charge* Pounds	Maximum Mixing Volume at Top of Ribbons		Shaft Speed	HP*	Bowl Dia. Inches	Bowl Height Inches	Bowl Length Inches	Floor Space** Inches		Height Inches	Clearance Under Valve Inches	Approx. Ship. Wt. Lbs.
		Cu. Ft.	Gals.						Length	Width			
0	3	0.10	0.75	125	¼	6	7	5	18	18	15	5	150
0-A	10	0.33	2.50	68	½	8	11½	12	30	22	40	28	300
1	30	1.00	7.50	68	¾	12	15	16	55	15	45	28	400
2	42	1.40	10.50	68	1	12	15	20	60	15	45	28	500
3	60	2	15	68	1	12	15	28	67	15	45	28	525
4	120	4	30	68	1½	14	17	40	82	18	47	28	650
4-A	150	5	37.5	60	1½	16 ¼	20	43	86	20	50	28	800
5	240	8	60	56	2	18	22	50	94	23	53	28	1000
6	360	12	90	56	3	18	22	74	121	23	53	28	1200
7	570	19	142	45	5	22	26	76	131	27	55	26	1900
8	660	22	165	45	5	22	26	90	145	27	55	26	2100
9	900	30	225	45	7½	26	30	84	146	31	58	26	2500
10	1200	40	300	37	10	30	35	88	152	35	61	24	3500
11	1500	50	375	37	10	30	35	114	178	36	61	24	3700
11-A	1950	65	487	37	10	36	42	100	168	42	69	24	4000
12	2400	80	600	25	15	42	48	90	165	48	75	24	5000
13	3000	100	750	25	15	42	48	114	189	48	73	22	5800
14	3900	130	975	25	20	48	54	114	190	55	79	22	6500
15	4950	165	1237	20	25	54	63	114	190	61	89	22	7500
16	6000	200	1500	20	30	60	69	114	197	67	95	22	9300

*Charging capacity and average horsepower requirements based on material weighing 30 pounds per cubic foot.

**Floor space will vary with drive arrangement. Where limited space is available, consult our engineering department.

***Other sizes than listed can be furnished.

These light duty mixers are lower cost sigma type mixers intended for pastes comparable to heavy paints and inks, as well as many dry mixing operations. Built in the same precise manner as their heavier counterparts, they can be counted upon for uninterrupted service.

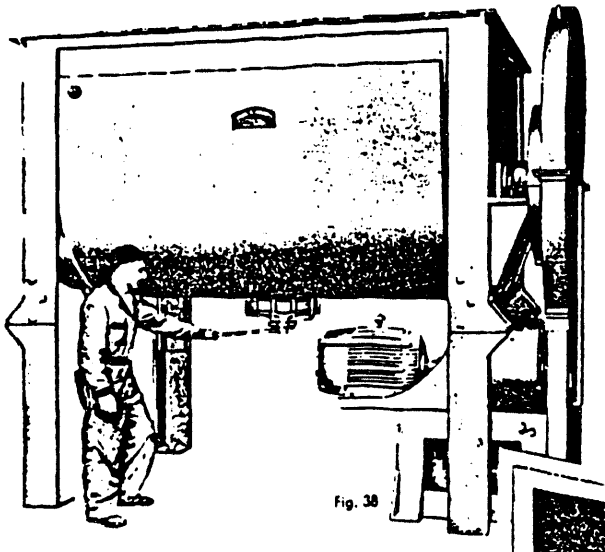


Fig. 38

This jacketed mixer is capable of mixing 2000 gallons per batch. The finished batch is discharged directly into drums for shipment to customer.

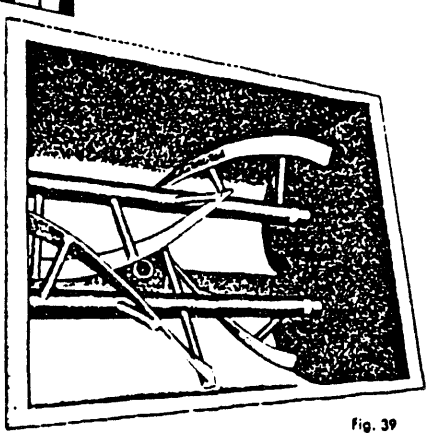


Fig. 39

Internal view of mixer shows general design of mixing blades.

Construction Features

Blades are formed steel designed to permit the same mixing action as the conventional sigma blade. They are mounted on steel arms connected to heavy steel tubing running through the mixer. The ends of the tube are taper bored to accommodate stub shafts extending through the ends of bowl and bearing. This construction assures perfect alignment sufficient for vacuum operation, if desired. Discharge is accomplished by use of a plug, gate, or ball valve, which is located in the bottom of the bowl and connected to both "U" segments. Additional construction details are the same as outlined for our Ribbon Mixers on page 2.

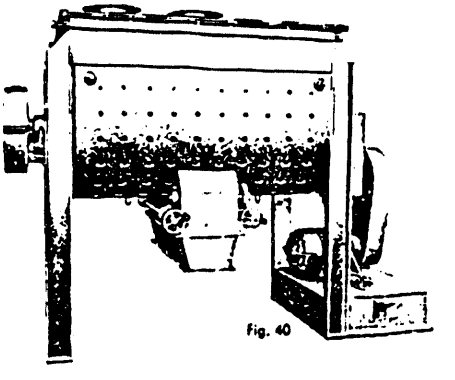


Fig. 40

Jacketed for high pressure, each bowl segment equipped with its own flush plug valve to be operated independently of the other.

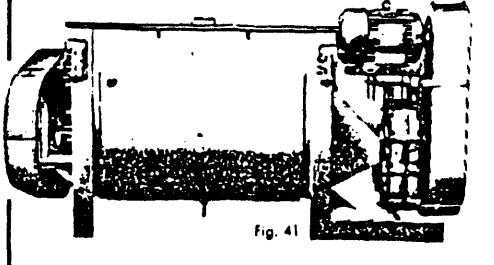
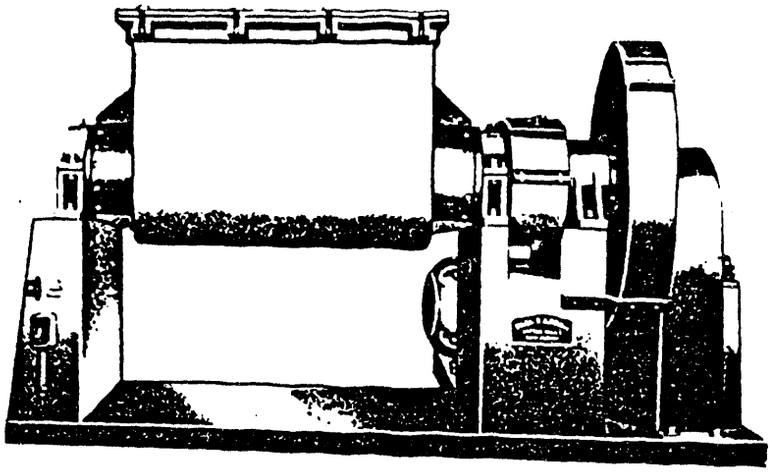


Fig. 41

Jacketed mixer with low stands for mounting close to floor to connect with storage facilities on floor below. Switches on each end of the mixer control air operated valves.

Light Duty Double Shaft Mixer Details

Size	Bowl Capacity Gallons	Mixing Capacity Gallons	Overall Height Inches	Clearance Under Bowl Inches	Floor Space Inches		For Aver. Loads HP	Approx. Ship. Wt. Lbs.
					Lgth.	Width		
1	38	25	42	24	55	24	1	1100
2	75	50	47	24	63	30	2	1600
3	150	100	62	36	84	36	5	2300
4	225	150	65	36	94	40	7½	3200
5	300	200	68	36	99	44	10	4100
6	450	300	75	36	105	54	15	5500
7	750	500	81	36	123	64	25	7200
8	1050	750	90	42	136	72	40	9200
9	1400	1000	95	42	142	80	50	12,000
10	2100	1500	100	42	168	88	75	15,000
11	2800	2000	106	42	186	96	100	18,500



No. 7 Mixer and larger with single end drive. Fig. 31

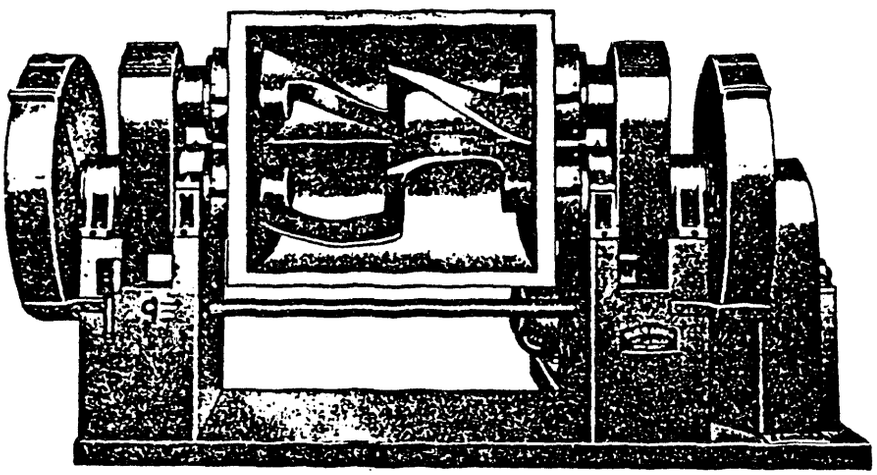


Fig. 32

No. 7 Mixer and larger with double end drive.

Sigma Blade Mixer Details

Size No.	Bowl* Capacity Gallons	Mixing* Capacity Gallons	Height (Maximum when tilting)	Discharging clearance from floor	Floor Space (Approximate)	**HP (For Average Loads)	Approximate Shipping Weight pounds
0B	0.5	0.25	11"	Bench Model	18" x 21"	1/4 - 1/2	175
0A	1	0.5	12"	"	18" x 24"	1/4 - 1/2	250
1B	2	1	18"	"	24" x 33"	1/2 - 1	388
1A	4	2	20"	"	26" x 36"	3/4 - 1-1/2	518
1	5	3	39"	23"	30" x 55"	3/4 - 2	950
2	8	5	39"	23"	38" x 60"	1 - 3	1300
3	20	10	46"	22"	38" x 75"	1-1/2 - 5	3100
5	40	20	56"	27"	48" x 88"	3 - 7-1/2	4350
7	70	40	64½"	24"	61" x 92"	7-1/2 - 15	5150
8	90	60	64½"	24"	61" x 106"	10 - 25	6000
9	115	75	83"	34"	84" x 110"	10 - 25	7920
10	160	100	83"	34"	84" x 127"	15 - 30	10140
11	250	150	93"	37"	108" x 144"	15 - 40	14150
12	300	200	98"	37"	108" x 152"	20 - 50	17270
13	450	300	101"	37"	120" x 168"	25 - 60	20620

*For overlapping blade arrangements. Tangential blade arrangements increase capacities approximately 10%.
**Mixers with higher horsepower ratings can be supplied.

Blade Design

The sigma type mixing blade has proven most popular for most mixers. Either overlapping or tangential arrangements can be supplied. When tangential blades are used, it is customary to operate at differential speeds.

Another popular blade is the dispersion blade.

Fig. 33

Sigma blade.

Fig. 34

Dispersion blade.

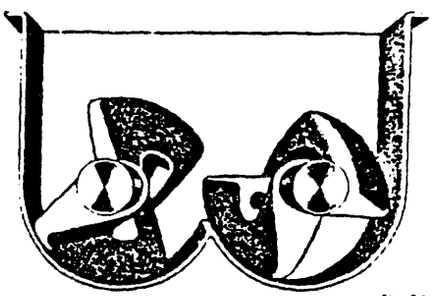


Fig. 35

Overlapping blades in mixer bowl.

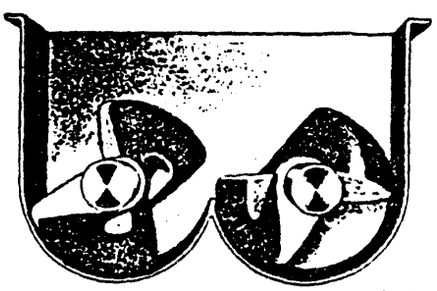


Fig. 36

Tangential blades in mixer bowl.

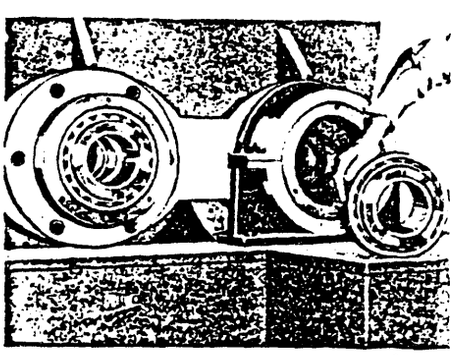


Fig. 37

End view of Heavy Duty Double Shaft Mixer showing the rugged bearing assembly, typical of all these mixers from the No. 1 and larger.

Production Blenders

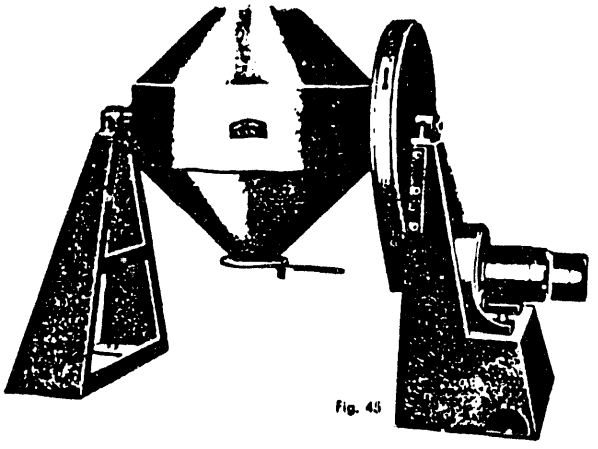


Fig. 45

Standard design of Rota-Cones 18" to 42" dia. Choice of discharge valves.

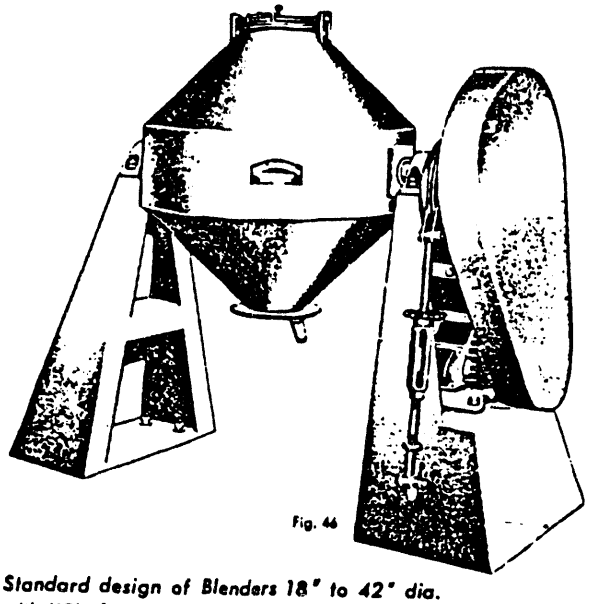


Fig. 46

Standard design of Blenders 18" to 42" dia. with "Shaft-Pack" drive.

60" dia. Rota-Cone with special high stands for additional working clearance.

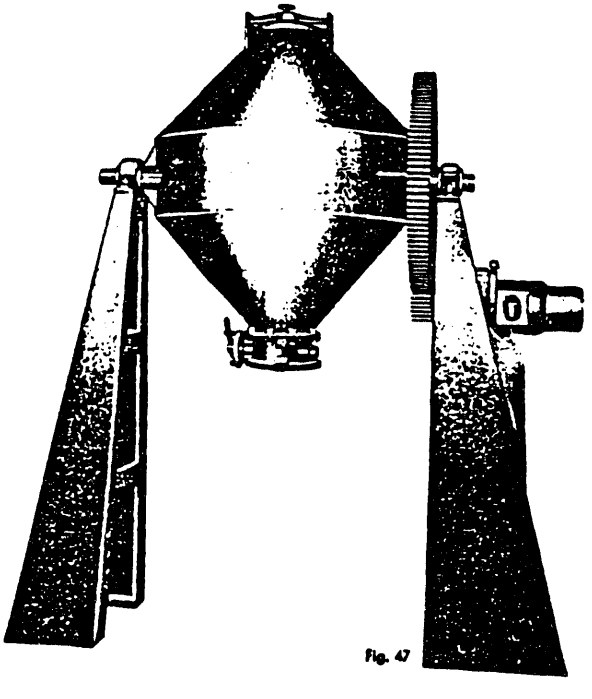


Fig. 47

Standard design of Rota-Cones 48" dia. and larger. Choice of discharge valves. Gear guard optional.

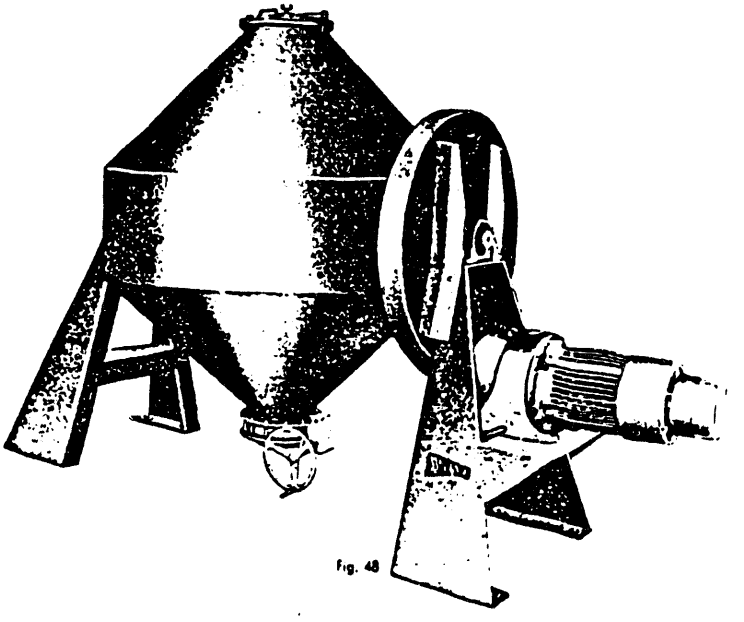


Fig. 48

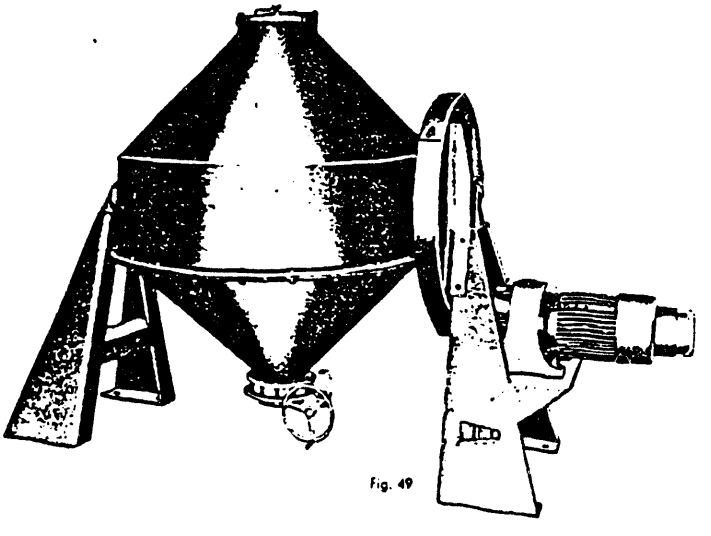


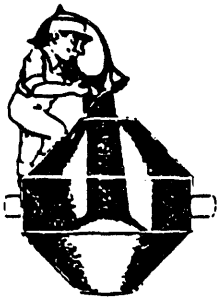
Fig. 49

Rota-Cone with bolted cone segment for installation of special liner.

Rota-Cone Dry Blenders

The Rota-Cone is unexcelled for rapid, homogeneous blending of dry and semi-dry products. To operate, it is revolved end over end, moving the materials in and out of the constricted conical areas. This causes a folding/spreading action that insures a thorough inter-meshing of all the ingredients in the batch.

The range of products being successfully mixed includes colors, plastics, flour, drugs, pharmaceuticals, metal powders, minerals, fibers, and many others.



Advantages

EFFICIENT—Variations in weight of materials or their proportions do not affect results. Overblending or classification cannot occur. Results are constant batch after batch.

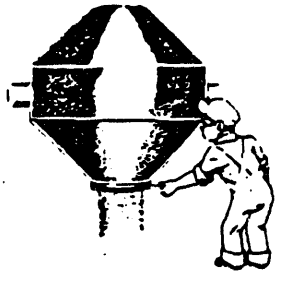
FAST—With most products only minutes are required to insure a complete mix.

VERSATILE—It will handle fibrous materials, as well as the average powders and granules. The addition of an atomized spray nozzle makes it possible to uniformly distribute liquids in limited quantities throughout the dry batch.

GENTLE—Despite its efficiency and the speed at which it mixes, the size and shape of the ingredients are not affected. Heat sensitive materials can be mixed without fear of damage.

EASY TO OPERATE—Large feed openings and discharges simplify loading and unloading. The absence of any baffles or constrictions in the interior, combined with the angle of the cones, insures complete discharge of the finished batch. Cleaning between batches is easy and fast.

ECONOMICAL—Power costs are low in comparison to other types of blender. No maintenance except occasional lubrication—no attention while running.



Construction Details

CONE SEGMENTS—Completely welded to rugged centerband—with solid steel trunnions heavily ribbed to body.

LATHE TURNED—The complete cone assembly is placed in a lathe, and the trunnions are machined to insure perfect alignment.

LOADING DOOR — Quick opening — and amply large for loading and cleaning.

DISCHARGE VALVES—See page 13 for details.

BEARINGS—Heavy duty anti-friction pillow blocks.

STANDS—Operating clearances are indicated in the chart on page 13. Special heights can be supplied to suit specific applications.

MOTOR DRIVES—18" to 42" dia. Blenders are driven by gearmotor and roller chain, or by "Shaft-Pack" drive if preferred. The larger units are equipped with gearwheel and pinion for connection to gearmotor. All drives are installed on a rugged steel base that is an integral part of the main stand.

GEAR GUARD—Completely enclosing gear and pinion, can be furnished when required.

SANITARY CONSTRUCTION—For food and pharmaceutical products requiring fast, easy cleaning in full compliance with government regulations.

MATERIALS OF CONSTRUCTION—Blenders can be built with various metals like steel, stainless steel, Monel, bronze, aluminum, etc. When the material being processed might be contaminated by metal contact, or when it has a tendency to adhere to the inside of the Blender, one of several types of plastic or rubber linings can be furnished.

FINISH—Standard Blenders are furnished with a mill finish on all interior surfaces. Polished interiors can be supplied when required.

Laboratory Blenders

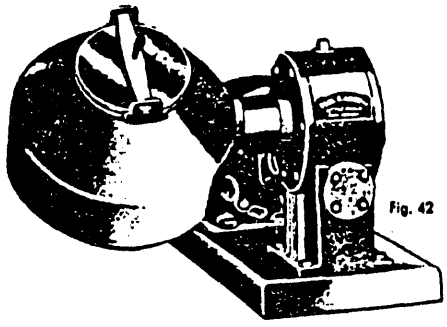


Fig. 42

Standard design of 9" and 12" dia. laboratory blenders. Cones are easily detachable for special cleaning or sterilization. Can be furnished in plastic as well as various types of metal.

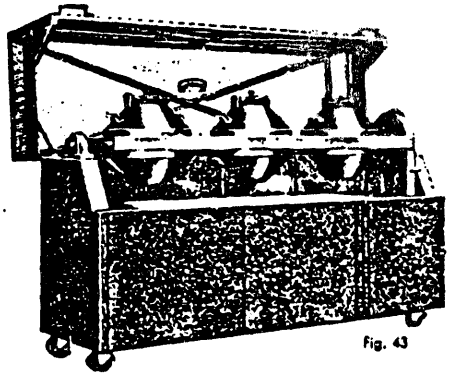


Fig. 43

3-Cone Laboratory Unit. Cones can be quickly removed for special cleaning or for interchange with other cones. Open guard automatically shuts off power for safety. Casters permit easy moving from one area to another.

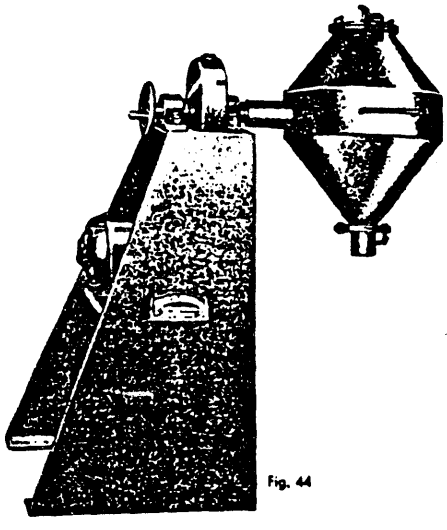


Fig. 44

Detachable cone makes it possible to load and discharge cone in another area, or to interchange with another cone.

Discharge Valves

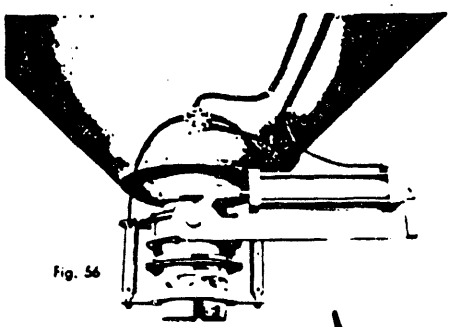


Fig. 56

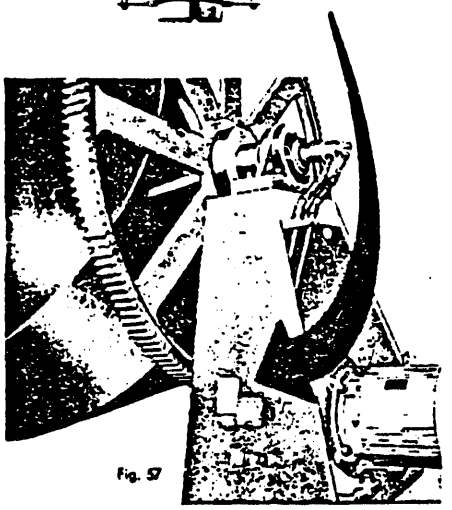


Fig. 57

Air Operated Valve. Retractable sleeve optional, for extra convenience and safety. Operation of the valve is controlled by a switch installed on the main support of the Rota-Cone or in some other convenient location.

The air supply for the valve is permanently piped from the switch through the center of the trunnion.

The retractable sleeve insures against excessive dust and spillage. When this is used, the blender is exactly positioned with the aid of a magnetic brake on the motor. A dual control switch extends the retractable sleeve into the opening of a storage bin, forming a tight seal. Another switch opens the butterfly for discharge. The same valve can be used for dust-free loading, as well, by spotting this in an upright position. When desired, the retractable sleeve can be equipped with a gasketed mating flange for a tight seal against flanges on the discharge bin or loading hopper. This arrangement not only insures dustless operation, but it also eliminates any danger of product exposure to the atmosphere.

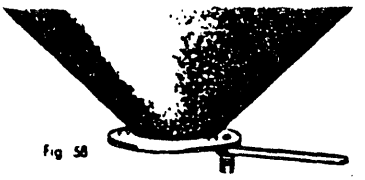


Fig. 58

Slide gate is standard valve for blenders 18" to 42" dia. Other types shown can be supplied, when desired.

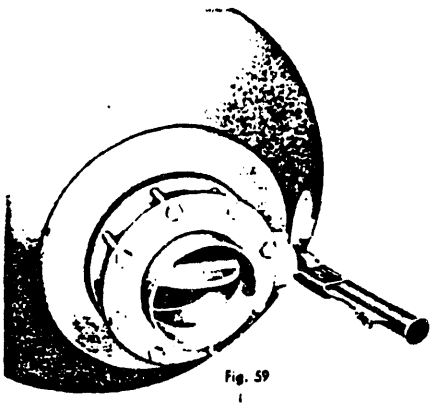


Fig. 59

Butterfly valve with resilient replaceable valve seat. Standard on all Rota-Cones 48" dia. and larger. These can be supplied with handwheel or handle, and they are available in different metals and resilient seats.

Weighing Systems

Weighing systems can be furnished with our equipment. This illustration shows a hydraulic type load cell installed between the main bearing and support of our Rota-Cone Blender. Under this system the load weight is converted into exactly proportional pressures which may then be displayed gravimetrically on suitable indicators, or recorders.

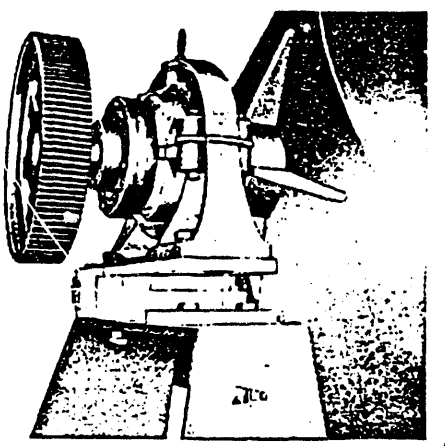


Fig. 60

Rota-Cone Blender Details

Diam. Inches	Total Volume Cu. Ft.	Maximum*** Operating Capacity Cu. Ft.	Floor Space with Motor & Magnetic Brake Inches	Height (running clearance) Inches	Clearance Under Valve Inches	HP**	Approx. Ship. Wt. Lbs.
9	.2	0.14	28x16	17	4	1/4	70
12	.5	0.3	36x18	19	3	1/4	80
18	1.7	1.1	54x30	48	18	1/3	250
24	3.9	2.5	65x36	54	18	1/2	330
30	7.7	5.0	72x45	63	18	3/4	500
36	13.5	8.8	85x53	71	18	1	650
42	21	13	94x61	79	18	2	1500
48	32	20	101x69	69	*	3	2000
54	45	30	120x77	77	*	5	2500
60	62	40	130x84	84	*	5	3000
66	83	54	138x92	92	*	7½	3600
72	108	70	144x100	100	*	10	4100
78	137	90	150x108	108	*	15	4900
84	172	114	158x116	116	*	20	5800
90	210	135	175x124	124	*	20	6600
96	255	165	199x131	131	*	25	7500
108	365	240	220x148	148	*	40	9600
120	500	325	234x162	162	*	50	11500

*Swing clearance only.

**Approximate HP requirements based on material weighing 100 pounds per cubic foot.

***Maximum operating capacities shown represent 65% of total volume.

Rota-Cone Blenders

For Liquids and Solids Blending, and Solids Coating

The Paul O. Abbé Rota-Cone is an excellent medium for adding liquids to a dry base—for blending and solids coating. The liquid is dispensed in the form of a fine mist by means of a stationary spray nozzle located above the mass of dry material, as the Rota-Cone is revolved. This insures a fine, uniform coating on the ever-changing surface of the dry product. The absence of any mechanical agitator for liquids distribution within the moving batch prevents all danger of change in the size and shape of the particles and the possibility of excessively wet areas.

The most popular agitating element is the off-set tooth shown in the cut-away illustration. Additional agitating elements are also shown at the right. In the cut-away illustration we show the liquid spray nozzle which is sometimes used in conjunction with the mechanical agitator.

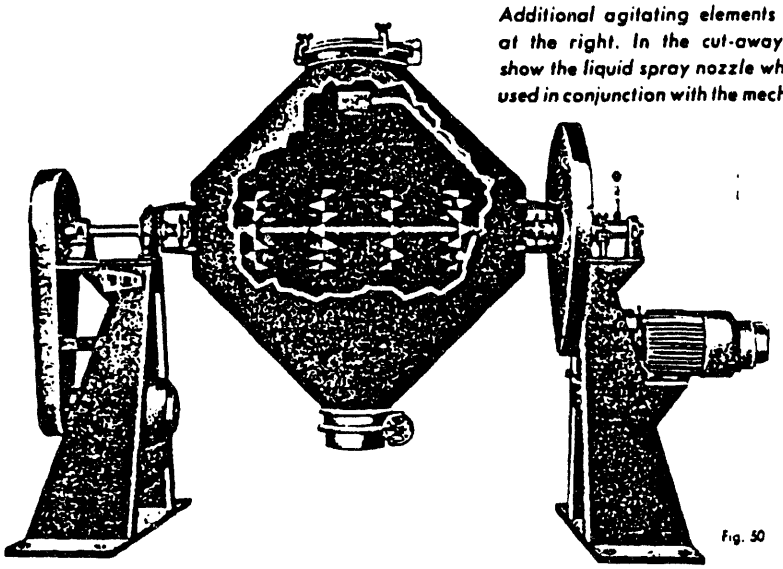


Fig. 50

Cut-away view of Rota-Cone illustrates method for adding liquids without moving parts. As the Rota-Cone revolves, the spray nozzle remains stationary. The liquids line is run to the outside through the center of the trunnion where it is locked in a fixed position.

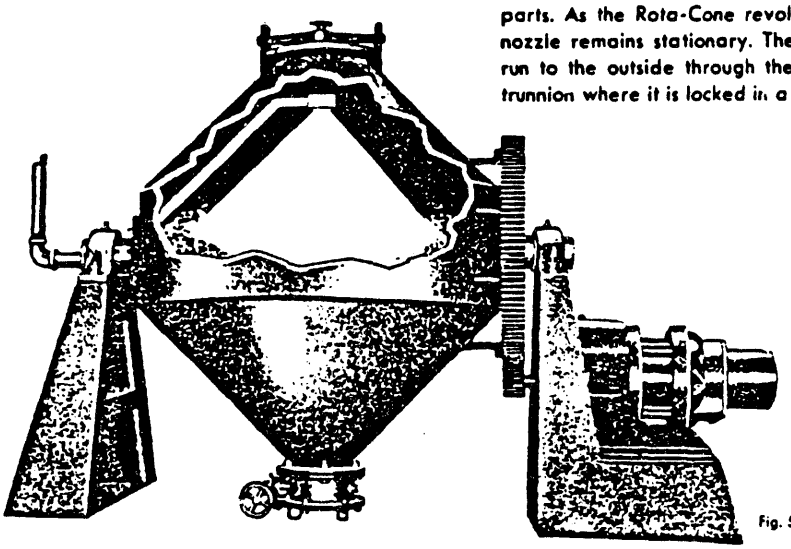
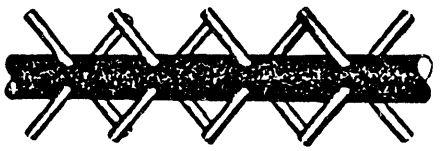


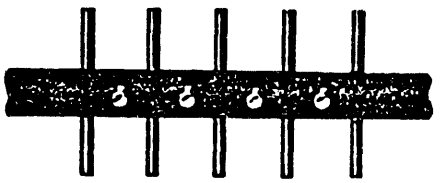
Fig. 51

Mechanical Agitators

Many products (whether a dry mix or with added liquids) have a tendency to re-aggregate and form lumps while being mixed or become cakey in storage. For these a mechanical (internal) agitator can be provided to aid in their complete dispersion. Simultaneously the agitator helps speed up the blending process. Fibrous materials can be successfully blended with powder without forming clusters, when the agitator is used.



Cross pin agitating element. Fig. 52



Straight pin agitating element. Fig. 53

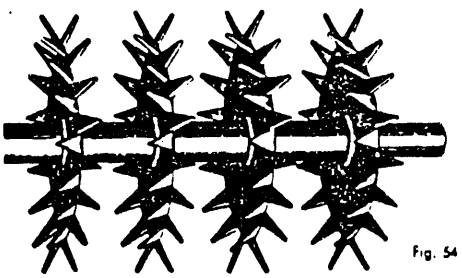


Fig. 54

Serrated blade element.

Liquid pressure system—connected to Rota-Cone Blender for uniformly adding liquids to dry powders.

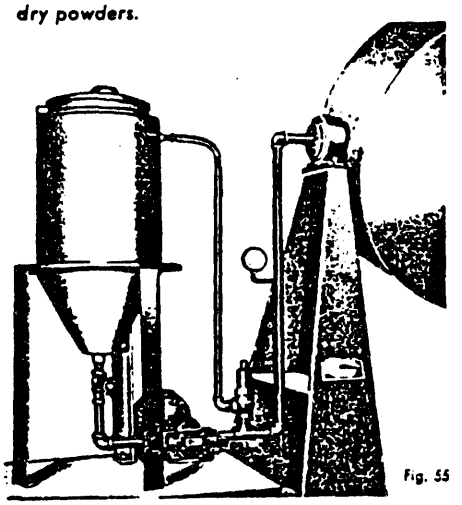


Fig. 55

motor.

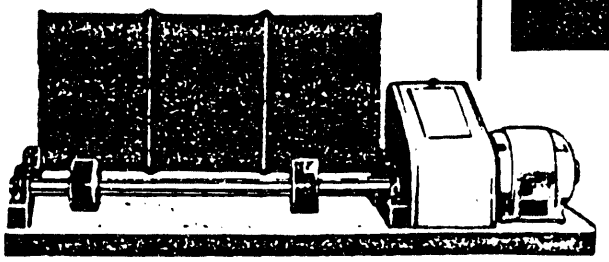


Fig. 63

Three Drum Roller. These drums are of a special heavy construction for mixing metal powders. Each drum is capable of handling 2000 lbs. of powder.

Drum Rollers

Size	Length Inches	Width Inches	HP*	Approx. Ship. Wt. Lbs.
1 Drum	65	26	¾	550
2 Drums	98	26	1	900
3 Drums	141	26	1½	1200
4 Drums	186	26	2	1500
5 Drums	226	26	3	2000

**Motor requirement can vary, depending on load conditions.*

Paul O. Abbé Drum Rollers are ideally suited for mixing and ball milling small batches. These rugged, heavy duty machines are built in single and multiple units, with spacing adjustable to accommodate different size drums. They are equipped with wide, flat, rubber covered wheels, which provide excellent traction and long service. The entire assembly is mounted on a rolled steel baseplate.

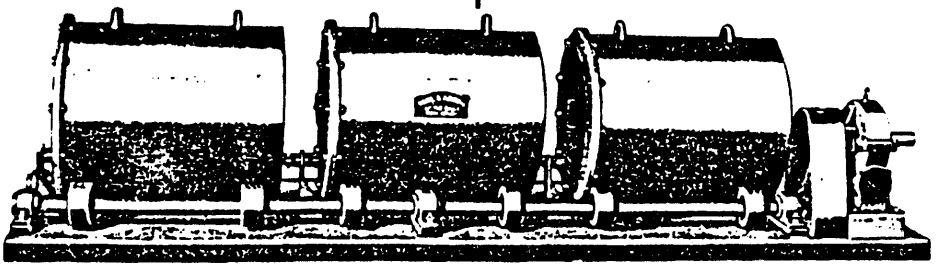


Fig. 64

Five Drum Unit.

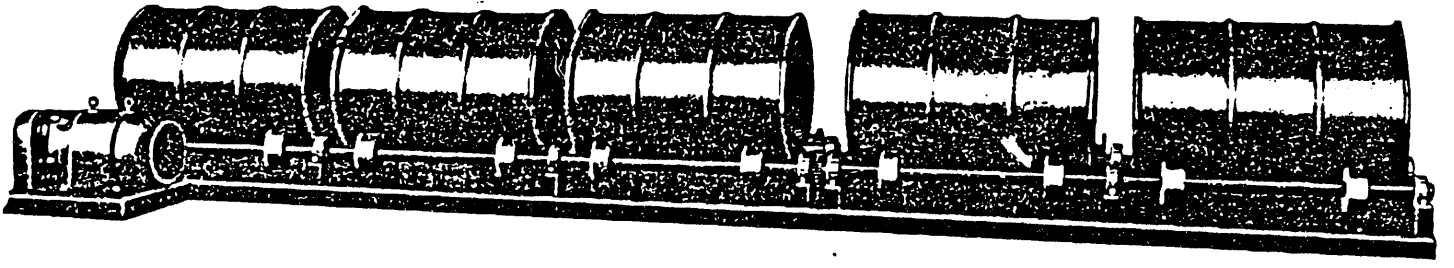


Fig. 65

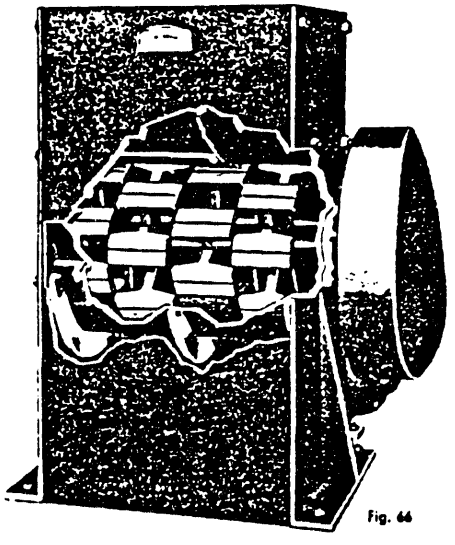


Fig. 66

Lump Breakers

Size No.	Top and Bottom Openings Inches	Standard Overall Height Inches	Minimum Overall Height* Inches	HP	Approx. Ship. Wt. Lbs.
00	10x10	18	10	¼	180
1	20x20	36	18	2	525
2	20x40	36	18	5	945

**Lowest possible height, where headroom is limited.*

Paul O. Abbé Lump Breakers are used for dispersing aggregates and restoring caked powders to their original condition. These machines are equipped with hammers which revolve at moderate speeds and beat the material until it passes through a perforated screen. They can also be installed either at the feed or discharge end of ribbon mixers where objectionable aggregates must be removed during the mixing operation and in the finished product.

Cylinder Mixers

There are many processes involving mixing and dispersing in which some degree of impact and attrition is required to disperse hard aggregates.

Paul O. Abbé Cylinder Mixers, including our conventional type Ball and Pebble Mills, are commonly employed in such applications. For detailed information concerning these mills, send for our complete catalog on Ball and Pebble Mills.

Large Jar Mill. The jar is made of "Lumard", which is an alumina reinforced ceramic body that has excellent resistance to abrasion and impact. It is made in one piece for ease in cleaning. Paul O. Abbé Jar Mills are made in sizes ranging from ½ pint to 57 gallons total volume. For complete details send for Jar Mill Catalog.

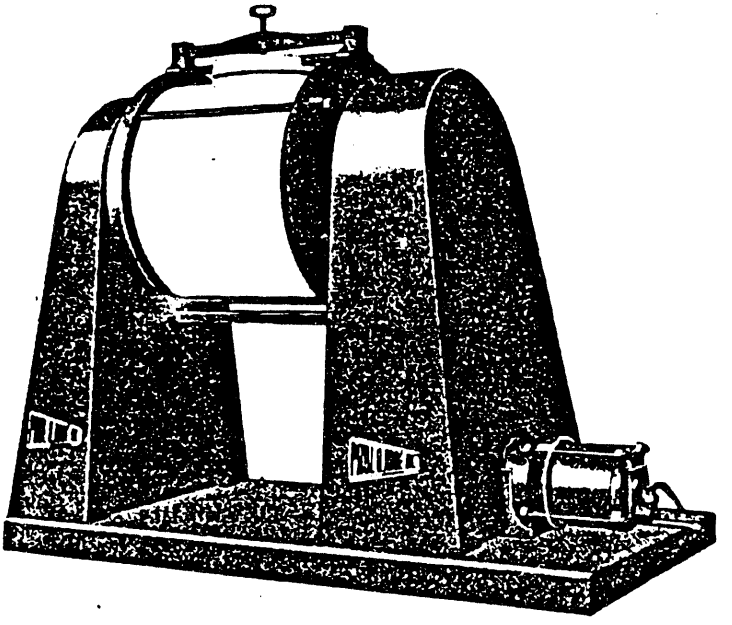
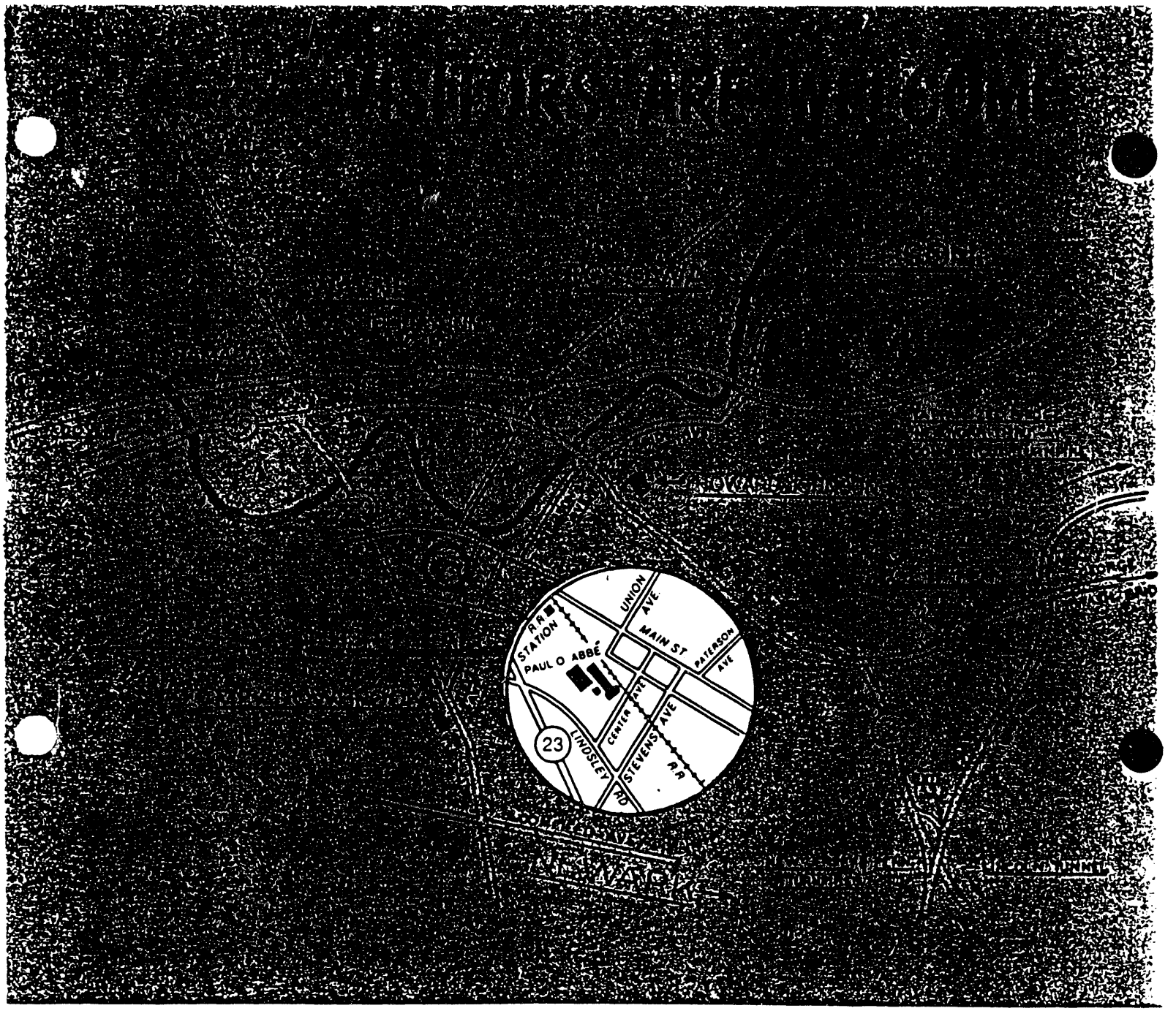


Fig. 61

WARRANTY

Paul O. Abbé Inc. does agree that it will replace F.O.B. Little Falls any part of any machine sold by it which is found to be defective, either in material or workmanship as determined by an inspection authorized by it, within one year from date of shipment to the original purchaser. With respect to all components or parts of any such machine made by other manufacturers, the warranty of the manufacturer of such component or part shall govern for the time period specified by said manufacturer and Paul O. Abbé Inc. shall have no obligation or responsibility with respect to same. There are no implied warranties and no representations as to performance. Paul O. Abbé Inc. is not responsible for any consequential damages due to any defect in the product or the operation of same. In no event shall the product be returned without authorization.



PAUL O. ABBÉ INC.

BALL & PEBBLE MILLS / *Grinding • Dispersing • Reactions*

MIXERS & BLENDERS / *Solids • Fluid-Solids • Slurries • Pastes*

DRYERS / *"Rota-Cone" Vacuum Drying • Processing*

Printed in U.S.A.

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/10/93
Time: 11:00 a.m.

From:	A. SHARPE	To:	JIM LARSON
Company:	UE&C	Company:	CELITE CORPORATION PO BOX 519 LOMPOC, CA 93438-0519
Phone:	303-843-3361	Phone:	805-735-7791
Project No.:	6237.008		
Subject:	MATERIAL TO ABSORB FREE WATER		

Topics of Conversation:

1. Mr. Larson was given background information on the WRAP 2A requirement to absorb free water from waste which is to be immobilized in polymer.

2. Mr. Larson recommended use of the following absorbent:

   Name: Microcell E

   Maximum Absorbent Efficiency: 550%

   Average Absorbent Efficiency: 400% (i.e., 5 lb of Microcell E will absorb 20 lbs of water)

   Bulk Density: 5 lb/Cuft

   PH: 10

3. Mr. Larson would send information on this product to UE&C.

S A Sharpe

A. Sharpe

WASTE RECEIVING AND PROCESSING FACILITY

TITLE: STUDY 1604-10 PROCESS SAMPLING

Rev. 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A **Raytheon** Company
Western Operations

January 7, 1994

STUDY 1604-10
PROCESS SAMPLING

Prepared by: _____ Date: 12/July 93
Senior Engineer

Reviewed by: _____ Date: 7/12/93
Engineering Manager

Approved by: _____ Date: 12 July 93
Project Manager

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Appendix A - WRAP 2A Sample Plan

1. Introduction
2. Listing of WRAP 2A Samples
3. Sample Detailed Description
4. SMA Operation

Table 1 - WRAP 2A Sample Requirements
Figure 1 - WRAP 2A Process Sample Points

1.0 OBJECTIVE

To prepare a Sampling Plan for WRAP 2A which will identify the process samples required and detail the location, method and frequency of taking each sample.

1.1 Scope

A. Review the sampling requirements for the WRAP 2A facility in light of changes made to the process or mechanical design during the ACDR. The review will encompass current requirements stated in the FDC or formal interpretations provided by WHC.

B. Define the sampling requirements and techniques for process, verification, certification and archive sampling. This includes identifying any testing required to confirm prototype sampling techniques.

C. Evaluate the analytical methods, the data requirements for each sample, the need for archive of product samples and equipment needs of the defined sampling scope. Develop the philosophy outlined by the sampling schedule in the CDR so that specific testing such as strength, pH, water detection can also be quantified.

D. Produce a definitive Sample Plan for WRAP 2A.

1.2 Background

A. Sample management as defined in the WRAP 2A CDR encompasses five major objectives:

- Lot verification of waste feedstreams
- Process control
- Certification of treated waste product
- Destructive examination of treated waste product
- Archival samples of treated waste product

B. The following CDR design review comments will be addressed in this study:

Comment #	Comment
48	Core drilling lubricating fluid to be determined.
122	Evaluate provisions for sampling/disposal of absorbent in 85 gallon overpacks.
123	Assess methods of sampling suitable for larger or non-homogeneous items.
185	Evaluate the analytical provision required within the Sample Management Area (SMA) in WRAP 2A in order to handle those samples requiring a quick turnaround of results.
186	The effectiveness of the current sample philosophy for waste lot verification shall be confirmed.

1.3 Purpose and Need

A. Sampling is critical to the operation of WRAP 2A. It will be used to confirm the characterization of waste entering the facility where necessary so that an appropriate treatment process including binder formulation can be determined. Process samples will demonstrate that product quality requirements are being met. Samples of the treated waste product will be taken where necessary to confirm that the final wasteform meets the disposal acceptance criteria and to support waste disposal certification.

B. All these requirements were identified in the CDR, but there was no attempt to optimize the number of samples to be taken or to detail methods of sample collection. These aspects need to be resolved prior to Title I design.

2.0 SUMMARY

A. This study reviews the sampling requirements of the WRAP 2A facility using the CDR Sample Management Schedule as a basis for discussion. All aspects of the sampling process are discussed including why, how, where and when the sample will be taken, where the sample will be analyzed and potential impacts on the CDR design of the Sample Management Area.

B. The study identifies twenty one sample points and twenty two samples as being required in WRAP 2A in order to satisfy both regulatory and process requirements. Of these 9 will be analyzed within the WRAP 2A Sample Management Area, 12 will be analyzed at an external facility and one will be analyzed at source. In-line "sampling" methods have not been discussed in the study where no physical sample will be taken as these will have no impact on the design of the Sample Management Area.

C. The analytical capabilities of the WRAP 2A SMA are equipment for determination of pH, equipment to determine bulk specific gravity, equipment to determine conductivity, equipment to determine penetration resistance, equipment to determine the viscosity of binder materials, equipment to test the compressive strength of immobilized product sample cubes, titration equipment to determine the quality of polymer raw materials and general laboratory equipment such as measuring vessels to allow the split between organic and aqueous phases in bleed liquor from polymer encapsulation to be determined. All other sample analysis within the SMA will be by visual inspection of solidified samples. However, sample preparation equipment will be required to allow destructive examination of samples (though not destructive examination of product drums which will take place in the Box Breakdown Area).

D. A proposed Sample Plan for the WRAP 2A facility is presented in **Appendix A** of this report.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Recommendations

A. The CDR Sample Management Schedule should be revised to incorporate the following changes:

1. Product Certification sampling is to be undertaken in the Grout and Polymer Immobilization Areas for immobilized sludges and particulates. Macroencapsulated products will be sampled in the SMA.

2. Raw binder material storage vessels shall have sample points but there should be no routine sampling of these materials.

3. Process samples of binder material mixes should not be taken routinely and will be at the discretion of the operator.

4. Lot verification should routinely be by visual inspection in the Open/Sort/Repack Area and the Box Breakdown Area. However, if required, a sample may also be taken in these areas.

5. Sampling of acid,caustic and decontaminant solutions to determine strength should not be required.

B. The sample handling capability of the Sample Management Area in WRAP 2A should not be reduced in scope from that detailed in the CDR. However, archive storage of product samples is unnecessary and should be deleted from the FDC.

C. The need to provide equipment for destructively examining product drums should be removed as a requirement of the FDC.

D. The CDR drawings should be revised to show those sample points detailed in the proposed Sample Plan.

E. The CDR design of the storage facilities for VES resin, VES promoter and VES catalyst should be re-examined. the outside storage of these chemicals under a sunroof could expose them to temperatures in excess of 100°F and could cause degradation of the chemicals.

F. As part of the ACDR design effort, process and block flow diagrams will be revised as needed to reflect changes in the design, including changes in the Sample Management Schedule.

3.2 Conclusions

A. The proposed sample plan fully complies with regulatory requirements and FDC requirements for process sampling within the WRAP 2A facility.

B. The proposed Sample Plan presented in this report should be used as a basis for detailed design of the WRAP 2A sampling facilities.

4.0 UNCERTAINTIES

A. This section details certain assumptions, made in support of this study, which may prove to be incorrect in the future. The uncertainties are as follows:

1. Waste Stream Chemical and Physical Characteristics: At this time wastes currently in storage that will be processed in WRAP 2A are poorly characterized. If these wastes are not appropriately characterized before they are transported to WRAP 2A it may be necessary to sample every drum and then return the drum to storage while the sample is analyzed. This would have serious implications on WRAP 2A and on the transportation system between the storage facility and WRAP 2A. It would be far easier to sample the waste at the storage facility prior to sending it to WRAP 2A. However, this option is outside the scope of this study. Consequently it has been assumed that waste lots will normally be well characterized prior to arriving at WRAP 2A. Therefore the maximum sampling requirement will be as specified in the FDC. Once existing wastes are better characterized and more is known about future wastes it is assumed that the FDC sampling frequencies will be revised based on a statistical assessment.

2. Sampling Methods: In selecting sampling equipment, waste physical properties have been assumed based on the waste description. Should the waste physical properties prove to be different to those assumed in this study it may be necessary to use alternative sample techniques in order to obtain a representative sample.

3. Polymer Encapsulation Sample No.4 - Bleed Liquor: In the CDR this liquor is assumed to be aqueous and therefore can be routed to the Active Waste Collection Tank. This assumption may be incorrect as the liquor could be organic. If this is the case then this sample will be required in order to determine the composition of this liquor and a discharge route to the Hydrocarbon Waste Tank will have to be provided in the event that the liquor is principally organic.

4. Polymer Encapsulation Sample No. 3 - Mixed VES Polymer and Catalyst: Under normal circumstances there will be a high level of confidence in the ability of an item of equipment to perform the duty for which it is installed in an operating plant. This confidence is generally based on past experience in industry and specific testing for purpose of the equipment prior to installation and during commissioning. In-line mixers have not been used in industry for the mixing of VES type polymers. Hence, even though it is proposed to fully test in-line mixing of VES polymer prior to installing this equipment in WRAP 2A, it is thought prudent to take a sample of the mixed binder material periodically during operation to provide confidence that the in-line mixer performance does not deteriorate with use.

5. Archiving of Product Samples: This is identified in the FDC as a requirement for WRAP 2A. However, it is not clear why it will be necessary to archive samples if they have already been successfully tested and the results of the tests have been logged in the records retention facility within WRAP 2A. If samples were to be archived, the archive store would be subject to RCRA sample storage requirements. As there appears to be no benefit from holding samples after they have successfully passed testing and noting the implications of including a long term radioactive mixed waste store in WRAP 2A it is recommended that archive storage of product samples is deleted from the FDC and from WRAP 2A.

6. CDR Baseline: It is assumed that the CDR baseline process will not change. Should the Single Immobilization Study recommend a change to the CDR approach there will be impacts on the findings of this study.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC Requirements

A. The WRAP Module 2A shall provide all necessary environmentally controlled space, equipment and ancillary items necessary for managing non-radioactive and radioactive solid and liquid samples including, but not limited to the following:

- Sample radiation dose rate screening.
- Sample storage, segregation and repackaging.
- Analytical and test capabilities including pH, bulk specific gravity, conductivity, compressive strength and penetration resistance.
- Immobilized waste form destructive examination of samples.
- Sample pig handling shall be provided including lag storage, loading/unloading, decontamination, receipt and shipping.
- Archive storage of representative samplings of all final waste forms from each lot for the life of this facility.
- Sample shipping to other laboratories.
- Office space for sample tracking, protocol management and analytical results tracking.
- Storage space for laboratory operating supplies.
- Obtaining analytical results electronically from the laboratory.
- Capability to bar code label all samples.
- The sample preparation area shall be designed to prevent cross contamination of samples.
- Capability to extract a representative sample of treated waste for certification of waste form and provide radionuclide data to support low-level waste category determination assay.
- Capability to extract samples from a container lot to verify record information.
- Capability to destructively examine treated waste drums exiting the facility.

5.1.2 Study Criteria

5.1.2.1 Study Basis

A. A review of the sampling needs of the WRAP 2A facility will be undertaken. In each area, the number of samples required, the information to be determined from each sample and the sample method will be reviewed.

5.1.2.2 Potential Study Impacts

A. The study will incorporate any additional sampling requirements identified by other ACDR studies.

5.2 Assumptions

5.2.1 Study Prerequisites

A. This study will be initiated using CDR data.

5.2.2 Study Assumptions

A. The sampling philosophy adopted for WRAP 2A shall satisfy all FDC requirements.

6.0 DESCRIPTION OF ALTERNATIVES AND SOLUTIONS

6.1 Listing of Alternatives

6.1.1 Introduction

A. This section describes alternative sample methods which may be applicable for use in WRAP 2A. Section 6.2, Detailed Description, will evaluate which of the following methods is most applicable for each material to be sampled.

B. The sampling method selected for each waste stream will be dependant on a number of factors, the main ones are as follows:

- Physical State: The sampling device will vary according to whether the sample is liquid, gas, solid or multiphase.
- Volume: The volume of waste will be represented by the number and size of samples taken and hence will impact on the sample equipment and sampling strategy.

6.1.2 Liquid Waste Samplers

6.1.2.1 Composite Liquid Waste Sampler (Coliwasa)[1,3]

A. The Coliwasa is a device used to sample free-flowing liquids and slurries contained in drums, shallow tanks, pits and similar containers. The Coliwasa consists of a tube equipped with an end closure that can be opened and closed while the tube is submerged in the material to be sampled. This sample technique is unsuitable for closed tank systems but may be used for tanks with manway access points.

6.1.2.2 Weighted Bottle or Bomb Sampler[1,3]

A. The weighted bottle and bomb sampler work using similar principles and are used for sampling liquids and free-flowing slurries in tanks or ponds. These samplers consist of a reservoir, a method of closing the reservoir and a line that is used to lower and raise the bottle/bomb. This sample technique is unsuitable for closed tank systems but may be used for tanks with manway access.

6.1.2.3 Sample Valve

A. A sample valve is used for taking samples of free-flowing liquids from vessels or pipework. In the case of a direct tap-in to a vessel the head of liquor in the tank will be used to fill the sample vessel. Where the sample point has to be at a higher elevation than the vessel the liquor will be pumped through a recirculation loop past the sample valve and back to the tank. A number of pumps could perform this duty though care will be required to ensure that the materials of construction are compatible with the waste to be sampled and clean-out/maintenance requirements.

6.1.3 Dry Granular/Powdered Material Samplers

6.1.3.1 Thief[1,2]

A. A Thief is used to sample dry granules or powdered wastes whose particle diameter is less than one third the width of the slots in the Thief. A Thief consists of two slotted concentric tubes. The outer tube has a conical pointed tip that permits the sampler to penetrate the material to be sampled. The inner tube is rotated to open and close the sampler.

6.1.3.2 Scoops and Shovels[1,2,3]

A. Scoops and Shovels are mainly used to sample granular or powdered material in bins, shallow containers and conveyor belts, however they could be used with sludge type material if required.

6.1.4 Sludge Samplers

6.1.4.1 Trier[1,2,3]

A. A Trier is used to sample moist or sticky solids with a particle diameter less than one-half the diameter of the Trier. A Trier consists of a tube cut in half lengthwise with a sharpened tip that allows the sampler to cut into the material to be sampled.

6.1.4.2 Scoops and Shovels[1,2,3]

A. Scoops and Shovels are mainly used to sample granular or powdered material in bins, shallow containers and conveyor belts, however they could be used with sludge type material if required.

6.1.5 Solid Material Samplers

6.1.5.1 Auger[1,2,3]

A. An auger is mainly used to sample hard or packed solid wastes or soil but could also be used to sample high viscosity sludges. There are two types of Auger. First is a sharpened spiral blades attached to a hard metal central shaft which is used to lift the loosened waste from the sample area. This method tends to mix the waste layers that are being sampled and therefore is not applicable where there are stratified layers which require sampling. The second type is a Hollow-core Auger which is used to remove waste to the desired depth for sampling. Once at the required depth a split spoon is used to take a sample of the waste.

6.1.5.2 Core Sampler[4]

A. A Core Sampler is mainly used to sample hard or packed solid wastes or soil, but could also be used to sample high viscosity sludges. A Core Sampler consists of a tubular drill bit with a cutting teeth on the annulus of the tube. The Core Sampler is drilled into the waste and when it is retracted the sample remains in the center of the drill. In the case of wet particulates the "Core Sampler" would be a split spoon which would be pushed or driven into the waste to take the sample.

6.1.5.3 Manipulators

A. Manipulators are used to pick samples of large solid items from either a sorting table or a container. The sample will be obtained using a snip and swipe method as proposed for WRAP Module 1.

6.1.6 Immobilization Waste/Binder Mix Samplers

6.1.6.1 Sleeve-in-Sleeve

A. A sleeve-in-sleeve device is used for obtaining samples of stabilized/ immobilized material. The sleeve-in-sleeve unit is inserted into the waste/binder mixture prior to set-up and the inner sleeve is removed with the waste core intact. The outer sleeve remains in the waste and the resulting void space is filled with a filler.

6.1.7 Gas Samplers

6.1.7.1 Sample Valve

A. A sample valve is used for sampling gases which are under pressure. Gas streams which are not under pressure will be sampled by using a pump to pull a sample of the gas stream through a tap-in point in the process system and then through a filter or scrubber system. In WRAP 2A an isokinetic sampling system similar to that proposed for WRAP 1 will be used. This system continuously samples the exhaust gases and monitors the gas flowrate. This allows the concentration of the contaminants to be calculated.

6.2 Detailed Discussion

6.2.1 Introduction

A. The WRAP 2A CDR Sample Management Schedule[5] is shown in **Figure 6-1**. For each sample point identified in the schedule, data used to justify the sample being included in the CDR schedule will be presented. The justification will then be reviewed in a discussion section which will determine if the sample is required or whether the data from the sample can be generated from some other source.

B. For those samples which are deemed to be necessary the sample method, sample analysis required and where the analysis will be undertaken will be described. This information is detailed in Sections 6.2.2 through 6.2.11 below and the results are tabulated in **Table 6-1**. The proposed WRAP 2A sample plan which details the findings of the study is given in **Appendix A**.

1106: SPECIAL WASTE	1	2	3	4	5	6	7	8	9
EQUIPMENT:	H-06-201	X-06-201	55 GAL DRUMS	T-06-101 A/B	55 GAL. DRUMS	CV-06-301	55 GAL. DRUMS	V-06-301	V-06-301
DETERMINANT:	RESIDUAL Hg	RESIDUAL Hg	WASTE CHARACTER	SIZE DISTRIBUTION	WASTE CHARACTER	OXIDIZING POTENTIAL	WASTE CHARACTER	TRACE Hg	CHEMICAL COMP.
FLUID:	PRETREATED WASTE	PRETREATED WASTE	REPACK/AMALGAM RETRACTED WASTE	BULK Hg OR Pb	REPACKED SHREDDED LEAD	DEACTIVATED REACTIVE METALS	REPACKED DEACTIVATED REACTIVE METALS	SCRUBBER OFF-GAS	SCRUBBER BLOWDOWN
TURN-ROUND TIME:	2 WEEKS	2 WEEKS	2 WEEKS	< 1 HR	2 WEEKS	1 DAY	2 WEEKS	< 1 HR	< 1 HR
FREQUENCY:	1 / DAY	1 / DAY	1 / DRUM	1 / DAY	1 / DRUM	1 / DAY	1 / DAY	1 / DAY	1 / DAY
CATEGORY:	A	A	A	C	A	B	A	C	C

1105: BOX BREAKDOWN CELL	1	2
EQUIPMENT:	CELL	BOX
DETERMINANT:	WASTE CHARACTER	LOT VERIFICATION
FLUID:	FEEDSTREAMS - 5C, 1D & HEPA FILTERS.	FEEDSTREAMS - 5C, 1D & HEPA FILTERS.
TURN-ROUND TIME:	1 WEEK	2 WEEKS
FREQUENCY:	1 / MONTH	1 / MONTH
CATEGORY:	A	A

1105: SIZE RED. & REPACK	1	2	3
EQUIPMENT:	GB-05-521 /SHREDDER)	GB-05-541 (PUG MILL)	GB-05-521 (REPACK)
DETERMINANT:	WASTE CHARACTER	WASTE CHARACTER	WASTE CHARACTER
FLUID:	FEEDSTREAMS - 1A, 1D, 2D, 3, 4 & 5D	FEEDSTREAMS - 1B, 1C & 6	FEEDSTREAMS - 2A, 2B, 2C, 5C, 7 & 8
TURN-ROUND TIME:	1 WEEK	1 WEEK	1 WEEK
FREQUENCY:	1 / MONTH	1 / MONTH	1 / MONTH
CATEGORY:	A	A	A

1112: AQUEOUS MAKE-UP	1	2	3
EQUIPMENT:	T-12-101 ACID FEED	T-12-102 CAUSTIC FEED	T-12-103 DECON SOLUTION
DETERMINANT:	VERIFY STRENGTH	VERIFY STRENGTH	VERIFY STRENGTH
FLUID:	DILUTE ACID (1-5%)	DILUTE CAUSTIC (1-5%)	DECON CHEMICAL
TURN-ROUND TIME:	1 DAY	1 DAY	1 DAY
FREQUENCY:	1/2 MONTH	1/2 MONTH	1/2 MONTH
CATEGORY:	C	C	C

1114: HVAC	1
EQUIPMENT:	EXHAUST STACK
DETERMINANT:	TEST FOR PARTICULATES
FLUID:	SOLIDS ON FILTER PAPER
TURN-ROUND TIME:	3-5 DAYS
FREQUENCY:	1/2 WEEK
CATEGORY:	B

1104: OFF-GAS	
EQUIPMENT:	
DETERMINANT:	
FLUID:	
TURN-ROUND TIME:	
FREQUENCY:	
CATEGORY:	

NOTES:

CATEGORY A = OFF-SITE ANALYSIS.
CATEGORY B = SMA ANALYSIS.
CATEGORY C = SOURCE ANALYSIS.

DRAWING TRACEABILITY LIST	NEXT USED ON.
	REFERENCE

FORM MODIFIED

SAMPLE MANAGEMENT	
MENT	WASTE DRUM
MINANT	LOT VERIF.
	WASTE
ROUND TIME:	2 WEEKS
ENCY:	DAILY
ORY	A

1105: POLYMER	1	2	3	4	5	6	7	8
EQUIPMENT:	T-05-401	T-05-402	M-07-404 THRU 407	V-05-401	55 GAL. DRUMS	T-05-304	T-05-303	T-05-305 A/B
DETERMINANT:	CHEMICAL COMP.	CHEMICAL COMP.	CHEMICAL COMP.	ACTIVITY & CHEM. COMP.	CERTIFY	Q.C. / PREMATURE POLYMERIZATION	Q.C. / PREMATURE POLYMERIZATION	Q.C. / PREMATURE POLYMERIZATION
FLUID:	MIXED POLYMER	WASTE	MIXED POLY & CATALYST	WASTE WATER	TREATED WASTE	PROMOTER	CATALYST	VES RESIN
TURN-ROUND TIME:	< 1 HR	< 1 DAY	< 1 HR	1 DAY	2 WEEKS	< 1 DAY	< 1 DAY	< 1 DAY
FREQUENCY:	1 / DAY	1 / WEEK	1 / DAY	1 / DAY	1 / DRUM	1 / WEEK	1 / WEEK	1 / WEEK
CATEGORY:	C	C	C	B	A	C	C	C

1105: GROUT	1	2	3	4	5	6	7
EQUIPMENT:	T-05-101 THRU 104	DRUM OF POLY. ADDITIVE	T-05-201 THRU 211	T-05-212	DRUM OF WASTE (VIBRO)	DRUM OF WASTE (AGIT)	P-05-203
DETERMINANT:	Q.C. BULK POWDER	Q.C. ADDITIVE	Q.C. BULK POWDER	WET GROUT MIX	RADIONUCLIDE INVENTORY	RADIONUCLIDE INVENTORY	RADIONUCLIDE INVENTORY
FLUID:	OPS, BFS, PFA & GYPSUM	POLYESTER	OPS, BFS, PFA & BLENDS	MIXTURE OF OPC, BFS & PFA	CERTIFY	CERTIFY	WATER
TURN-ROUND TIME:	2 DAYS	DAYS	2 HOURS	1 HOUR	2 WEEKS	2 WEEKS	1 DAY
FREQUENCY:	1 / MONTH	1 / MONTH	DAILY / 10 DAY	10 / DAY	1 / LOT	1 / LOT	1 / MONTH
CATEGORY:	C	C	C	C	A	A	B

SAMPLE MANAGEMENT

1107: SECONDARY WASTE	1	2	3
EQUIPMENT:	T-07-101 A/B NON-ACTIVE TANKS	T-07-201 ACTIVE TANK	T-07-202 TREATED ACTIVE TANK
DETERMINANT	CHEMICAL CHARACTERIZATION	RADIOACTIVE CHARACTERIZATION	RADIOACTIVE CHARACTERIZATION
FLUID:	NON-ACTIVE LIQUID WASTE	ACTIVE LIQUID WASTE	TREATED ACTIVE LIQUID WASTE
TURN-ROUND TIME:	2 WEEKS	2 WEEKS	2 WEEKS
FREQUENCY:	1/2 MONTH	1/2 MONTH	1/2 MONTH
CATEGORY:	A	B	B

	2	3	4	5	6	7	8	9
F-04-101 A/B	F-04-102 A/B	F-04-103 A/B	F-04-101 A/B	F-04-105 A/B	F-04-106	F-04-107 A/B	F-04-108	F-04-109 A/B
DOP TEST FOR LEAKS	DOP TEST FOR LEAKS	DOP TEST FOR LEAKS	CHECK FOR HYDROCARBON	DOP TEST FOR LEAKS	DOP TEST FOR LEAKS	CHECK FOR HYDROCARBON	CHECK FOR HYDROCARBON	DOP TEST FOR LEAKS
VENT FROM ACTIVE TANKS	OFF-GAS FROM SIZE REDUCTION	OFF-GAS FROM POLYMER ENCAP.	OFF-GAS FROM POLYMER ENCAP.	OFF-GAS FROM INDOOR GROUT SILO'S	OFF-GAS FROM GROUT STABILIZATION	OFF-GAS FROM SPECIAL WASTE	OFF-GAS FROM SAMPLE MAN. HOODS	OFF-GAS FROM NON-ACTIVE TANKS
TEST WHEN SITE	DOP TEST IMMEDIATE	DOP TEST IMMEDIATE	1-2 DAYS	DOP TEST IMMEDIATE	DOP TEST IMMEDIATE	DOP TEST IMMEDIATE (B) 1-2 DAYS	DOP TEST IMMEDIATE (B) 1-2 DAYS	DOP TEST IMMEDIATE
FILTER INSTALL	AFTER FILTER INSTALL	AFTER FILTER INSTALL	AFTER FILTER INSTALL ONCE PER WEEK	AFTER FILTER INSTALL	AFTER FILTER INSTALL	AFTER FILTER INSTALL (B) CARBON 2 WEEKS	AFTER FILTER INSTALL (B) CARBON 2 WEEKS	AFTER FILTER INSTALL
								C

FIGURE 5.1

PROCESS SAMPLING

United Engineers & Constructors
A Raytheon Company

Western Operations

TRANSMITTAL # 30-W100-CDR-001

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
WESTINGHOUSE HANFORD COMPANY

	BY	DATE
DESIGNED	S MADKAY	05-11-92
DRAWN	C MOORE	05-12-92
CHECKED		
APPROVED		
Q.A.		
OTHER		
OTHER		
OTHER		

APPROVED FOR DETAILED DESIGN
BY
FOR DATE

WRAP 2A CONCEPTUAL DESIGN
SAMPLE MANAGEMENT SHEDULE

SIZE	BLDG NO	FOCUS NO	DRAWING NUMBER	REV
D	2337-W		Figure 1.10-1	A

SCALE NONE | DATABASE NO: W- | SHEET 1 OF 1

A PRELIMINARY

REV NO	DESCRIPTION	REV BY/DATE	CHK BY/DATE	APPROVAL DATE

REVISIONS

DRAWING

CADFILE: WP2TC11A ADCODE: 2 (BM: ACD2 11:N)

COMPUTER GENERATED: NO MANUAL CHANGES ALLOWED

TABLE 6-1
WRAP 2A CDR SAMPLE SCHEDULE

Sample Number	Material To Be Sampled	Where To Be Sampled	CDR Data			Recommended Changes to CDR Data (Where Analyzed)
			Reason For Sample	CDR Sample Frequency	Where Analyzed	
SPECIAL WASTE AREA SAMPLES						
1	Shredded Heat Treated waste	Mercury Evaporator	Determine Mercury Content	Once Per Day	Off Site	Not Required
2	Stabilized Mercury	Jar Mills	Determine Mercury Content	Once Per Day	Off Site	Not Required
3	Stabilized Mercury	Product Drum	To Characterize Waste	Once Per Drum	Off Site	Not Required
4	Shredded Lead and Mercury	Shredder Discharge Bins	Determine Size Distribution	Once Per Day	At Source	Not Required
5	Shredded Lead	Product Drum	To Characterize Waste	Once Per Drum	Off Site	Not Required
6	Deactivated "Reactive" Metals	Humidifier Discharge Conveyor	Determine Oxidizing Potential	Once Per Day	SMA	Not Required
7	Deactivated "Reactive" Metals	Product Drum	To Characterize Waste	Once Per Day	Off Site	Not Required
8	Scrubber Off-gas	Off-gas Flue	Determine Mercury Content	Once Per Day	At Source	Mercury Content Not Required, Moisture Content (In-Line Monitoring) And pH Check (SMA) Required
9	Scrubber Blowdown	Scrubber Drain Line	Determine Chemical Composition	Once Per Day	At Source	Dissolved Salts Concentration Required (In-Line Monitoring)
SAMPLE MANAGEMENT AREA SAMPLES						
1(a)	Incoming Waste	Waste Drum	Lot Verification	Once Per Drum	Off Site	Required If Poorly Characterized (SMA)
1(b)	Outgoing Product	Product Drum	Certification	Once Per Drum	Off Site	To Comply With FDC Requirements (SMA)
POLYMER ENCAPSULATION SAMPLES						
1	Mixed VES Polymer	Polymer Mixing Tank	Determine Chemical Composition	Once Per Day	At Source	Required Infrequently (SMA)
2	Hydrocarbon Wastes	Hydrocarbon Waste Tank	Determine Chemical Composition	Once Per Week	At Source	Required (External Facility)
3	Mixed VES And Catalyst	In-line Mixers	Confirm Successful mix	Once Per Day	At Source	Required Infrequently (SMA)
4	Ion Exchange Effluent	Liquor Catch Drum	Determine Composition	Once Per Day	SMA	Check For Organic/Aqueous Liquor Required (SMA)
5	VES/Waste Product	Product Drum	Certification of Product	Once Per Drum	Off Site	Required (External Facility)
6	VES Promoter	Storage Tank	Quality Control	Once Per Week	At Source	Required Infrequently (SMA)
7	VES Catalyst	Storage Tank	Quality Control	Once Per Week	At Source	Required Infrequently (SMA)
8	VES Resin	Storage Tanks	Quality Control	Once Per Week	At Source	Required Infrequently (SMA)

TABLE 6-1 (CONTINUED)
WRAP 2A CDR SAMPLE SCHEDULE

Sample Number	Material To Be Sampled	Where To Be Sampled	CDR Data			Recommended Changes to CDR Data (Where Analyzed)
			Reason For Sample	CDR Sample Frequency	Where Analyzed	
GROUT IMMOBILIZATION SAMPLES						
1	Grout Powders	Storage Silos	Quality Control	Once Per Month Per Silo	At Source	Required Infrequently (External Facility)
2	Polymer Additive	Raw Material Drum	Quality Control	Once Per Month	At Source	Required (SMA)
3	Grout Powder Blends	Silos/Weigh Hoppers	Quality Control	Ten Per Day	At Source	Not Required
4	Liquid Grout	Wet Grout Mixing Tank	Quality Control	Ten Per Day	At Source	Viscosity Check Daily (At Source). Infrequent Testing Of Cured Samples (SMA).
5	Vibrogrouted Product	Product Drum	Certification Of Product	Once Per Lot	Off Site	Required (External Facility).
6	Agitated Grout Product	Product Drum	Certification Of Product	Once Per Lot	Off Site	Required (External Facility).
7	Grout Bleed Water	Pump Discharge Line	Determine Radionuclide Inventory	Once Per Month	SMA	Not Required
SECONDARY WASTE SAMPLES						
1	Non-active Aqueous Waste	Collection Tanks	Determine Chemical Composition	Once Per Two Months	At Source	pH Required When Tank is Full (SMA).
2	Active Aqueous Waste	Collection Tanks	Determine Radionuclide Inventory	Once Per Two Months	SMA	Not Required
3	Treated Active Waste	Collection Tank	Determine Chemical Composition and Radionuclide Inventory	Once Per Two Months	SMA	Required When Tank Is Full. Detailed Characterization Analysis and Radiochemical Composition (External Facility).
BOX BREAKDOWN AREA SAMPLES						
1	Lead, Misc. Waste And HEPA Filters	Box Breakdown And Repack	To Characterize Waste	Once Per Month	Off Site	Not Considered Further (Same as Box Breakdown Sample No. 2).
2	Lead, Misc. Waste And HEPA Filters	Box Breakdown And Repack	Lot Verification	Once Per Lot	Off Site	Required Infrequently (External Facility)
SIZE REDUCTION AND REPACK SAMPLES						
1	Wastes For Shredding	Shredder/ Repack Enclosure	To Characterize Waste	Once Per Month	Off Site	Required Infrequently (External Facility)
2	Wastes For Pug Mill Processing	Pug Mill	To Characterize Waste	Once Per Month	Off Site	Required Infrequently (External Facility)
3	Wastes For Direct Repack	Shredder/ Repack Enclosure	To Characterize Waste	Once Per Month	Off Site	Required Infrequently (External Facility)

TABLE 6-1 (CONTINUED)
WRAP 2A CDR SAMPLE SCHEDULE

Sample Number	Material To Be Sampled	Where To Be Sampled	CDR Data			Recommended Changes to CDR Data (Where Analyzed)
			Reason For Sample	CDR Sample Frequency	Where Analyzed	
AQUEOUS MAKE-UP SAMPLES						
1	Acid	Acid Feed Tank	Verify Acid Strength	Once Per Two Months	At Source	Not Required
2	Caustic Soda Solution	Caustic Feed Tank	Verify Caustic Strength	Once Per Two Months	At Source	Not Required
3	Decontam Solution	Decontam Solution Feed Tank	Verify Solution Strength	Once Per. Two Months	At Source	Not Required
HVAC SAMPLES						
1	HVAC Exhaust Gases	Discharge Stack	Determine Solids Content	Once Per Two Weeks	SMA	Continuous Sampling Through Filter Required, Filters Analyzed For Chemical And Radionuclide Composition (External Facility).
OFF-GAS SAMPLES						
1	Off-gas Active Tanks	Off-gas Filters	Test For Leaks	After Filter Installation	At Source	Not Considered Further
2	Off-gas Size Reduction	Off-gas Filters	Test For Leaks	After Filter Installation	At Source	Not Considered Further
3	Off-gas Polymer Encap Area	Off-gas Filters	Test For Leaks	After Filter Installation	At Source	Not Considered Further
4	Off-gas Polymer Encap Area	Off-gas Filters	Test For Presence Of Hydrocarbon	Once Per Week	At Source	In-Line Monitoring For Hydrocarbons Required
5	Off-gas Grout Silos	Off-gas Filters	Test For Leaks	After Filter Installation	At Source	Not Considered Further
6	Off-gas Grout Immob Area	Off-gas Filters	Test For Leaks	After Filter Installation	At Source	Not Considered Further
7	Off-gas Special Waste Area	Off-gas Filters	Test For Presence Of Hydrocarbon	Once Per Two Weeks	At Source	In-Line Monitoring For Hydrocarbons Required
8	Off-gas Sample Fume Hoods	Off-gas Filters	Test For Presence Of Hydrocarbon	Once Per Two Weeks	At Source	In-Line Monitoring For Hydrocarbons Required
9	Off-gas Non-active Tanks	Off-gas Filters	Test For Leaks	After Filter Installation	At Source	Not Considered Further

6.2.2 Special Waste Samples

6.2.2.1 Sample No. 1: PFD H-2-140650
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	HEAT TREATED SHREDDED MERCURY CONTAMINATED WASTE
WHERE TO BE SAMPLED	:	MERCURY EVAPORATOR (H-06-201)
REASON FOR SAMPLE	:	TO DETECT PRESENCE OF MERCURY
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	13.3 Cu Ft / DAY
HOLDING VESSEL VOLUME	:	14.7 Cu Ft (EVAPORATOR VOLUME)

DISCUSSION OF CDR DATA

A. The evaporator is sized so that it can treat one days arisings of waste as one batch. This is based upon the time required to heat the evaporator, allow the mercury to evaporate and then cool the evaporator. Consequently, assuming that it is necessary to sample the waste after evaporation, the basis is to take one sample per day would have to be continued.

B. It will not be necessary to take this sample provided that the equipment has been tested at full scale with surrogate waste forms prior to the plant going operational. This will demonstrate that provided the waste has been kept at a specific temperature for a specific length of time in the evaporator, the mercury content is no longer significant (below 0.2 mg/liter and non-toxic[6]). A second reason why it will not be necessary to sample this waste is that the retorting of mercury contaminated waste is a technology based treatment standard and therefore the treated waste does not need to be sampled. In order to confirm that the equipment is functioning as designed, the evaporator temperature will be recorded throughout the processing period.

CONCLUSION

A. The CDR Special Waste Sample No. 1 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.2 Sample No. 2: PFD H-2-140650
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	AMALGAMATED MERCURY
WHERE TO BE SAMPLED	:	JAR MILLS (X-06-201 A,B)
REASON FOR SAMPLE	:	TO DETERMINE IF ELEMENTAL MERCURY IS PRESENT IN THE WASTE
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	1.8 Cu Ft / DAY (AMALGAMATED)
HOLDING VESSEL VOLUME	:	4 X 1 LITER JAR MILLS

DISCUSSION OF CDR DATA

A. Each day there will be approximately 52 batches (one liter each) processed through this equipment. The CDR recommends that one sample per day is taken to confirm that the amalgamation process is working.

B. It is proposed to confirm that the process is working as expected by checking for elemental mercury remaining after the amalgamation process. It will not be necessary to take this sample as it will be demonstrated prior to the plant going operational, that provided sufficient amalgamating chemical has been added to the mercury and the Jar Mills have been operated for a specific length of time that all elemental mercury will be amalgamated. The other reason why it will not be necessary to take this sample is because the amalgamation of mercury is a technology based treatment standard and there is no regulatory requirement to sample the product.

CONCLUSION

A. The CDR Special Waste Sample No. 2 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.3 Sample No. 3: PFD H-2-140649
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	AMALGAMATED MERCURY PRIOR TO IMMOBILIZATION
WHERE TO BE SAMPLED	:	PRODUCT DRUM
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER DRUM
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	1.8 Cu Ft / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The amalgamated Mercury will be placed, in bottles, into product drums for immobilization. The number of bottles per drum has yet to be determined, however it is proposed that the drum will be filled to a predetermined level prior to the sample being taken. This sample was identified in the CDR as being required for waste characterization purposes. For the characterization to be meaningful, it would be necessary to demonstrate that a representative sample had been taken. The nature of this waste within the drum would make this difficult to demonstrate.

B. It will not be necessary to take this sample as this waste will have been characterized prior to amalgamation and the amount of amalgamating chemical added will be known, hence the chemical composition of the drummed waste will be known without sampling. The other reason why it will not be necessary to take this sample is because the amalgamation of mercury is a technology based treatment standard and, therefore, there is no regulatory requirement to sample the product.

CONCLUSION

A. The CDR Special Waste Sample No. 3 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.4 Sample No. 4: PFD H-2-140649
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	SHREDDED LEAD AND MERCURY CONTAMINATED WASTE
WHERE TO BE SAMPLED	:	SHREDDER DISCHARGE BINS (T-06-101 A,B)
REASON FOR SAMPLE	:	TO DETERMINE SIZE DISTRIBUTION
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	0.3 Cu Ft / DAY LEAD CONTAM. WASTE 24.3 Cu Ft/ DAY MERCURY CONTAM. WASTE
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. Shredding of this waste will be carried out for two reasons: first to reduce the waste to an optimum size for macro-infilling within a product drum and second, in the case of mercury contaminated waste, to expose additional surface area to allow mercury evaporation in the evaporator.

B. It will not be necessary to take this sample in order to determine the size distribution of the waste for macro-infilling. The impact of waste particle size on macro-infilling has been investigated to some extent by BNFL in the UK and the general conclusions are as follows[7]:

- Provided the bulk of the waste has dimensions in excess of 1/4 inch then the waste can be successfully vibromixed providing a high fluidity binder is used.
- There is no upper limit on particle dimension other than the drum dimensions.

C. In order to confirm that the shredder is performing to the required standard, i.e. that the particle size range for mercury evaporation is not exceeded either due to wear of any components or simply because of the properties of the waste being shredded, a visual checking position will be provided either using a camera or a window. In order to minimize problems due to the wear of the cutting blades, this equipment should be inspected during routine maintenance periods and blades replaced as appropriate. If, during testing of the equipment, certain waste types are shown to exceed the maximum allowable particle size on occasions, all lots of that waste should be given a double pass through the shredder as part of operating philosophy.

CONCLUSION

A. The CDR Special Waste Sample No. 4 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.5 Sample No. 5: PFD H-2-140649
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	SHREDDED LEAD
WHERE TO BE SAMPLED	:	PRODUCT DRUM
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER DRUM
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	0.5 Cu Ft / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The problem here will be how to take a sample which is representative of the whole drum. In order to do this it would be necessary to tip out the drum contents and take a random sample using manipulators.

B. The waste will be fully characterized before it enters WRAP 2A, hence it will not be necessary to take this sample as nothing will have been done to change the characterization other than it will have been size reduced. A second reason why it will not be necessary to take this sample is because macro-encapsulation of radioactive lead is a technology based treatment standard and therefore there is no regulatory requirement to sample the product[6].

CONCLUSION

A. The CDR Special Waste Sample No. 5 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.6 Sample No. 6: PFD H-2-140651
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	DEACTIVATED "REACTIVE" METALS
WHERE TO BE SAMPLED	:	HUMIDIFIER DISCHARGE VIBRATORY CONVEYOR (CV-06-301)
REASON FOR SAMPLE	:	TO DETERMINE THE OXIDIZING POTENTIAL
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	SAMPLE MANAGEMENT AREA
MATERIAL THROUGHPUT	:	0.8 Cu Ft / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The reactive metals are segregated as they enter the humidifier into coarse and fines streams (assumed split is 50:50 coarse:fine). Only the fine material has the potential to react and hence requires treatment. The humidifier is sized to treat 0.5 cu ft / day of the reactive fines and in the CDR it is proposed to sample once per day. This sample is to confirm that the process is working as designed.

B. It will not be necessary to take this sample provided that the equipment has been tested at full scale with surrogate waste forms prior to the plant going operational to demonstrate that this process will always produce a deactivated product. The only parameter that needs to be carefully controlled in order to ensure that the process is working as designed is the humidity of the air entering the humidifier. This data is determined using Special Waste Area Sample No. 8.

CONCLUSION

A. The CDR Special Waste Sample No. 6 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.7 Sample No. 7: PFD H-2-140649
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	DEACTIVATED "REACTIVE" METALS
WHERE TO BE SAMPLED	:	PRODUCT DRUM
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	0.8 Cu Ft / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. It will not be necessary to take this sample as this waste will have been characterized prior to deactivation, hence the chemical composition after deactivation can be determined without sampling.

CONCLUSION

A. The CDR Special Waste Sample No. 7 will not be required in WRAP 2A and will not be considered further in this study.

6.2.2.8 Sample No. 8: PFD H-2-140651
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	SCRUBBER OFF-GAS
WHERE TO BE SAMPLED	:	OFF-GAS FLUE
REASON FOR SAMPLE	:	TO DETERMINE MERCURY CONTENT
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	13 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. This sample was identified in the CDR as being required to determine the mercury content of off-gases being released into the vent system and hence determine the efficiency of the scrubber.

B. The sampling of mercury in-line is possible, or a grab sample (using a Tedlar bag for example), followed by analysis of the gas using a mass spectrometer could be used. However, the need to take this sample has to be questioned. The off-gases from the scrubber will routinely contain mercury; the scrubber will not remove 100 % of the mercury in the gas stream. For this reason there is a down stream filter to remove any mercury which passes through the scrubber. This sample point is between the scrubber and the filter and hence performs no other task than to provide data on the amount of mercury in the gas stream at this point.

C. This scrubber will also remove acidic vapors from the gas stream. It is important to check that the scrubber is removing all the acidic vapors otherwise there will be corrosion of the ventilation ducting. Consequently a sample of the off-gas will be required. A grab sample will be taken via a valved tap-in point. The vapor will be condensed and analyzed for pH in the SMA.

D. Another "sample" which will be required but was not identified in the CDR is to determine the moisture content of the off-gas. This is required as the off-gas will be used as a feed to the reactive metals humidifier which must be maintained at a pre-determined humidity when treating reactive metal fines. As it is not proposed to treat mercury wastes and reactive metals at the same time it will not be necessary to sample the off-gas for any contaminants which may be carried over into the humidifier.

E. In order to determine the moisture content of the gas stream a physical sample could be taken, however, the moisture content of a gas stream can be determined using in-line instrumentation.

CONCLUSION

A. The CDR Special Waste Sample No. 8 to determine the mercury content of the off-gas will not be required in WRAP 2A and will not be considered further in this study. However, a sample of the off-gas will be required to determine the pH of the vapor leaving the scrubber and the moisture content of the off-gas.

B. The preferred method of determining the moisture content is to use an in-line method as this does not require a physical sample to be taken through the SMA and will provide a continuous reading of the moisture content.

RECOMMENDED SAMPLE METHOD: NONE (IN-LINE MONITORING)

C. The only method identified to determine the pH of the off-gas is to take a grab sample via a sample valve. The vapor will then be condensed and analyzed for pH in the SMA.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

6.2.2.9 Sample No. 9: PFD H-2-140651
BFD H-2-140648

CDR DATA

MATERIAL TO BE SAMPLED	:	SCRUBBER BLOWDOWN
WHERE TO BE SAMPLED	:	SCRUBBER RECIRCULATION LOOP
REASON FOR SAMPLE	:	TO DETERMINE CHEMICAL COMPOSITION
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	TBD
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. As this waste has only one disposal route and that is to the Active Waste Collection Tank, T-07-201, where it will be combined with other wastes, the sampling of this waste in the scrubber recirculation loop serves no purpose in terms of providing an analysis which could be used for determining the characterization of the immobilized product from this waste. One reason for taking this sample would be to confirm that the waste contains mercury and hence has to be designated as a hazardous waste stream and treated accordingly prior to land disposal. However, it can be determined from process knowledge that this waste stream will always contain mercury during the three years that mercury is campaigned through the plant and therefore there is no need to sample to prove this fact[9]. Prior to mercury being campaigned in WRAP 2A there will be no regulated hazardous materials in this waste stream. The only reason why this sample would be required would be to monitor the build-up of salts in the scrubber liquor as a result of removing acidic vapors from the off-gas. The actual chemical composition would be of no importance and a simple check of the change in conductivity of the scrubber liquor would provide sufficient information to determine when the scrubber liquor may need to be changed. This can be determined relatively easily using in-line instrumentation.

CONCLUSION

A. The CDR Special Waste Sample No. 8 will not be required in WRAP 2A and will not be considered further in this study. However, a sample of the scrubber liquor will be required to monitor the conductivity of the liquor to determine the dissolved solids build-up.

B. The preferred method of determining the extent of salt build-up in the scrubber liquor is to use an in-line technique as it does not require a physical sample to be taken and handling through the SMA and it will provide a continuous reading of how the salt concentration is changing.

RECOMMENDED SAMPLE METHOD: NONE (IN-LINE MONITORING)

6.2.3 Sample Management Area Samples

6.2.3.1 Sample No. 1(a): PFD H-2-140633
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	INCOMING WASTE DRUMS
WHERE TO BE SAMPLED	:	WASTE DRUM
REASON FOR SAMPLE	:	LOT VERIFICATION
SAMPLE FREQUENCY	:	DAILY
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	5.86 (55 GALLON DRUMS/DAY)
	:	6.0 (83 GALLON DRUMS/DAY)
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The regulations (40-CFR-264.13[10] and WAC 173-303-300[6]) require that the owner or operator sample the waste "if necessary". If the waste has already been characterized before entering WRAP 2A and a visual inspection can confirm that the waste type is as expected, then there is no requirement to sample any drums. The FDC[11] requires that there is "Capability to extract samples from a lot of containers to verify record information including:

- Receipt of drums and boxes into the enclosure.
- Handling to extract a representative sample from at least one drum of a lot or 20 % of the waste containers of a lot which ever is greater.
- Exiting the container out of the enclosure and transport back to storage."

B. It will be possible to take samples from opened containers in the Open/Sort/Repack Area and in the Box Breakdown Area and, if required, it will be possible to repack the waste in new drums and return it to storage. Hence it would be possible to comply with both the regulatory requirements and the requirements of the FDC without having any sampling facilities in the SMA. The only potential problem would be if a lot of drums when opened did not appear to have the same characteristics as recorded on the paperwork accompanying the drums. In this case, where there may be a large number of samples required, there would be implications on the throughput of WRAP 2A.

C. All wastes should be well characterized before they are routed to WRAP 2A. For wastes that are not well characterized or where the amount of a particular waste component which may affect the immobilization process is unknown (eg. nitrate content) a sample will be required both for lot verification and as a 'process' sample to allow the binder formulation to be determined. This may require the drum to be tipped out in the Open/Sort/Repack area or box breakdown area.

D. Raw waste feedstreams brought into this area for lot verification fall into four categories of physical characteristics for sampling:

- Dry Particulates
- Wet Particulates (and sludges)
- Solid Loose Items
- Solidified Liquids

E. Alternatives for sampling raw waste drums are to tip the waste onto a sorting table and to use a manipulator or scoop to take a random sample, or to use an Auger or Core Sampler to sample solids in-drum, or to use a Trier, Scoop, Auger or Core Sampler to sample sludges in-drum, or to use a Thief or a Scoop to sample dry particulate solids in-drum.

CONCLUSION

A. Lot verification should be routinely carried out by visual examination in either the Open/Sort/Repack Area or in the Box Breakdown Area especially when the properties of the incoming waste stream are well characterized and vary little between lots. Only if there appears to be a discrepancy between the appearance of the waste and the waste characterization accompanying the drum should a sample be taken. The waste should then be repacked into a new drum and sent back to storage. This waste drum would the be treated as a reject from the incoming lot and would be dealt with as a new lot of one drum. Following analysis of the sample if it is decided that a significant number of drums will need to be sampled, the sampling should take place in the SMA. For waste streams that are not well characterized or where there is significant differences are expected between the properties of one lot with the next, it is recommended that drums are taken direct to the SMA for sampling to allow lot verification/process sampling to be performed prior to bringing a large number of drums from that lot into the plant. Analysis of samples will be undertaken at an external facility. The frequency of taking samples needs to be reviewed statistically once there is sufficient information known about the waste feedstream characteristics to make such an exercise meaningful.

B. The sample technique employed for each type of waste will be dependant on whether the sample is taken from the drum or if the waste is tipped out of the drum prior to sampling. If an out of drum technique were to be employed it would require the addition of a sorting table to the Sample Management Area. This is undesirable as it would mean that after sorting/sampling, the waste would have to be repacked into a drum in this area. If a new drum were used there would be the problem of how to dispose of the old drum. If the waste were repacked into the original drum there would be the problem of handling the contaminated drum without spreading the contamination through the area. The addition of a sorting table is also undesirable as it would require significantly more equipment in an area of WRAP 2A which is already tight for space and could have impacts not only on the SMA but on the layout of adjoining areas. Finally, it should be recognized that the prime reason for taking these samples is to confirm that the waste is as described on the accompanying manifest. It is not being taken in order to perform a detailed characterization of the waste. It will be possible to achieve such a confirmation by sampling from the top of the drum. For these reasons only in-drum techniques are considered necessary within the SMA and hence other methods will not be considered further.

C. Dry Particulates: Dry particulates could be sampled using a Thief or a Scoop held by a robotic arm or manipulator. However a scoop could only be used to take a sample from the surface of the drum and therefore may not be representative of the whole drum contents. A Thief would be pushed into the waste before being opened so that the waste would be sampled at varying depths through the drum. Also, if more than one sample point was required, with a Thief it would be possible to take samples from near the center of the drum or at the edge. With a Scoop, all the samples would be from the surface layer of the waste.

RECOMMENDED SAMPLE METHOD: THIEF/MANIPULATOR

D. Wet Particulates (and Sludges): Wet particulates could be sampled using a Trier, Scoop, Auger or a Core Sampler held by a robotic arm or manipulator. Some of the same arguments apply as for dry particulates in that a Scoop could only be used to sample the surface layer of the drum where as a Trier, Auger or a Core Sampler could sample the full depth of the drum at any position on the cross section of the drum. There is little difference between a Trier, Auger and a Core Sampler in terms of obtaining a sample from wet particulates other than when transferring the waste to the sample container. With both the Trier and the Auger the core taken is exposed and hence there is the possibility of waste being dropped from the sampler and contaminating the area. With a Core Sampler the waste is held within the sampler until it is released by opening the sampler.

RECOMMENDED SAMPLE METHOD: CORE SAMPLER/MANIPULATOR

E. Solid Loose Items: It has to be questioned as to why this sample is required. In terms of the stabilization and immobilization processes, the route that each waste will take is clearly defined. The regulations[10] state that the waste shall be inspected and if necessary sampled to determine if it matches the identity specified on the accompanying manifest. For this waste type, a visual inspection should be sufficient to determine if the waste matches the identity specified on the manifest. However, if there is doubt as to the nature of the waste, it should be adequate to take a sample from the top of the drum with manipulators to determine the waste type. For some larger items it may be necessary to cut a piece of the waste as a sample however this would also require the use of the manipulator to hold the cutting device.

RECOMMENDED SAMPLE METHOD: CUTTING DEVICE/MANIPULATOR

F. Solidified Liquids: Solidified liquids could be sampled using either an Auger or a Core Sampler held by a robotic arm or a manipulator or the drum could be sawn into pieces to allow a sample to be taken. Sawing a raw waste drum is undesirable as it would require destruction of the drum. Hence, the waste would have to be repacked before it could be returned to storage to await the sample results. If the sample were taken with a Core Sampler or an Auger, the drum would still be intact and could be returned to storage. Comparing a Core Sampler with an Auger: The major problem which would be encountered with an auger is that it would be unable to cut through any solid items, for example steel bar, that may be in the waste. This would effectively prevent samples being taken from certain WRAP 2A waste product drums. Diamond tipped core drills however would be able to cut through virtually any material held firm in an immobilized product and hence would be ideal for WRAP 2A where the

physical properties of the waste can vary so much. Whether a core sampler or an auger is used it will be necessary to use a lubricant to keep the sample device cool as it is being drilled into the product. There are many lubricants which could be used however the two most common are water and air. Either of these could be used in WRAP 2A. If water were used as the lubricant it could be filtered and recycled and when it requires disposal it could be immobilized in grout. If air were used there would be no secondary wastes other than the dust generated by the drilling process. Hence, the design would have to ensure that the dust was contained and does not contaminate the enclosure. Such a system has been tested successfully by WHC. If sampling is required, a Core Sampler should be used and air should be used as a lubricant.

RECOMMENDED SAMPLE METHOD : CORE SAMPLER

G. These samples will only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. The extent of the characterization required will be determined on a case by case basis.

6.2.3.2 Sample No. 1(b): PFD H-2-140633
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OUTGOING PRODUCT DRUMS
WHERE TO BE SAMPLED	:	WASTE DRUM
REASON FOR SAMPLE	:	CERTIFICATION
SAMPLE FREQUENCY	:	DAILY
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	NOT KNOWN
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The regulatory requirements for certification of outgoing treated wastes and treatment residues are set forth in 40-CFR-268.7[8] and WAC 173-303-140[6]. The requirements vary depending on the waste designation category and the corresponding treatment standard.

B. If the treatment standard is expressed as concentrations in the waste extract (TCLP limits) the certifier must state familiarity with the treatment technology and operation of the treatment process, and must certify that the process has been operated and maintained properly so as to comply with the performance levels specified in 40 CFR 268.7, Subpart D (treatment standards)[8].

C. If the treatment standard is expressed as a technology based standard, the certification must state that the waste has been treated by the required technology, in accordance with the requirements of 40 CFR 268.42 (technology based treatment standards).

D. If the treatment standard is expressed as concentrations in the waste, compliance with the treatment standard must be certified by stating that the hazardous constituents are undetectable or below the regulatory limits.

E. The FDC[11] requires that there is "Capability to extract a representative sample of all treated waste for certification of successful treatment and provide radionuclide data required to support low-level waste category determination assay. At a minimum the capability to sample at least one container in each lot or 10 % of the exiting lot of drums, which ever is greater."

F. Alternatives for sampling the product drum are to use a saw to cut the drum into pieces and then take a sample or to use a Core Sampler or Auger to sample the product or to take a sample of the product before it sets up and while it is still in the grout/polymer immobilization areas. This second alternative has clear advantages over other techniques in that it does not require destruction of the final product.

G. If the product is sampled before it sets up it will be possible to use a Coliwasa, sample cup or a sleeve-in-sleeve device for many of the waste types. Solid items which have been macroencapsulated will be difficult to sample. It may be possible to put a case together for not sampling all vibro-infilled products as macroencapsulation may be a BDAT process for some of the waste streams.

H. If destructive examination of a product drum is required[11] this can be performed in the Box Breakdown Area. However, if a macroencapsulated product requires sampling and it is not wished to destroy the product completely this will have to be carried out with a Core Sampler or an Auger in the SMA.

CONCLUSION

A. There will be no requirement to take product certification samples in the SMA other than to take a sample of a macroencapsulated product.

B. Macroencapsulated product drums could be sampled using either an Auger or a Core Sampler held by a robotic arm or a manipulator. Comparing a Core Sampler with an Auger: The major problem which would be encountered with an auger is that it would be unable to cut through any solid items, for example steel bar, that may be in macroencapsulated product. This would effectively prevent samples being taken from certain WRAP 2A waste product drums. Diamond tipped core drills however would be able to cut through virtually any material held firm in an immobilized product and hence would be ideal for WRAP 2A where the physical properties of the waste can vary so much. Whether a Core Sampler or an Auger is used, it will be necessary to use a lubricant to keep the sample device cool as it is being drilled into the product. There are many lubricants which could be used however the two most common are water and air. Either of these could be used in WRAP 2A. If water were used as the lubricant it could be filtered and recycled and when it requires disposal it could be immobilized in grout. If air were used there would be no secondary wastes other than the dust generated by the drilling process. Hence, the design would have to ensure that the dust was contained and does not contaminate the enclosure. Such a system has been tested successfully by WHC. If sampling is required, a Core Sampler should be used and air should be used as a lubricant.

RECOMMENDED SAMPLE METHOD : CORE SAMPLER

C. This sample is taken for certification purposes. The sample will be tested for one or more of the following criteria:

- Compressive Strength
- Leachability Index
- Biodegradation
- Thermal Cycling
- Radiation Stability
- Immersion
- Free Liquids
- Hazardous Characteristics
- Toxicity Characteristics

D. The ability to destructively examine product drums is a requirement of the FDC. However, the need to do this is unclear if there is the capability to sample the final product. WRAP 2A will have the capability to destructively examine products in the Box Breakdown Area. However, it is recommended that this option is not exercised and the need to provide destructive examination in WRAP 2A is removed from the FDC.

6.2.4 Polymer Encapsulation Samples

6.2.4.1 Sample No. 1: PFD H-2-140621
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	MIXED VES POLYMER
WHERE TO BE SAMPLED	:	POLYMER MIXING TANK (T-05-401)
REASON FOR SAMPLE	:	TO DETERMINE CHEMICAL COMPOSITION
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	886 GAL / DAY
HOLDING VESSEL VOLUME	:	1058 GAL

DISCUSSION OF CDR DATA

A. In this tank the VES resin, extender and promoter will be mixed prior to being transferred to the drum. The plant will be designed so that the agitator used to mix these materials will always produce a homogenous mix within a specified residence time. This will be demonstrated prior to the plant going operational. The polymer composition will be determined using process knowledge. A batch of polymer will contain sufficient binder material to complete one full day's throughput of drums. Depending on when the batch is prepared, the binder may be used over a period of two days. This sample is required to determine if the binder material has started to polymerize and hence the viscosity of the mix has increased to an extent where it is unsuitable for waste infilling. Analysis of the sample viscosity will be performed in the SMA.

B. This material is sampled in the Polymer Mixing Tank (T-05-401). These wastes could be sampled using either the weighted bottle/bomb sampler technique or a Coliwasa or using a pump or by draining some of the liquid from the tank direct into a sample jar through a valved connection.

CONCLUSION

A. The CDR Polymer Encapsulation Sample No. 1 will be required in WRAP 2A.

B. As the polymer raw materials are volatile and toxic, man access into this area will be restricted. However, as this sample will only be required infrequently and man access will be permitted into this area provided suitable protective equipment and breathing apparatus is worn, it is recommended that a simple sampling method is used which will allow the sample to be taken in the area by an operator rather than by some remote technique which may require long lengths of pipework where blockages could occur due to improper cleaning after the sample has been taken. Any of the suggested methods could be used to take this sample. The polymer could be sampled using a Coliwasa or a suitably designed weighted bottle. Alternatively a sample point could be put in the existing pump discharge line. As the polymer system will be flushed routinely with solvent it is unlikely that the polymer will set up in the pipework and block the sample point. If a sample valve were used it would allow the sample to be collected easily and an appropriate sample vessel may be used to send for analysis.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. The sample will be tested for viscosity to confirm that the binder has not started to polymerize.

6.2.4.2 Sample No. 2: PFD H-2-140621
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	HYDROCARBON WASTES
WHERE TO BE SAMPLED	:	HYDROCARBON WASTE TANK (T-05-402)
REASON FOR SAMPLE	:	TO DETERMINE CHEMICAL COMPOSITION
SAMPLE FREQUENCY	:	ONCE PER WEEK
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	TBD
HOLDING VESSEL VOLUME	:	1100 GAL

DISCUSSION OF CDR DATA

A. These wastes arise from the polymer/catalyst/promoter storage tanks and are inactive. In general, these wastes will be diluted using solvent to allow them to be easily removed from the plant. This sample is required for hazardous waste chain-of-custody manifest purposes. A waste sample will be taken and routed through the SMA for analysis at an external facility. This waste stream will be sampled once the normal fill level has been reached. Waste discharge routes to the tank will be interlocked closed during taking of the sample and will remain closed until the tank has been emptied and is ready to accept new waste effluents.

B. These wastes are sampled in the Hydrocarbon Waste Tank (T-05-402). These wastes could be sampled using either the weighted bottle technique or via a sample valve in the process pipework or by draining some of the liquid from the tank through a sample valve.

CONCLUSION

A. The CDR Polymer Encapsulation Sample No. 2 will be required in WRAP 2A.

B. The Weighted Bottle technique is clearly the cheapest in terms of capital cost. However, on safety grounds this alternative is potentially dangerous as they would normally require an operator to come in close contact with the hydrocarbon waste. Even draining from the tank through a specialized sample valve is undesirable as it would require the operator to be close to the tank and hence put him in danger if there were a leak in any part of the system. This waste will be sampled via a sample valve in the process pipework.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. This sample is required to allow the chemical composition to be determined. The waste will be a dilute solution of polymer components in an organic solvent. Information on the chemical composition will be required by the disposal facility prior to accepting the waste.

6.2.4.3 Sample No. 3: PFD H-2-140621
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	MIXED VES POLYMER AND CATALYST
WHERE TO BE SAMPLED	:	IN-LINE MIXERS (M-05-404 THRU 407)
REASON FOR SAMPLE	:	TO CONFIRM SUCCESSFUL MIX
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	AGITATED MIXING - 648 GAL/DAY VIBRO-MIXING - 210 GAL/DAY VACUUM DEWATERING -32 GAL/DAY
MIXING THROUGHPUT	:	5 GAL PER MINUTE

DISCUSSION OF CDR DATA

A. In-line mixers are used to mix the VES resin/extender/promoter with the catalyst prior to being transferred to a drum for vibro-infilling. The system will be designed to provide a homogenous mix. However, use of an in-line mixer for polymers is presently an untested technology and therefore even though the mixer will have been tested prior to installation in the plant it is felt prudent that a sample point is provided so that mixer performance can be monitored against time. For this reason a sample point will be provided. Analysis of sample will take place in the SMA.

B. As these are in-line mixers, the only sample method identified is to use a valve in the pipework downstream of the mixers.

CONCLUSION

A. The CDR Polymer Encapsulation Sample No. 3 will be required in WRAP 2A.

B. The polymer mix will be sampled via a valve in the mixer discharge line.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. This sample will be allowed to set-up and then will be tested for compressive strength to assess if complete mixing is occurring.

6.2.4.4 Sample No. 4: PFD H-2-140621
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	WATER FROM ION EXCHANGE DEWATERING OR ENCAPSULATION BLEED LIQUOR
WHERE TO BE SAMPLED	:	LIQUOR CATCH DRUM (V-05-401)
REASON FOR SAMPLE	:	TO DETERMINE ACTIVITY AND CHEMICAL COMPOSITION
SAMPLE FREQUENCY	:	ONCE PER DAY
WHERE ANALYZED	:	SAMPLE MANAGEMENT AREA
MATERIAL THROUGHPUT	:	65 GAL / DAY
HOLDING VESSEL VOLUME	:	70 GAL

DISCUSSION OF CDR DATA

A. As this waste has only one disposal route and that is to the Active Waste Collection Tank, T-07-201, where it will be combined with other wastes, the sampling of this waste at this location serves no purpose in terms of providing an analysis which could be used for determining the characterization of the immobilized product from this waste. One reason for taking this sample would be to determine if the waste has to be designated as a hazardous waste stream and treated accordingly prior to land disposal, however, this information could be determined by using the initial waste characterization data and process knowledge[9]. This would eliminate the need to take this sample for the reasons identified in the CDR[5].

B. One possibility not identified in the CDR is that this liquor could be a mixture of organic materials, for example Styrene, in which case the liquor should not be discharged to the Active Waste Collection Tank. An alternative discharge route from the Liquor Catch Drum should be provided so that organic liquors can be routed to the Hydrocarbon Waste Tank (T-05-402). Hence a sample point will be required so that the routing of the waste can be determined. Analysis of the sample will take place in the SMA.

C. In order to allow this liquor to be sampled prior to it being discharged from the Liquor Catch Drum a recirculation loop will have to be included in the design. This will allow the liquor to be pumped to a sample point and recirculated back to the vessel.

CONCLUSION

A. Polymer Encapsulation Sample No. 4 will not be taken for the reasons given in the CDR. However, a sample will be required to determine if the waste liquor is organic, aqueous or a combination of both (in which case the relative quantities of organic material vs. aqueous liquor will need to be known to determine the most appropriate routing for this waste).

B. The CDR design for this part of the plant will need to be revised to incorporate a route to the Hydrocarbon Waste Tank and a recirculation line for the Liquor Catch Drum. Only one sample technique has been identified to collect this material and that is to use a sample point in the recirculation pipework of the Liquor Catch Drum.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. This sample is required to determine the composition of the bleed liquor. This does not need to be a detailed analysis as it will only be used to determine the routing of the liquor i.e. either to the Hydrocarbon Waste Tank or to the Active Liquor Collection Tank.

6.2.4.5 Sample No. 5: PFD H-2-140621
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	VES/WASTE PRODUCT
WHERE TO BE SAMPLED	:	PRODUCT DRUM
REASON FOR SAMPLE	:	CERTIFICATION OF THE PRODUCT
SAMPLE FREQUENCY	:	ONCE PER DRUM
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	236.8 Cu Ft / DAY (37 DRUMS / DAY)
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The regulatory and FDC requirements for certification of treated waste product is detailed in the discussion section of SMA Sample 1(b). Agitated product drums may be sampled for certification purposes in this area. The product could be sampled prior to curing by using a Coliwasa, a sample cup or a sleeve-in-sleeve device. Macroencapsulated products are discussed under SMA Sample 1(b). Analysis of samples will take place at an external facility.

CONCLUSION

A. In order to comply with the FDC, WRAP 2A will have the capability to take samples from agitated product drums in the Polymer Encapsulation Area. The frequency of taking samples needs to be reviewed statistically once there is sufficient data about the waste feedstream characteristics to make such an exercise meaningful.

B. It is recommended that samples of agitated waste products are either taken in the Polymer Encapsulation Area before the product sets up or that a sleeve-in-sleeve device is used so that the sample can be easily extracted once the product has set-up. As the product will be completely homogenized prior to the sample being taken, any of the suggested sample methods would be acceptable. However, in terms of minimizing the risk of contaminating equipment in the polymer encapsulation area the sleeve-in-sleeve method is preferred as it does not require the sample to be extracted until the product has set-up where as the other techniques require the sample to be extracted while the binder is still fluid where there is the risk of dripping waste/binder material onto equipment. Another reason why the sleeve-in-sleeve device is preferable is that the sample can be extracted from the product off-line. Hence there will be no implications on throughput. The other samples would need to be extracted while the product drum was positioned at the mixing station.

RECOMMENDED SAMPLE METHOD: SLEEVE-IN-SLEEVE

C. This sample is taken for certification purposes. The sample will be tested for one or more of the following criteria:

- Compressive Strength
- Leachability Index
- Biodegradation
- Thermal Cycling
- Radiation Stability
- Immersion
- Free Liquids
- Hazardous Characteristics
- Toxicity Characteristics

6.2.4.6 Sample No. 6: PFD H-2-140620
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	VES PROMOTER
WHERE TO BE SAMPLED	:	STORAGE TANK (T-05-304)
REASON FOR SAMPLE	:	QC AND TO CHECK FOR PREMATURE POLYMERIZATION
SAMPLE FREQUENCY	:	ONCE PER WEEK
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	5 GAL / DAY
HOLDING VESSEL VOLUME	:	140 GAL

DISCUSSION OF CDR DATA

A. The onus for demonstrating that the VES promoter meets quality control standards when it is delivered will be placed on the supplier who should provide quality assurance documentation. However, this promoter is stable and will not degrade unless heated. This promoter will not self polymerize as suggested in the CDR. If the promoter is kept in sealed drums in a temperature controlled environment it can be kept for years without degrading[12,13]. If the promoter is exposed to air its reactivity will not change with time though it will darken in color. Consequently there should be no reason to sample this promoter on a routine basis if the promoter storage temperature is carefully controlled. However, the current CDR design shows that this material will be stored outside with a sun roof for protection. The maximum ambient temperature on the Hanford site can be in excess of 100° F. At these temperatures the promoter would quickly start to degrade. It is recommended therefore that the CDR design of the storage facilities for this material be re-examined so that its temperature can be carefully controlled. If process problems occur during operation of the plant and it is suspected that the VES promoter may be the cause of the problems or if the temperature of the storage facilities is allowed to rise it may be necessary to take a sample. For this reason a sample point will be provided. Analysis of samples will take place in the SMA.

B. These wastes are sampled in the Promotor Storage Tank (T-05-304). These wastes could be sampled using either the weighted bottle technique or via a sample valve in the process pipework or by draining some of the liquid from the tank via a sample valve.

CONCLUSION

A. The CDR Polymer Encapsulation Sample No. 6 will be required in WRAP 2A.

B. The Weighted Bottle technique is clearly the cheapest in terms of capital cost, followed by draining direct from the tank or taking a sample from a sample valve on the existing pump discharge. On safety grounds all these alternatives are potentially dangerous as they would normally require an operator to come in close contact with the VES Promoter. However, this tank is in a well ventilated area and operator access to this area will normally be required when deliveries of raw materials are made. Of the suggested sample methods the preferred method is to take a sample from a sample valve in the process pipework. If the weighted bottle technique were used it would require the operator to be on a platform above the tank which would expose him to any fumes rising from the tank and if he were affected by fumes would make his escape from the vicinity of the tank difficult. Draining direct from the tank could be problematic as the sample line may have the tendency to block and there may be insufficient head in the tank to clear the blockage. This would expose the operator to further risk in trying to unblock the sample line.

RECOMMENDED SAMPLE METHOD : SAMPLE VALVE IN PIPEWORK

C. The VES promoter has a long shelf life if kept at the correct temperature and is unlikely to start to decompose in the timeframe that it is held in WRAP 2A, however, samples may be taken in order to produce a test VES product and confirm that the promoter has not started to decompose.

6.2.4.7 Sample No. 7: PFD H-2-140620
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	VES CATALYST
WHERE TO BE SAMPLED	:	STORAGE TANK (T-05-303)
REASON FOR SAMPLE	:	QC AND TO CHECK FOR PREMATURE POLYMERIZATION
SAMPLE FREQUENCY	:	ONCE PER WEEK
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	5 GAL PER WEEK
HOLDING VESSEL VOLUME	:	140 GAL

DISCUSSION OF CDR DATA

A. The onus for demonstrating that the VES catalyst meets quality control standards when it is delivered will be placed on the supplier who should provide quality assurance documentation. However, this material has a limited shelf life after which it will start to degrade. This material will not self polymerize as suggested in the CDR. Provided that the catalyst is kept in sealed drums in a temperature controlled environment and is used within the timeframe of its working life (Note: AKZO Chemicals provide a guarantee of quality of 3 months following delivery, however the catalyst should not start to degrade within the first 12 months following delivery[14,15] there should be no requirement to sample this material on a routine basis. However, the current CDR design shows that this material will be stored outside with a sun roof for protection. The maximum ambient temperature on the Hanford site can be in excess of 100° F. At these temperatures the catalyst would quickly start to degrade. It is recommended therefore that the CDR design of the storage facilities for this material be re-examined so that its temperature can be carefully controlled. If process problems occur during operation of the plant and it is suspected that the VES catalyst may be the cause of the problems or if the temperature of the storage facilities is allowed to rise it may be necessary to take a sample. For this reason a sample point will be provided. Samples will be analyzed for their active oxygen content[16] in the SMA.

B. These wastes are sampled in the Catalyst Storage Tank (T-05-303). These wastes could be sampled using either the weighted bottle technique or by pumping to a sample point or by draining some of the liquid from the tank via a sample valve.

CONCLUSION

A. The CDR Polymer Encapsulation Sample No. 7 will be required in WRAP 2A.

B. The Weighted Bottle technique is clearly the cheapest in terms of capital cost, followed by draining direct from the tank or taking a sample from a tap-in point on the existing pump discharge. On safety grounds all these alternatives are potentially dangerous as they would normally require an operator to come in close contact with the VES catalyst. However, this tank is in a well ventilated area and operator access to this area will normally be required when deliveries of raw materials are made. Of the suggested sample methods the preferred method is to take a sample from a valve in the process pipework. If the weighted bottle technique were used it would require the operator to be on a platform above the tank which would expose him to any fumes rising from the tank and if he were affected by fumes would make his escape from the vicinity of the tank difficult. Draining direct from the tank could be problematic as the sample line may have the tendency to block and there may be insufficient head in the tank to clear the blockage. This would expose the operator to further risk in trying to unblock the sample line.

RECOMMENDED SAMPLE METHOD: PUMP TO SAMPLE VALVE

C. The VES catalyst has a long shelf life if kept at the correct temperature and is unlikely to start to decompose in the timeframe that it is held in WRAP 2A, however, samples may be taken in order to test for active oxygen content of the material[16].

6.2.4.8 Sample No. 8: PFD H-2-140620
BFD H-2-140619

CDR DATA

MATERIAL TO BE SAMPLED	:	VES RESIN
WHERE TO BE SAMPLED	:	STORAGE TANKS (T-05-305 A,B)
REASON FOR SAMPLE	:	QC AND TO CHECK FOR PREMATURE POLYMERIZATION
SAMPLE FREQUENCY	:	ONCE PER WEEK
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	815 GAL / DAY
HOLDING VESSEL VOLUME	:	2 X 5900 GAL

DISCUSSION OF CDR DATA

A. The onus for demonstrating that the VES resin meets quality control standards when it is delivered will be placed on the supplier who should provide quality assurance documentation. However, this material has a limited shelf life (3 months) after which it will start to polymerize[17]. Consequently, care will be required when ordering supplies of this material to ensure that it will be used within the timeframe of its working life. In the CDR two 5900 gal tanks are identified for the storage of VES resin and the throughput of resin for the process is approximately 800 gal per day. Hence, WRAP 2A has sufficient storage capacity for approximately 15 days operation (3 weeks assuming a 5 day week). Consequently, there should be no requirement to sample this material on a routine basis. However, the outside storage of VES resin could expose the resin to temperatures in excess of 100°F, and may cause degradation of the resin. For this reason, the CDR design of the storage facility (under a sunroof) should be re-examined. If process problems occur during operation of the plant and it is suspected that the VES resin may be the cause of the problems it may be necessary to take a sample. For this reason a sample point will be provided. Analysis of samples will take place in the SMA.

B. These wastes are sampled in the Resin Storage Tank (T-05-305 A, B). These wastes could be sampled using either the weighted bottle technique or using a sample valve in the process pipework or by draining some of the liquid from the tank direct into a sample jar through a valved connection.

CONCLUSION

A. The CDR Polymer Encapsulation Sample No. 8 will be required in WRAP 2A.

B. The Weighted Bottle technique is clearly the cheapest in terms of capital cost, followed by draining direct from the tank or taking a sample from a valve in the process pipework. On safety grounds all these alternatives are potentially dangerous as they would normally require an operator to come in close contact with the VES resin. However, this tank is in a well ventilated area and operator access to this area will normally be required when deliveries of raw materials are made. Of the suggested sample methods the preferred method is to take a sample from a valve in the process pipework. If the weighted bottle technique were used it would require the operator to be on a platform above the tank which would expose him to any fumes rising from the tank and if he were affected by fumes would make his escape from the vicinity of the tank difficult. Draining direct from the tank could be problematic as the sample line may have the tendency to block and there may be insufficient head in the tank to clear the blockage. This would expose the operator to further risk in trying to unblock the sample line.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. VES resin has a reasonable shelf life if kept at the correct temperature and is unlikely to start to polymerize in the timeframe that it is held as a raw material in WRAP 2A. However, it will be possible to do a visual check if polymerization has started to occur as polymer strands will form in the liquid. No further testing should be necessary.

6.2.5 Grout Immobilization Samples

6.2.5.1 Sample No. 1: PFD H-2-140607
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	BFS, OPC, PFA AND GROUT ADDITIVE
WHERE TO BE SAMPLED	:	STORAGE SILOS (T-05-101 THRU 104)
REASON FOR SAMPLE	:	QUALITY CONTROL
SAMPLE FREQUENCY	:	ONCE PER MONTH PER SILO
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	OPC - 4.1 Cu Ft/DAY BFS - 21.7 Cu Ft/DAY PFA & ADDITIVE - NOT KNOWN
HOLDING VESSEL VOLUME	:	T-05-101 (ADD) - 1140 Cu Ft T-05-102 (PFA) - 5250 Cu Ft T-05-103 (BFS) - 5250 Cu Ft T-05-104 (OPC) - 1140 Cu Ft

DISCUSSION OF CDR DATA

A. Certification that the grout bulk raw materials meet quality control requirements when delivered will be placed on the supplier. If process problems occur during operation of the plant and it is suspected that the grout raw materials may be the cause of the problems or if raw materials have been held in the silos for a long period due to the plant being shut down for maintenance it may be necessary to take a sample. For this reason a sample point will be provided. Due to the low frequency of taking a sample and the extensive analytical equipment required to determine the physical and chemical properties of the grout raw materials, analysis of the sample will be performed at an external facility.

B. These powders could be sampled directly from the silos using a thief or a tap-in point could be put in the screw feeder off the bottom of each silo.

CONCLUSION

A. The CDR Grout Immobilization Sample No. 1 will be required in WRAP 2A.

B. These materials could be sampled using a thief direct from the silos or by taking a sample from the screw feeder when the powder is being transferred. Using a thief would require the manhole to be opened on the top of the silo; this is not desirable as it would be a time consuming activity and, if the weather were bad, would result in the grout powders becoming wet and setting up prematurely. If a sample point were put in the screw conveyor at the base of the silo the operator could easily and quickly take a sample when powder was being transferred. If it was decided to take a sample when powder transfer to the plant was not required, it would be possible to remove a spool piece from the pipework after the screw feeder and feed the powder into bags or a collection vessel.

RECOMMENDED SAMPLE METHOD: DIRECT FROM SCREW FEEDER

C. Samples of grout powders will be analyzed to confirm that they comply with the purchasing requisition specifications and the following ASTM specifications:

- C989 - Ground Granulated Blast Furnace Slag
- C618 - Pulverized Fly Ash
- C150 - Type I/II Portland Cement

6.2.5.2 Sample No. 2: PFD H-2-140607
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	POLYMER ADDITIVE
WHERE TO BE SAMPLED	:	RAW MATERIAL DRUM
REASON FOR SAMPLE	:	QUALITY CONTROL
SAMPLE FREQUENCY	:	ONCE PER MONTH
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	TBD
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The ability to mix a polymer modified grout was included in the CDR because of the uncertainty as to whether grout only and VES only binders could successfully immobilize all WRAP 2A feedstreams at high waste loadings. The type of polymer additive was not specified. However, it may be assumed that if a polymer additive is required that the problems associated with storage of this material will be the same as for VES resin (Polymer Encapsulation Sample No. 8) and hence the sampling requirements will be the same.

B. It is assumed that this material will have similar properties to VES resin and therefore the sample techniques available will be the same i.e. weighted bottle, pump or draining direct from the tank.

CONCLUSION

A. The CDR Grout Immobilization Sample No. 2 will be required in WRAP 2A.

B. The Weighted Bottle technique is clearly the cheapest in terms of capital cost, followed by draining direct from the tank or taking a sample from a valve in the process pipework. On safety grounds all these alternatives are potentially dangerous as they would normally require an operator to come in close contact with the polymer additive. However, this tank is in a well ventilated area and operator access to this area will normally be required when deliveries of raw materials are made. Of the suggested sample methods the preferred method is to take a sample from a valve in the process pipework. If the weighted bottle technique were used it would require the operator to be on a platform above the tank which would expose him to any fumes rising from the tank and if he were affected by fumes would make his escape from the vicinity of the tank difficult. Draining direct from the tank could be problematic as the sample line may have the tendency to block and there may be insufficient head in the tank to clear the blockage. This would expose the operator to further risk in trying to unblock the sample line.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. It is assumed that this material will be similar in nature to VES resin (Polymer Encapsulation Sample No.8) and will therefore require similar analysis.

6.2.5.3 Sample No. 3: PFD H-2-140608/609
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	OPC, BFS, PFA AND POWDER BLENDS
WHERE TO BE SAMPLED	:	SILOS/WEIGH HOPPERS (T-05-201 THRU 211)
REASON FOR SAMPLE	:	QUALITY CONTROL
SAMPLE FREQUENCY	:	TEN PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	4.1 Cu Ft/DAY OPC 21.7 Cu Ft/DAY BFS PFA ETC. UNKNOWN
HOLDING VESSEL VOLUME	:	65 Cu Ft OPC SILOS 170 Cu Ft BFS AND PFA SILOS 20 Cu Ft WEIGH HOPPERS

DISCUSSION OF CDR DATA

A. It should not be necessary to take samples to confirm the quality control of powders within the process. Process control will ensure that the correct amounts of powder are transferred from the bulk storage silos to downstream vessels and it should be demonstrated on test equipment that the process control is within the required tolerances for product quality.

CONCLUSION

A. The CDR Grout Immobilization Sample No. 3 will not be required in WRAP 2A and will not be considered further in this study.

6.2.5.4 Sample No. 4: PFD H-2-140608
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	LIQUID GROUT
WHERE TO BE SAMPLED	:	WET GROUT MIXING TANK (T-05-212)
REASON FOR SAMPLE	:	QUALITY CONTROL
SAMPLE FREQUENCY	:	TEN PER DAY
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	27.9 Cu Ft / DAY
HOLDING VESSEL VOLUME	:	8 Cu Ft

DISCUSSION OF CDR DATA

A. It should not be necessary to sample this material to determine if the correct amount of each binder component has been delivered to the mixing tank as the process control features should ensure the correct mix is achieved. A simple check on viscosity will confirm that mixing is progressing as required and that the fluidity of the grout is within the parameters required for vibro-infilling. The viscosity check would need to be undertaken at source as the grout will start to gel once recirculation in the mixer is stopped. In-line viscosity measurement is not recommended as the instrument is difficult to clean fully between batches of grout and hence will fail or become inaccurate due to grout build-up. If confirmation of the cured grout properties is required it will be relatively simple to take a sample of the grout for archive purposes; analysis of the sample would not be for process control purposes. Analysis of the cured sample will take place in the SMA.

B. Liquid grout is prepared by mixing cement powders with water in tank T-05-212. Once a liquid grout has been produced, it is kept fluid by recycling through a pump and back into the mixing tank. The liquid grout could be sampled directly from the mixing tank using a Coliwasa or a sample valve in the grout recirculation line could be used.

CONCLUSION

A. The CDR Grout Immobilization Sample No. 4 will be required in WRAP 2A.

B. The liquid grout could be sampled using a Coliwasa or alternatively a sample point could be put in the grout recycle line. As the whole of the grout system including the sample point will be flushed with water following grout preparation it will be possible to use the tap in point without the concern of whether the grout will set up in the pipework and block the sample point. If the tap-in point were used it would allow the sample to be collected easily and an appropriate sample vessel may be used which could also act as the mould for the grout to set up in, or as the vessel for determination of the viscosity.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. This sample will be tested for viscosity and then, if required, allowed to cure. The cured product will be tested for compressive strength.

6.2.5.5 Sample No. 5: PFD H-2-140608
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	MACROENCAPSULATED PRODUCT
WHERE TO BE SAMPLED	:	PRODUCT DRUM
REASON FOR SAMPLE	:	CERTIFICATION OF THE PRODUCT
SAMPLE FREQUENCY	:	ONCE PER LOT
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	55.7 Cu Ft / DAY (8.32 DRUMS / DAY)
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The regulatory and FDC requirements for certification of treated waste product is detailed in the discussion section of SMA Sample No. 1(b). Macroencapsulated products could not be representatively sampled in the Grout Immobilization Area. Sampling of macroencapsulated products is discussed under SMA Sample 1(b).

CONCLUSION

A. In order to comply with the FDC, WRAP 2A will have the capability to destructively examine macroencapsulated products in the Box Breakdown Area or to take a core sample in the SMA. Sampling of macroencapsulated products in the Grout Immobilization Area will not be considered further in this study.

6.2.5.5 Sample No. 6: PFD H-2-140609
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	AGITATED GROUT PRODUCT
WHERE TO BE SAMPLED	:	PRODUCT DRUM
REASON FOR SAMPLE	:	CERTIFICATION OF THE PRODUCT
SAMPLE FREQUENCY	:	ONCE PER LOT
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	66 Cu Ft / DAY (9.34 DRUMS / DAY)
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The regulatory and FDC requirements for certification of treated waste product is detailed in the discussion section of SMA Sample No. 1(b). Product drums may be sampled prior to curing by using a Coliwasa, a sample cup or a sleeve-in-sleeve device. Analysis of samples will take place at an external facility.

CONCLUSION

A. In order to comply with the FDC, WRAP 2A will have the capability to take samples from agitated product drums in the drum mixing area. The frequency of taking samples needs to be reviewed statistically once there is sufficient data about the waste feedstream characteristics to make such an exercise meaningful.

B. It is recommended that samples of agitated waste products are either taken in the Grout Immobilization Area before the product sets up or that a sleeve-in-sleeve device is used so that the sample can be easily extracted once the product has set-up. As the product will be completely homogenized prior to the sample being taken, any of the suggested sample methods would be acceptable. However, in terms of minimizing the risk of contaminating equipment in the polymer encapsulation area the sleeve-in-sleeve method is preferred as it does not require the sample to be extracted until the product has set-up where as the other techniques require the sample to be extracted whilst the binder is still fluid where there is the risk of dripping waste/binder material onto equipment. Another reason why the sleeve-in-sleeve device is preferable is that the sample can be extracted from the product off-line. Hence there will be no implications on throughput. The other samples would need to be extracted whilst the product drum was positioned at the mixing station.

RECOMMENDED SAMPLE METHOD: SLEEVE-IN-SLEEVE

C. This sample is taken for certification purposes. The sample will be tested for one or more of the following criteria:

- Compressive Strength
- Leachability Index
- Biodegradation
- Thermal Cycling
- Radiation Stability
- Immersion
- Free Liquids
- Hazardous Characteristics
- Toxicity Characteristics

6.2.5.7 Sample No. 7: PFD H-2-140609
BFD H-2-140606

CDR DATA

MATERIAL TO BE SAMPLED	:	BLEED WATER FROM GROUTED PRODUCT
WHERE TO BE SAMPLED	:	DISCHARGE LINE FROM PUMP P-05-203
REASON FOR SAMPLE	:	TO DETERMINE RADIONUCLIDE INVENTORY
SAMPLE FREQUENCY	:	ONCE PER MONTH
WHERE ANALYZED	:	SAMPLE MANAGEMENT AREA
MATERIAL THROUGHPUT	:	UNKNOWN
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. Under normal process conditions the grouting formulations used in WRAP 2A should not produce any bleed water on the final product. If WRAP 2A does produce grouted products which routinely has bleed water on the surface of the product, this is an indication of the wrong grout formulations or wrong waste loadings being used and the plant should cease operation until these problems are resolved. On an infrequent basis an abnormal product may be produced, as a result of adding insufficient grout to the waste for instance, under these circumstances it may be assumed that the bleed water has the same properties and constituents as the original waste and therefore does not need to be sampled in order to categorize it. If a 'normal' product is produced which has bleed water on the surface, the amount of liquid is likely to be so low that it will be impossible to remove the liquor from the drum and transfer it to the Active Waste Collection Tank, T-07-201. Under these circumstances it would be better to let the drum stand in the cure area until the bleed water has evaporated (Note: the hydration temperature of the drum and the surrounding temperature in the cure area will assist evaporation).

B. Assuming that the capability to remove bleed water from a drum is retained as currently identified in the CDR (i.e. a dedicated abnormal product station is not provided in the facility) this waste has only one disposal route and that is to the Active Waste Collection Tank, T-07-201, where it will be combined with other wastes. The waste designation will be known through process knowledge.In order to determine the waste characterization for the final product, the waste must be in its final form prior to immobilization, hence sampling upstream of the Active Waste Collection Tank will be meaningless.

CONCLUSION

A. The CDR Grout Immobilization Sample No. 7 will not be required in WRAP 2A and will not be considered further in this study.

6.2.6 Secondary Waste Samples

6.2.6.1 Sample No. 1: PFD H-2-140659
BFD H-2-140657

CDR DATA

MATERIAL TO BE SAMPLED	:	NON-ACTIVE AQUEOUS WASTE
WHERE TO BE SAMPLED	:	COLLECTION TANKS (T-07-101 A,B)
REASON FOR SAMPLE	:	TO DETERMINE CHEMICAL COMPOSITION
SAMPLE FREQUENCY	:	ONCE EVERY TWO MONTHS
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	5 GAL / DAY
HOLDING VESSEL VOLUME	:	500 GAL EACH

DISCUSSION OF CDR DATA

A. This waste consists mainly of aqueous make-up system flushes and air compressor condensate. The CDR shows that analysis is required to characterize the waste to determine whether it is suitable for recycle to grout make-up or whether it requires disposal. This analysis is shown as being undertaken in the SMA, however the CDR PFDs show that this waste should be fully characterized to confirm that it contains no hazardous or radioactive material: such an analysis could not be performed in the SMA without the provision of a mass spectrometer. The need to determine a detailed characterization of this waste has to be questioned as there is no possible route identified in the CDR where this waste could be contaminated with either hazardous or radioactive material. Consequently it is recommended that this sample is only analyzed for pH to allow the waste to be neutralized and reused as a feed to grout preparation. The pH analysis could be undertaken in the SMA. This waste stream will be sampled once the normal fill level has been reached. Waste discharge routes to the tank will be interlocked closed during taking of the sample and will remain closed until the tank has been emptied and is ready to accept waste.

B. This sample will be taken directly from the collection tanks (T-07-101 A, B). This waste will be predominantly water with potentially a small amount of contamination and will be sampled using either the weighted bottle technique or via a valve in the process pipework or by draining some of the liquid from the tank via a sample tap-in point.

CONCLUSION

A. The CDR Secondary Waste Sample No. 1 will be required in WRAP 2A.

B. The Weighted Bottle technique is clearly the cheapest in terms of capital cost, followed by draining direct from the tank or taking a sample from a valve in the process pipework. Operator access to this area is unrestricted. Of the suggested sample methods the preferred method is to take a sample from a valve in the process pipework. If the weighted bottle technique were used it would require a platform to be constructed above the tank to allow the operator to lower the bottle into the waste. This is less desirable on safety grounds than other techniques which will allow the operator to take the sample from the ground. Draining direct from the tank could be problematic as the sample line may have the tendency to block and there may be insufficient head in the tank to clear the blockage. This would expose the operator to further risk in trying to unblock the sample line.

RECOMMENDED SAMPLE METHOD: SAMPLE VALVE IN PIPEWORK

C. This waste will be sampled to determine if it is contaminated with any hazardous material. Potential contaminants of this waste stream have yet to be identified. Analysis for pH will be done in the SMA.

6.2.6.2 Sample No. 2: PFD H-2-140659
BFD H-2-140657

CDR DATA

MATERIAL TO BE SAMPLED	:	ACTIVE AQUEOUS WASTE
WHERE TO BE SAMPLED	:	COLLECTION TANK (T-07-201)
REASON FOR SAMPLE	:	TO DETERMINE RADIONUCLIDE INVENTORY
SAMPLE FREQUENCY	:	ONCE EVERY TWO MONTHS
WHERE ANALYZED	:	SAMPLE MANAGEMENT AREA
MATERIAL THROUGHPUT	:	160 GAL / DAY
HOLDING VESSEL VOLUME	:	10,000 GAL

DISCUSSION OF CDR DATA

A. This waste consists of aqueous wastes from immobilization processes, special waste treatment, decontamination/wash down processes, HVAC and other miscellaneous wastes. No wastes are generated in this tank and therefore the waste designation for the effluents in this tank will already be known based on the source of the feeds to this tank. Analysis is required to characterize the effluent prior to immobilization. However, prior to immobilization this waste undergoes treatment in the Treated Active Waste Tank where it is sampled, neutralized and then resampled. Consequently any sample results from the Active Waste Collection Tank would be meaningless.

CONCLUSION

A. The CDR Secondary Waste Sample No. 2 will not be required in WRAP 2A and will not be considered further in this study.

6.2.6.3 Sample No. 3: PFD H-2-140659
BFD H-2-140657

CDR DATA

MATERIAL TO BE SAMPLED	:	TREATED ACTIVE WASTE
WHERE TO BE SAMPLED	:	COLLECTION TANK (T-07-202)
REASON FOR SAMPLE	:	TO DETERMINE RADIONUCLIDE INVENTORY
SAMPLE FREQUENCY	:	ONCE EVERY TWO MONTHS
WHERE ANALYZED	:	SAMPLE MANAGEMENT AREA
MATERIAL THROUGHPUT	:	161 GAL /.DAY
HOLDING VESSEL VOLUME	:	3000 GAL

DISCUSSION OF CDR DATA

A. This analysis is required to characterize the waste to determine whether or not the waste should be immobilized in WRAP 2A or whether it should be sent for off site disposal. For those wastes which require encapsulation the pH of the waste will have to be determined and the waste neutralized prior to immobilization. All of this analysis is shown in the CDR as being undertaken in the SMA, however, the detailed characterization analysis required will need to be performed at an external facility. This waste stream will be sampled once the normal fill level has been reached. Waste discharge routes to the tank will be interlocked closed during taking of the sample and will remain closed until the tank has been emptied and is ready to accept waste.

B. This sample will be taken directly from the collection tank (T-07-202). This waste will be predominantly water with potentially a small amount of contamination and will be sampled using either the weighted bottle technique or via a sample valve in the process pipework or by draining some of the liquid from the tank via a sample valve.

CONCLUSION

A. The CDR Secondary Waste Sample No. 3 will be required in WRAP 2A.

B. Although there is man access to this area, access is restricted and therefore should not be used for taking routine samples. Consequently on safety grounds the weighted bottle and draining direct from the tank alternatives are not desirable as they would normally require an operator to enter the potentially active area. Hence, the preferred alternative is to take the sample via a valve in the process pipework.

RECOMMENDED SAMPLE METHOD : SAMPLE VALVE IN PIPEWORK

C. This sample will be taken to fully characterize the waste and to confirm that the pH is within acceptable limits for immobilization in grout. The waste will be analyzed for both its chemical and radiochemical compositions.

6.2.7 Box Breakdown Samples

6.2.7.1 Sample No. 1: PFD H-2-140628 SHT 2
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	LEAD, 183H BASIN MISC. CLEAN-UP WASTE AND HEPA FILTERS
WHERE TO BE SAMPLED	:	BOX BREAKDOWN AND REPACK CELL
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER MONTH
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	0.01 BOX/110 GAL DRUMS PER DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. This sample is additional to the lot verification sample (Sample No. 2 below) and as such will not normally be required to be taken. However, in the event that a poorly characterized waste is accepted into the plant, it will be possible to sample at this point rather than repacking a drum and sending it to the SMA.

CONCLUSION

A. The CDR Box Breakdown Sample No. 1 is the same as Box Breakdown Sample No.2 and therefore will not be considered further in this study.

6.2.7.2 Sample No. 2: PFD H-2-140628 SHT 2
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	LEAD, 183H BASIN MISC. CLEAN-UP WASTE AND HEPA FILTERS
WHERE TO BE SAMPLED	:	BOX BREAKDOWN AND REPACK CELL
REASON FOR SAMPLE	:	LOT VERIFICATION
SAMPLE FREQUENCY	:	ONCE PER LOT
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	0.01 BOX/110 GAL DRUMS PER DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The regulatory and FDC requirements for lot verification of incoming waste and certification of treated waste product is detailed in the discussion sections of SMA Sample Nos. 1(a) and 1(b).

B. Boxes and drums of waste brought into this area contain solid material and will be broken down using manipulators. The size reduced waste will then be placed in new 55 gallon drums for immobilization. In the CDR the intent is that if lot verification is required that one of the "new" drums is sent to the Sample Management Area for this purpose. However, if required, a sample could be taken from the broken down box/drum using the manipulator in this area and placed in a sample bottle and transferred for analysis using a purged port bagless transfer system. This would remove the need to send the "new" drum to the SMA. No other sample techniques are identified for this waste.

C. Product drums which are to be destructively examined will be treated in the same manner as solidified waste. Material not required for the sample will be recycled back through the immobilization process.

CONCLUSION

A. Lot verification of these wastes should be routinely carried out by visual examination in the Box Breakdown Area. Only if there appears to be a discrepancy between the appearance of the waste and the waste characterization accompanying the drum should a sample be taken. The waste should then be repacked into a new drum and sent back to storage. This waste drum would then be treated as a reject from the incoming lot and would be dealt with as a new lot of one drum. Following analysis of the sample if it is decided that more drums from the lot need to be sampled, the sampling should still be carried out in the Box Breakdown Area unless the number of drums to be sampled is sufficiently large as to affect the throughput of other drums/boxes in the Box Breakdown Area. In which case the sampling would have to be done in the SMA with a Core Sampler. Analysis of samples will take place at an external facility. The frequency of taking samples needs to be reviewed statistically once there is sufficient known about the waste feedstream characteristics to make such an exercise meaningful.

B. Only one sample technique has been identified for this area and that is to use manipulators to place pieces of solid waste into a sample jar and transfer to analysis using a purge port bagless transfer system.

RECOMMENDED SAMPLE METHOD: MANIPULATORS

C. Lot verification samples will only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. The extent of the characterization required will be determined on a case by case basis.

D. Samples taken for certification purposes will be tested for one or more of the following criteria:

- Compressive Strength
- Leachability Index
- Biodegradation
- Thermal Cycling
- Radiation Stability
- Immersion
- Free Liquids
- Hazardous Characteristics
- Toxicity Characteristics

6.2.8 Size Reduction and Repack

6.2.8.1 Sample No. 1: PFD H-2-140628 SHT 1
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	FEEDSTREAMS 1A, 1D, 2D, 3, 4 AND 5D
WHERE TO BE SAMPLED	:	SHREDDER/REPACK ENCLOSURE (GB-05-521) (SORTING/TIPPING TABLE ST-05-521 A)
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER MONTH
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	30.6 RAW WASTE DRUMS / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. As discussed under Sample Management Area Sample No. 1(a), this sample point should be used for lot verification. In the event that the waste does not appear to have the same characteristics as described on the accompanying paperwork when examined visually, the waste should be sampled and then repacked into a 55 gallon drum and returned to storage whilst the results of the sample analysis are processed. This waste drum would then be treated as a reject from the incoming lot and would be dealt with as a new lot of one drum. Analysis of samples will take place at an external facility.

B. Wastes which are well characterized will be brought straight into this area and tipped onto the sorting table. If the waste does not appear to comply with the waste description accompanying the drum a sample could be taken using the manipulator in this area and placed in a sample bottle and transferred for analysis using a purged port bagless transfer system. No other sample techniques are identified for this waste.

CONCLUSION

A. The CDR Size Reduction and Repack Sample No. 1 will be required in WRAP 2A.

B. Manipulators shall be used to place pieces of solid waste into a sample jar and transfer to analysis using a purge port bagless transfer system.

RECOMMENDED SAMPLE METHOD: MANIPULATORS

C. Lot verification samples will only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. The extent of the characterization required will be determined on a case by case basis.

6.2.8.2 Sample No. 2: PFD H-2-140628 SHT 1
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	FEEDSTREAMS 1B, 1C AND 6
WHERE TO BE SAMPLED	:	PUG MILL (GB-05-541) (SORTING TABLE ST-05-541)
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER MONTH
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	6.72 PRODUCT DRUMS / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. As discussed under Sample Management Area Sample No. 1, this sample point should be used for lot verification. In the event that the waste does not appear to have the same characteristics as described on the accompanying paperwork when examined visually, the waste should be sampled and then repacked into a 55 gallon drum and returned to storage whilst the results of the sample analysis are processed. This waste drum would then be treated as a reject from the incoming lot and would be dealt with as a new lot of one drum. Analysis of samples will take place at an external facility.

B. Wastes which are well characterized will be brought straight into this area and tipped onto the sorting table. If the waste does not appear to comply with the waste description accompanying the drum a sample could be taken using a scoop held by the manipulator in this area and placed in a sample bottle and transferred for analysis using a purged port bagless transfer system. No other sample techniques are identified for this waste.

CONCLUSION

A. The CDR Size Reduction and Repack Sample No. 2 will be required in WRAP 2A.

B. A scoop held by the manipulator will be used to place waste into a sample jar and transfer to analysis using a purge port bagless transfer system.

RECOMMENDED SAMPLE METHOD: SCOOP/MANIPULATOR

C. Lot verification samples will only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. The extent of the characterization required will be determined on a case by case basis.

6.2.8.3 Sample No. 3: PFD H-2-140628 SHT 1
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	FEEDSTREAMS 2A, 2B, 2C, 5C, 7 AND 8
WHERE TO BE SAMPLED	:	SHREDDER/REPACK ENCLOSURE (GB-05-521) (SORT/TIPPING TABLE ST-05-521 B)
REASON FOR SAMPLE	:	WASTE CHARACTERIZATION
SAMPLE FREQUENCY	:	ONCE PER MONTH
WHERE ANALYZED	:	EXTERNAL FACILITY
MATERIAL THROUGHPUT	:	14.41 RAW WASTE DRUMS / DAY
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. As discussed under Sample Management Area Sample No. 1, this sample point should be used for lot verification. In the event that the waste does not appear to have the same characteristics as described on the accompanying paperwork when examined visually, the waste should be repacked into a 55 gallon drum and returned to storage whilst the results of the sample analysis are processed. This waste drum would then be treated as a reject from the incoming lot and would be dealt with as a new lot of one drum. Analysis of samples will take place at an external facility.

B. Wastes which are well characterized will be brought straight into this area and tipped onto the sorting table. If the waste does not appear to comply with the waste description accompanying the drum a sample could be taken using the manipulator in this area and placed in a sample bottle and transferred for analysis using a purged port bagless transfer system. No other sample techniques are identified for this waste.

CONCLUSION

A. The CDR Size Reduction and Repack Sample No. 3 will be required in WRAP 2A.

B. Manipulators will be used to place pieces of solid waste into a sample jar.

RECOMMENDED SAMPLE METHOD: MANIPULATORS

C. Lot verification samples will only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. The extent of the characterization required will be determined on a case by case basis.

6.2.9 Aqueous Make-Up Samples

6.2.9.1 Sample No.1: PFD H-2-140687
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	ACID
WHERE TO BE SAMPLED	:	ACID FEED TANK (T-12-101)
REASON FOR SAMPLE	:	TO VERIFY ACID STRENGTH
SAMPLE FREQUENCY	:	ONCE EVERY TWO MONTHS
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	0.5 GAL / DAY
HOLDING VESSEL VOLUME	:	75 GAL

DISCUSSION OF CDR DATA

A. This sample is only required if a very accurate acid concentrations are required and if the process control for metering the acid and water into the Acid Feed Tank is particularly inaccurate. As this dilute acid is only to be used for pH adjustment where the aim is likely to be to achieve a product within a range of pH only and because it should be possible to meter the required amounts of water and concentrated acid into the Acid Feed Tank with some accuracy it should not be necessary to take this sample.

CONCLUSION

A. The CDR Aqueous Make-Up Sample No. 1 will not be required in WRAP 2A and will not be considered further in this study.

6.2.9.2 Sample No.2: PFD H-2-140687
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	CAUSTIC SODA SOLUTION (NaOH SOLN.)
WHERE TO BE SAMPLED	:	CAUSTIC FEED TANK (T-12-102)
REASON FOR SAMPLE	:	TO VERIFY CAUSTIC STRENGTH
SAMPLE FREQUENCY	:	ONCE EVERY TWO MONTHS
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	0.5 GAL / DAY
HOLDING VESSEL VOLUME	:	75 GAL

DISCUSSION OF CDR DATA

A. This sample is only required if a very accurate caustic soda solution concentrations are required and if the on-line pH control for metering the caustic soda and water into the Caustic Feed Tank is particularly inaccurate. As this dilute caustic is only to be used for pH adjustment where the aim is likely to be to achieve a product within a range of pH only or for chemical scrubbing of off gasses and because it should be possible to meter the required amounts of water and concentrated caustic soda into the Caustic Feed Tank with some accuracy it should not be necessary to take this sample.

CONCLUSION

A. The CDR Aqueous Make-Up Sample No. 2 will not be required in WRAP 2A and will not be considered further in this study.

6.2.9.3 Sample No.3: PFD H-2-140687
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	DECONTAMINANT SOLUTION
WHERE TO BE SAMPLED	:	DECON SOLUTION FEED TANK (T-12-103)
REASON FOR SAMPLE	:	TO VERIFY SOLUTION STRENGTH
SAMPLE FREQUENCY	:	ONCE EVERY TWO MONTHS
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	NORMALLY NO FLOW
HOLDING VESSEL VOLUME	:	150 GAL

DISCUSSION OF CDR DATA

A. This sample is only required if a very accurate decontaminant solution concentrations are required and if the process control for metering the decontaminant and water into the Decon Solution Feed Tank is particularly inaccurate. As this dilute decontaminant will only be used to enhance the cleaning efficiency of the decontam sprays used in the plant if required and because it should be possible to meter the required amounts of water and concentrated decontaminant solution into the Decontam Solution Feed Tank with some accuracy it should not be necessary to take this sample. This is the approach taken by BNFL in the UK for making up decontamination solutions.

CONCLUSION

A. The CDR Aqueous Make-Up Sample No. 3 will not be required in WRAP 2A and will not be considered further in this study.

6.2.10 HVAC Samples

6.2.10.1 Sample No.1: PFD H-2-140727 & 729
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	EXHAUST GASES
WHERE TO BE SAMPLED	:	DISCHARGE STACK
REASON FOR SAMPLE	:	TO DETERMINE SOLIDS (RADIOACTIVE AND HAZARDOUS) CONTENT OF EXHAUST GASES
SAMPLE FREQUENCY	:	ONCE EVERY TWO WEEKS
WHERE ANALYZED	:	SAMPLE MANAGEMENT AREA
MATERIAL THROUGHPUT	:	71,280 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. In the CDR it only identifies sampling the stack exhaust gases for radionuclide content. This is consistent with regulatory requirements. However it will probably be a requirement that the gases are also analyzed for their hazardous components, though in terms of the type of sampling equipment required there will be little difference between the method used to collect a sample for radiochemical analysis and that used for chemical analysis. Exhaust gases from the ventilation stack will be sampled continuously and the gas flowrate recorded so that the average discharge rate over a fixed time period can be calculated. This analysis is currently shown as being undertaken in the SMA, however if a detailed characterization is required it may be necessary to perform this analysis at an external facility.

B. This sample will be taken direct from the stack using an Isokinetic Exhaust Stack Monitoring System. This requires the use of rake type probes (multiple probes) inserted into the stack. This system will measure the total air volume passing through the stack and collect representative stack exhaust particulates on a filter. With this information the concentration of particles being exhausted can be calculated.

CONCLUSION

A. The CDR HVAC Sample No. 1 will be required in WRAP 2A.

B. A continuous sample of the exhaust gases will be taken by pulling a fixed volumetric flowrate through a filter. The method used to obtain this sample will be in accordance with 40 CFR 61 Subpart H[18].

RECOMMENDED SAMPLE METHOD: PUMP TO SAMPLE POINT

C. This sample point will collect particulates carried in the exhaust off-gases. The particulates will be analyzed for their chemical and radiochemical compositions.

6.2.11 Off-Gas Samples

6.2.11.1 Sample No.1: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM ACTIVE TANKS
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-101 A,B)
REASON FOR SAMPLE	:	TEST FOR LEAKS
SAMPLE FREQUENCY	:	AFTER INSTALLATION OF FILTER
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	170 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study.

CONCLUSION

A. The CDR Off-Gas Sample No. 1 will not be considered further in this study.

6.2.11.2 Sample No. 2: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM SIZE REDUCTION
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-102 A,B)
REASON FOR SAMPLE	:	TEST FOR LEAKS
SAMPLE FREQUENCY	:	AFTER INSTALLATION OF FILTER
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	6000 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study.

CONCLUSION

A. The CDR Off-Gas Sample No. 2 will not be considered further in this study.

6.2.11.3 Sample No. 3: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM POLYMER ENCAPSULATION
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-103 A,B)
REASON FOR SAMPLE	:	TEST FOR LEAKS
SAMPLE FREQUENCY	:	AFTER INSTALLATION OF FILTER
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	200 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study.

CONCLUSION

A. The CDR Off-Gas Sample No. 3 will not be considered further in this study.

6.2.11.4 Sample No. 4: PFD H-2-140600 SHT 2
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM POLYMER ENCAPSULATION
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-103 A,B)
REASON FOR SAMPLE	:	CHECK FOR PRESENCE OF HYDROCARBONS
SAMPLE FREQUENCY	:	ONCE PER WEEK
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	200 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. This sample is required to confirm that the carbon adsorbers are removing all hydrocarbons in the off-gases. The exhaust gases from the carbon adsorbers will be sampled continuously. Analysis of samples will take place at source.

B. This sample could be taken using a similar system to that used for stack exhaust sampling i.e. using rake type probes inserted into the ventilation duct or could be determined using an in-line detection method. In-line detectors can be set up to take a direct reading of the amount of any particular organic material in the gas stream.

CONCLUSION

A. Of the two sample methods identified the preferred method is to use an in-line detector. This would provide an instantaneous indication of a break down of the filter and would not require a physical sample to be taken. If a physical sample were to be taken it could result in volatile organics or other contaminants being released into the atmosphere for a period of days depending on the sample frequency and the turn around time for sample analysis.

RECOMMENDED SAMPLE METHOD: NONE (IN-LINE MONITORING)

B. The CDR Off-Gas Sample No. 4 will be required in WRAP 2A but will be obtained using in-line detection methods and therefore will not be discussed further in this study.

6.2.11.5 Sample No. 5: PFD H-2-140600
BFD N/A

CDR DATA

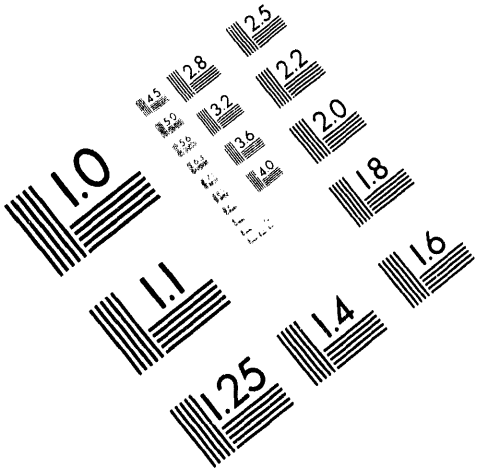
MATERIAL TO BE SAMPLED	:	OFF-GAS FROM GROUT SILOS
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-105 A,B)
REASON FOR SAMPLE	:	TEST FOR LEAKS
SAMPLE FREQUENCY	:	AFTER INSTALLATION
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	200 CFM (MAX)
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The silo filters will not be HEPA filters and will not required a DOP test to be performed. Hence this sample will not be required.

CONCLUSION

A. The CDR Off-Gas Sample No. 5 will not be considered further in this study.



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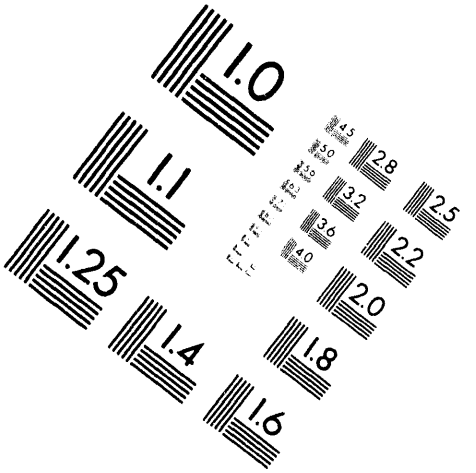

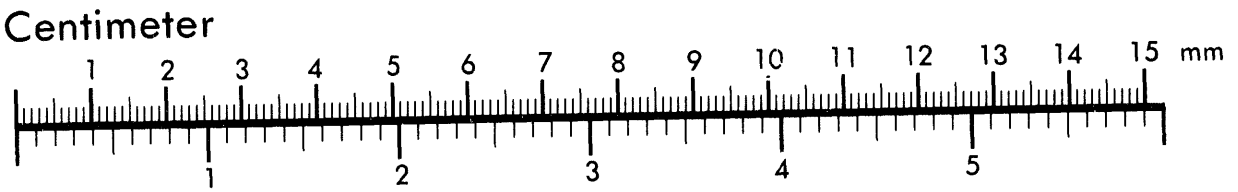

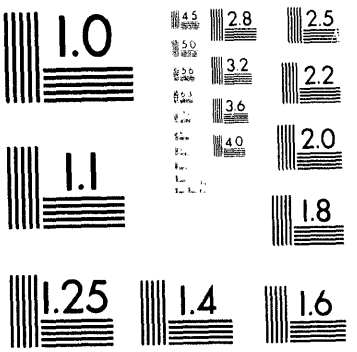

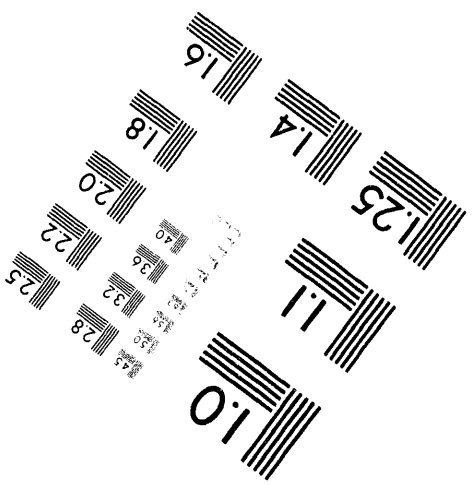

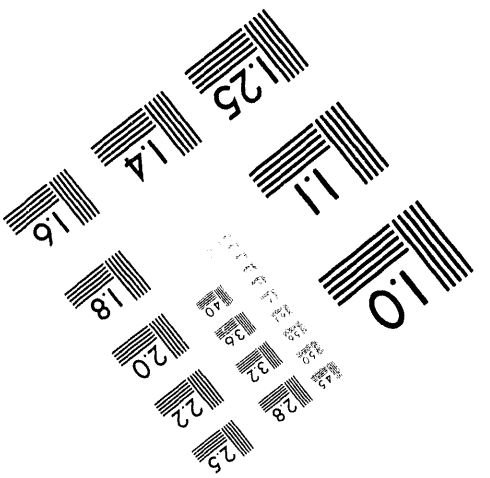

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6.2.11.6 Sample No. 6: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM GROUT IMMOBILIZATION
WHERE TO BE SAMPLED	:	OFF-GAS FILTER (F-04-106)
REASON FOR SAMPLE	:	TEST FOR LEAKS
SAMPLE FREQUENCY	:	AFTER INSTALLATION
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	2500 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study.

CONCLUSION

A. The CDR Off-Gas Sample No. 6 will not be considered further in this study.

6.2.11.7 Sample No. 7: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM SPECIAL WASTE ENCLOSURES
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-107 A,B)
REASON FOR SAMPLE	:	CHECK FOR PRESENCE OF HYDROCARBONS
SAMPLE FREQUENCY	:	ONCE PER TWO WEEKS
WHERE SAMPLED	:	AT SOURCE
MATERIAL THROUGHPUT	:	1220 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study.

B. The second sample to confirm that the carbon adsorbers are removing all hydrocarbons in the off-gases is required. Exhaust gases from the adsorbers will be sampled continuously. Analysis of samples will take place at source.

C. The sample to confirm that the carbon adsorbers are working could be taken using a similar system to that used for stack exhaust sampling i.e. using rake type probes inserted into the ventilation duct or could be determined using an in-line detection method. In-line detectors can be set up to take a direct reading of the amount of any particular organic material in the gas stream.

CONCLUSION

A. Of the two sample methods identified for confirming the performance of the carbon adsorbers the preferred method is to use an in-line detector. This would provide an instantaneous indication of a break down of the filter and would not require a physical sample to be taken. If a physical sample were to be taken it could result in volatile organics or other contaminants being released into the atmosphere for a period of days depending on the sample frequency and the turn around time for sample analysis.

RECOMMENDED SAMPLE METHOD: NONE (IN-LINE MONITORING)

B. The sample to check for presence of hydrocarbons will be required in WRAP 2A but will be obtained using in-line detection methods and therefore will not be discussed further in this study. The test of HEPA filter efficiency will not be considered further in this study.

6.2.11.8 Sample No. 8: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM SAMPLE FUME HOODS AND DRUM SAMPLING ENCLOSURE
WHERE TO BE SAMPLED	:	OFF-GAS FILTER (F-04-108)
REASON FOR SAMPLE	:	CHECK FOR PRESENCE OF HYDROCARBONS
SAMPLE FREQUENCY	:	ONCE PER TWO WEEKS
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	1200 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study. Analysis of samples will take place at source.

B. The second sample to confirm that the carbon adsorbers are removing all hydrocarbons in the off-gases is required. The exhaust gases from the carbon adsorbers will be sampled continuously.

C. The sample to confirm that the carbon adsorbers are working could be taken using a similar system to that used for stack exhaust sampling i.e. using rake type probes inserted into the ventilation duct or could be determined using an in-line detection method. In-line detectors can be set up to take a direct reading of the amount of any particular organic material in the gas stream.

CONCLUSION

A. Of the two sample methods identified for confirming the performance of the carbon adsorbers the preferred method is to use an in-line detector. This would provide an instantaneous indication of a break down of the filter and would not require a physical sample to be taken. If a physical sample were to be taken it could result in volatile organics or other contaminants being released into the atmosphere for a period of days depending on the sample frequency and the turn around time for sample analysis.

RECOMMENDED SAMPLE METHOD: NONE (IN-LINE MONITORING)

B. The sample to check for presence of hydrocarbons will be required in WRAP 2A but will be obtained using in-line detection methods and therefore will not be discussed further in this study. The test of HEPA filter efficiency will not be considered further in this study.

6.2.11.9 Sample No. 9: PFD H-2-140600
BFD N/A

CDR DATA

MATERIAL TO BE SAMPLED	:	OFF-GAS FROM NON-ACTIVE TANKS
WHERE TO BE SAMPLED	:	OFF-GAS FILTERS (F-04-109 A,B)
REASON FOR SAMPLE	:	TEST FOR LEAKS
SAMPLE FREQUENCY	:	AFTER INSTALLATION
WHERE ANALYZED	:	AT SOURCE
MATERIAL THROUGHPUT	:	20 CFM
HOLDING VESSEL VOLUME	:	N/A

DISCUSSION OF CDR DATA

A. The DOP test is not a process sample, it is simply a test performed by the operator of the facility to check the filter efficiency. This is a standard test performed at the Hanford site on all HEPA filter systems and therefore needs no further description in this study.

CONCLUSION

A. The CDR Off-Gas Sample No. 9 will not be considered further in this study.

6.3 WRAP 2A Sample Management Area Evaluation

6.3.1 SMA Analytical Capabilities

A. The only analytical capabilities identified in this study as being required in the WRAP 2A SMA are equipment for determination of pH, equipment to determine the viscosity of binder materials, equipment to test the compressive strength of immobilized product sample cubes, titration equipment to determine the quality of polymer raw materials and general laboratory equipment such as measuring vessels to allow the split between organic and aqueous phases in bleed liquor from polymer encapsulation to be determined. All other sample analysis within the SMA will be by visual inspection of solidified samples. However, sample preparation equipment will be required to allow destructive examination of samples (though not destructive examination of product drums which will take place in the Box Breakdown Area). The analytical requirements for each sample point are presented in tabular form in **Table 6-2** below.

TABLE 6-2
WRAP 2A SMA ANALYTICAL CAPABILITIES

SAMPLE FOR ANALYSIS	ANALYSIS REQUIRED	COMMENTS
SPECIAL WASTE AREA SAMPLES		
No.8 Scrubber Off-Gas	pH determination	To confirm scrubber is functioning correctly
POLYMER ENCAPSULATION SAMPLES		
No.1 Uncatalyzed VES Polymer	Viscosity determination	Used to determine if binder is starting to polymerize
No.3 Catalyzed VES Polymer	Compressive strength	Product Quality
No.4 Bleed Liquor	Measure relative volumes of organic and aqueous phases	Used to determine routing for disposal of the bleed liquor
No.6 VES Promoter	Determine compressive strength of a test specimen of VES binder	To check for degradation of the promoter
No.7 VES Catalyst	Titration to check for active oxygen content	To check for degradation of the catalyst
No.8 VES Resin	Visual check/viscosity determination	To check for degradation of the resin
GROUT IMMOBILIZATION SAMPLES		
No.2 Polymer Additive	Visual check/viscosity determination	To check for degradation of the polymer
No.4 Liquid Grout	Compressive strength	Product quality
SECONDARY WASTE SAMPLES*		
No.1 Non-active Aqueous Waste	pH determination	To allow pH adjustment for immobilization with grout
No.3 Treated Active Aqueous Waste	pH determination	To allow pH adjustment for immobilization with grout

* These samples will also be analyzed at an external facility to determine their chemical composition.

B. In the CDR, it was proposed that the SMA would have four fume hoods of which one was to be used for the small scale analysis to be performed in the SMA. For greater flexibility it is proposed that two of the fume hoods be designated 'active' and two designated 'inactive' and that all four fume hoods are equipped to be used to perform small scale analysis work and to be used for sample repackaging. The fume hoods will be positioned and labelled so that there is a clear distinction between the active and inactive fume hoods. In addition the inactive fume hoods will not be equipped to handle shielded sample pigs. The SMA will be manned by competent laboratory personnel and therefore further physical methods of preventing samples being treated in the wrong fume hood will not be necessary.

6.3.2 SMA Throughput

A. In the SMA the term 'throughput ' is used to signify the flow of samples through the facility. Three categories of sample were proposed in the CDR. **Table 6-3** explains the categories and gives the total of samples in each category.

TABLE 6.3
WRAP 2A SMA THROUGHPUT

	Samples for transfer to external analytical facility			Samples for analysis within SMA			Samples for analysis local to process		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
CDR Design	9	0	5	2	1	3	7	4	15
Study 1604-10	6	3	3	4	0	5	1	0	0

B. From the above table it can be seen that although there has been a significant reduction in the number of samples in comparison with the CDR, the number of samples which need to be routed through the SMA (i.e. not including samples analyzed at source) has not changed significantly as a result of this study. Hence, the two fume hoods for the handling of active samples and the two fume hoods for the handling of inactive samples will still be required.

6.3.3 SMA Sampling Equipment

A. Although it is proposed that lot verification of well characterized wastes is done visually in either the Open/Sort/Repack Area or the Box Breakdown Area, there will still be the requirement to sample poorly characterized drums in the SMA. Hence the following equipment for this purpose will be required:

1. Core Sampler

2. Manipulators

3. Sample Thief (To be operated using the manipulators)

6.3.4 SMA Archiving of Product Samples

A. An area was set aside in WRAP 2A for the purpose of holding archive samples of product. As it is proposed to test each sample and record the results of those tests in the SMA, there does not seem to be any justification for also archiving some of the sample. If samples were to be archived, the archive store would have to be controlled as a long term radioactive mixed waste storage area which would have implications on the operation of the SMA. As there appears to be no benefit from holding samples after they have successfully passed testing and noting the implications of including a long term radioactive mixed waste store in WRAP 2A it is recommended that archive storage of product samples is deleted from the FDC and from WRAP 2A.

6.4 CDR Design Review Comments

6.4.1 Comment 48 - Identify Core Drilling Lubricant

A. The CDR comment was that the water supply to the core drilling equipment was not shown on the PFD. The answer given by the AE was that some other lubricating fluid will be used.

B. Whichever lubricant is used it will need to be supplied to the area, there will need to be a collection system for the lubricant and/or the dust generated and there will need to be a disposal route for the waste lubricant and/or powder. Hence in answer the CDR Review Comment: The PFD does need to be updated to show the Core Drilling lubrication system - whichever lubricant is used.

C. In answer to the side issue that has now been raised and that is which lubricant shall be used, the most common lubricants used when core drilling are water and air. Either of these could be used in WRAP 2A. If water were used as the lubricant it could be filtered and recycled and when it requires disposal it could be immobilized in grout. If air were used there would be no secondary wastes other than the dust generated by the drilling process. Hence, the design would have to ensure that the dust was contained and does not contaminate the enclosure. Such a system has been tested successfully by WHC. In conclusion, if sampling is required, a Core Sampler should be used and air should be used as a lubricant.

6.4.2 Comment 122 - Sampling 85 Gallon Overpacks

A. 55 gallon drums will be placed in 85 gallon overpacks if the integrity of the drum is suspect and waste is leaking from the drum. Under these circumstances it would be undesirable to remove the 55 gallon drum from the overpack unless it was proposed to treat the waste and repack it in a new 55 gallon drum for treatment. The area of WRAP 2A designed for this is the Box Breakdown Area where it will be possible to sample both the 55 gallon drum and the 85 gallon overpack. As there will be relatively few drums requiring processing via this route the Box Breakdown Area will have sufficient capacity to handle these wastes and there will be no requirement to take 85 gallon drums into the SMA.

B. The effect on the analytical results of using air as the core drilling lubricant should be negligible as only dust is generated. If water were used as the lubricant, a slight leaching of the sample might be possible. If water were encapsulated with the sample, lubrication water might slightly distort the analytical results.

6.4.3 Comment 123 - Sampling Larger Items

A. This comment was specifically aimed at the sampling of wastes such as dry active waste or construction debris. As stated in Section 6.2.3.1, it is hoped that it will be unnecessary to sample these wastes provided that it is confirmed visually that the waste is "debris". However, in the event that a sample of a sheet of plastic or a piece of wood is required the most appropriate place to do this is in the Open/Sort/Repack Area after the waste has been tipped onto the sort table. If an item of waste is suspect it could be sampled using the manipulators which could also be used to hold a cutting tool in order to obtain a small sample if necessary.

6.4.4 Comment 185 - SMA Analytical Provisions

A. This comment related to the fact that there was no mention of the SMA analytical capability in the CDR. The AE response to this comment was to include Figure 1.10-1 in the CDR. This study reviews Figure 1.10-1 and identifies what analysis is required in the SMA in Section 6.3.1.

6.4.5 Comment 186 - Sample Philosophy For Lot Verification

A. This comment was questioning how representative it was taking a sample from the top of each drum. This issue has been addressed in Section 6.2.3.1 and different sample techniques suggested for different waste types. However, the AE response to this comment still holds true and that is that these samples are for verification of the lot only, not to provide a sample so that the waste can be fully recharacterized.

7.0 DISCUSSION OF PREFERRED ALTERNATIVES

A. A detailed discussion of the sampling alternatives and preferred options is presented in Section 6.0. The conclusions drawn from this section have allowed a proposed sample plan for WRAP 2A to be compiled. The proposed sample plan is attached to this report as **Appendix A**.

8.0 REFERENCES

1. EPA-SW-846. Test Methods For Evaluating Solid Waste. Physical/Chemical Methods. 3rd Edition.

2. WHC-CM-7-7. Environmental Investigations And Site Characterization Manual : Soil And Sediment Sampling. 7 July 1992.

3. EPA-600-2-80-013. Samplers And Sampling Procedures For Hazardous Waste Streams. January 1980.

4. WHC-SD-W026-TRP-002. Test Report For Compacted Waste Drum Sampling. K J Hull. April 1992.

5. Conceptual Design For The Waste Receiving And Processing Facility Module 2A. Vol 5. System Descriptions.

6. Washington Administrative Codes 173-303. Dangerous Waste Regulations.

7. Facsimile From S Mackay (BNF plc) to R Voke/D Swale (BNFL inc). 14 December 1992.

8. 40-CFR Part 268. Land Disposal Restrictions.

9. Memo : Rationale For Determining The Point Of Dangerous Waste Designation. R J Landon. Regulatory Analysis Section. Westinghouse Hanford Company.

10. 40-CFR-264.13. General Waste Analysis.

11. Functional Design Criteria. Rev 1. Waste Receiving And Processing Facility Module 2A. Project W100. December 14 1992.

12. RSA Corporation Material Safety Data Sheet For N,N-Dimethyl-p-Toluidine.

13. Telecon between R Voke and RSA Corporation. 6 April 1993.

14. AKZO Chemicals Material Safety Data Sheet For Cadox 40E.

15. Telecon between R Voke and AKZO Chemicals. 6 April 1993.

16. Memo : Analysis Of Cadox 40E. W Riley (AKZO Chemicals) to R Voke. 7 April 1993.

17. Dow Chemical Company Material Safety Data Sheet For Derakane (R) 470-36 Vinyl Ester Resin.

18. 40 CFR 61 Subpart H. National Emission Standards For Emissions Of Radionuclides Other Than Radon From DOE Facilities.

APPENDIX A
PROPOSED WRAP 2A SAMPLE PLAN

1.0 Introduction

A. The WRAP 2A Sample Plan is based on the findings of the ACDR Process Sample Study 1604-10 and will be used as the basis for detailed design of the WRAP 2A sampling system and SMA.

B. The Sample Plan shall describe the objectives and details of the sampling effort and how they will be performed including which samples are required and why they are required, how samples are to be taken, sample frequency, sample analysis requirements and the function of the SMA in WRAP 2A.

C. **Figure 1** shows the position of the various sample points within WRAP 2A.

2.0 Listing of WRAP 2A Samples

A. A total of twenty two samples have been identified as being required to satisfy both regulatory and process requirements of WRAP 2A. A listing of the sample points and the materials to be sampled is given in **Table 1**.

3.0 Sample Detailed Description

3.1 Special Waste Area: Sample No.8 - Scrubber Off-gas

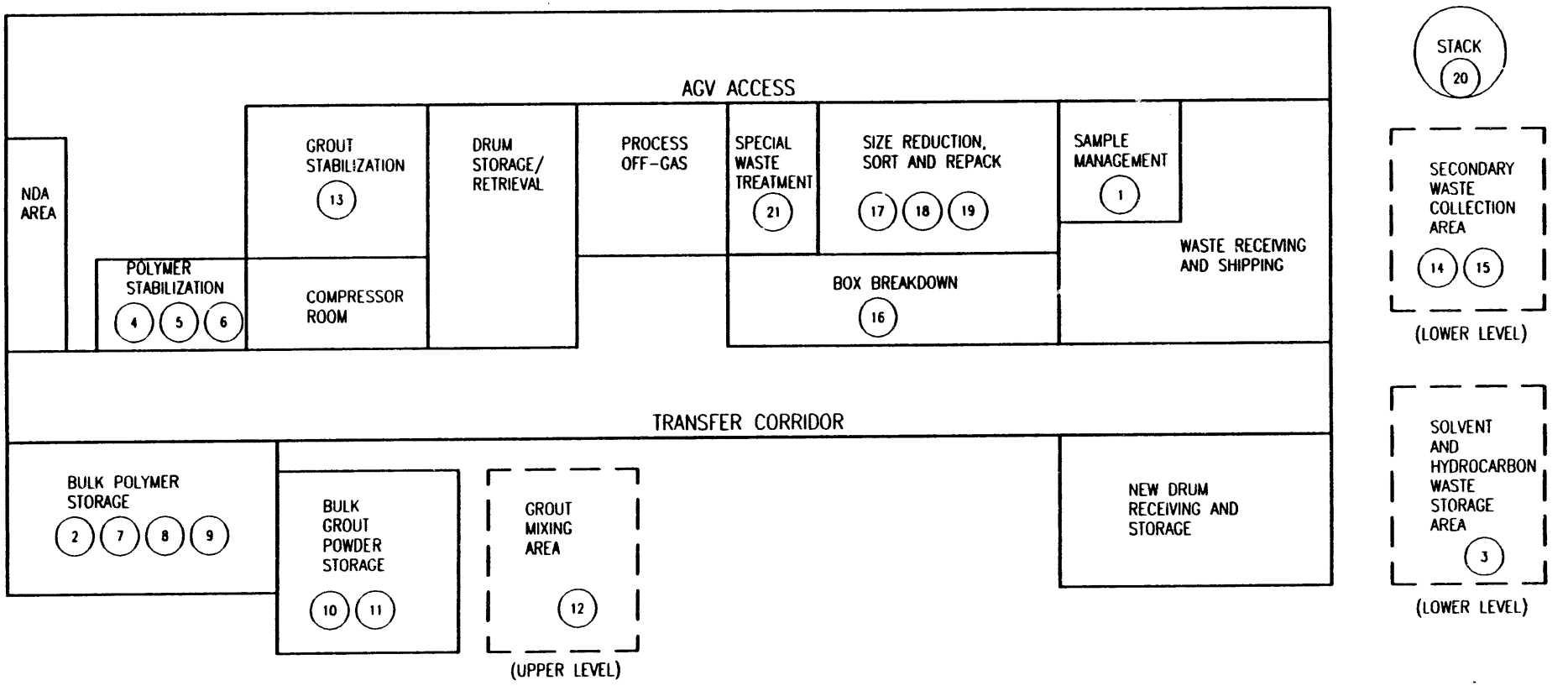
A. This sample is required to confirm that all acidic vapors are being removed by the scrubber system. If acidic vapors are detected it would be an indication that the scrubber system had failed. A grab sample will be taken through a valved connection in the off-gas pipework. The sample will be taken to the SMA where the vapor will be condensed and tested for pH.

3.2 Sample Management Area: Sample No. 1(a) - Incoming Waste Drums

A. The Sample Management Area shall have the capability to extract a representative sample from at least one drum of a lot or 20 % of the waste containers of a lot whichever is greater. However, these samples will normally only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. In either case a full characterization of the waste will be required including: chemical and physical properties, water content, pH etc.

B. Dry particulate materials such as Feedstream 2A, Ammonium Sulphate, will be sampled using a Thief which will be pushed into the drum using a robotic arm. The Thief containing the sampled material shall be placed in a container and posted out of the enclosure. The sampled material will be removed from the Thief in one of the sample fume hoods and repackaged in a bar coded sample container and logged onto the data record system prior to transfer to an external facility for analysis. The Thief will be cleaned and then posted back into the enclosure for reuse.

FIGURE 1 WRAP 2A
PROCESS SAMPLE POINTS



KEY

1. LOT VERIFICATION OF INCOMING WASTE/CERTIFICATION OF MACROENCAPSULATED PRODUCTS
2. QC CHECK ON POLYMER MIX
3. CHARACTERIZATION OF HYDROCARBON WASTES
4. QC CHECK ON POLYMER MIX
5. DETERMINE IF BLEED LIQUOR IS ORGANIC OR AQUEOUS.
6. CERTIFICATION OF VES/WASTE AGITATED PRODUCT
7. QC CHECK OF VES PROMOTOR
8. QC CHECK OF VES CATALYST
9. QC CHECK OF VES RESIN
10. QC CHECK OF GROUT POWDERS
11. QC CHECK OF POLYMER ADDITIVE
12. QC CHECK OF GROUT MIX
13. CERTIFICATION OF AGITATED GROUT PRODUCT
14. CHARACTERIZATION OF NON-ACTIVE AQUEOUS WASTE
15. CHARACTERIZATION OF ACTIVE AQUEOUS WASTE
16. LOT VERIFICATION OF BOXES/110 GAL. DRUMS
17. LOT VERIFICATION OF INCOMING SHREDDABLE WASTES
18. LOT VERIFICATION OF INCOMING WASTES FOR PUG MILL PROCESSING
19. LOT VERIFICATION OF INCOMING WASTES FOR DIRECT REPACK
20. CHARACTERIZATION OF STACK OFF-GASES
21. PH CHECK ON SCRUBBER OFF-GASES

SK_WR2A

TABLE 1
WRAP 2A SAMPLE REQUIREMENTS

Process Sample Point (Figure 1)	Sample No.	Material To Be Sampled	Where To Be Sampled	Reason For Sample	Sample Method	Sample Frequency	Analysis Required	Where Analyzed
SPECIAL WASTE AREA SAMPLES								
21	8	Scrubber Off-Gas	Special Waste Area	Process Sample: To Determine If Scrubber Is Working	Valved Sample Point	Non-Routine (During Mercury Campaign)	pH Of Vapor Condensate	SMA
SAMPLE MANAGEMENT AREA SAMPLES								
1	1(a)	Incoming Waste Drum	Sample Management Area	FDC[11]/Regulatory[10] Requirement: To Characterize Poorly Characterized Wastes	Thief Core Sampler Manipulators	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
1	1(b)	Outgoing Product Drums	Sample Management Area	FDC[11] Requirement: Certification Of Macroencapsulated Product	Core Sampler	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
POLYMER ENCAPSULATION SAMPLES								
2	1	Mixed VES Polymer	Polymer Mixing Tank (T-05-401)	Process Sample: To Determine The Quality Of Mixing	Valved Sample Point	At Operator Discretion	Determine Viscosity	SMA
3	2	Hydrocarbon Wastes	Hydrocarbon Waste Tank (T-05-402)	Process Sample: Detailed Chemical Analysis Required For Off-Site Disposal	Valved Sample Point	Non-Routine (When Tank Is Full)	Chemical Composition	External Facility
4	3	Mixed VES Polymer and Catalyst	In-Line Mixers (M-05-404 thru 407)	Process Sample: To Confirm Successful Mix	Valved Sample Point	At Operator Discretion	Product Homogeneity And Compressive Strength	SMA
5	4	Product Bleed Liquor	Liquor Catch Drum (V-05-401)	Process Sample: To Determine If Liquor Is Organic Or Aqueous	Valved Sample Point	Non-Routine (Abnormal Product)	Measure Relative Volumes Of Organic And Aqueous Phases	SMA
6	5	VES/Waste Product (Agitated Product)	Product Drum in Polymer Encap Area	FDC[11] Requirement: Product Certification	Sample Cup Or Coliwasa	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
7	6	VES Promoter	Storage Tank (T-05-304)	Process Sample: Quality Check	Valved Sample Point	Non-Routine (Time/Temp Dependant)	Compressive Strength Of Test Specimen	SMA
8	7	VES Catalyst	Storage Tank (T-05-303)	Process Sample: Quality Check	Valved Sample Point	Non-Routine (Time/Temp Dependant)	Titration To Determine Active Oxygen Content	SMA

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

Process Sample Point (Figure 1)	Sample No.	Material To Be Sampled	Where To Be Sampled	Reason For Sample	Sample Method	Sample Frequency	Analysis Required	Where Analyzed
9	8	VES Resin	Storage Tank (T-05-305 A, B)	Process Sample: Quality Check	Valved Sample Point	Non-Routine (Time/Temp Dependant)	Visual Check, Viscosity	SMA
GROUT IMMOBILIZATION SAMPLES								
10	1	PFA, OPC, BFS and Grout Additive	Storage Silos (T-05-101 thru 104)	Process Sample: Quality Check	Valved Sample Point	Non-Routine (Time/Temp Dependant)	Chemical And Physical Properties	External Facility
11	2	Polymer Additive	Raw Material Drum	Process Sample: Quality Check	Valved Sample Point	Non-Routine (Time/Temp Dependant)	Visual Check, Viscosity	SMA
12	4	Liquid Grout	Wet Grout Mixing Tank (T-05-212)	Process Sample: 1. Determine Viscosity 2. Product Quality	Valved Sample Point	1. Daily 2. At Operator Discretion	Viscosity, Compressive Strength	At Source, SMA
13	6	Agitated Grout Product	Product Drum In Grout Immob Area	FDC Requirement: Product Certification	Sleeve-in-Sleeve Sampler	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
SECONDARY WASTE SAMPLES								
14	1	Non-Active Aqueous Waste	Collection Tanks (T-07-101 A, B)	Regulatory[9] Requirement: Detailed Chemical Analysis Required For Off-Site Disposal	Valved Sample Point	Non-Routine (When Tank Is Full)	pH, Chemical Composition if Off-site Disposal Required	SMA, External Facility
15	3	Treated Active Waste	Collection Tank (T-07-202)	Regulatory[9] Requirement: Detailed Chemical Analysis Required To Determine Treatment /Disposal Route	Valved Sample Point	Non-Routine (When Tank Is Full)	pH, Chemical Composition	SMA, External Facility
BOX BREAKDOWN AREA SAMPLES								
16	2	Lead, Misc. Waste And HEPA Filters /Vibro-Infilled Product Drums	Box Breakdown And Repack Area	FDC[11]/Regulatory[10] Requirement: To Characterize Poorly Characterized Wastes	Manipulators	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
SIZE REDUCTION AND REPACK SAMPLES								
17	1	Shreddable Waste	Size Reduction And Repack Area (ST-05-521 A)	FDC[11]/Regulatory[10] Requirement: To Characterize Poorly Characterized Wastes	Manipulators	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

Process Sample Point (Figure 1)	Sample No.	Material To Be Sampled	Where To Be Sampled	Reason For Sample	Sample Method	Sample Frequency	Analysis Required	Where Analyzed
18	2	Wastes For Pug Mill Processing	Size Reduction And Repack Area (ST-05-541)	FDC[11]/Regulatory[10] Requirement: To Characterize Poorly Characterized Wastes	Scoop / Manipulator	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
19	3	Wastes For Direct Repack	Size Reduction And Repack Area (ST-05-521 B)	FDC[11]/Regulatory[10] Requirement: To Characterize Poorly Characterized Wastes	Manipulators	See: WRAP 2A FDC	Chemical And Physical Properties	External Facility
HVAC SAMPLES								
20	1	HVAC Exhaust Gases	Discharge Stack	Regulatory[10] Requirement: To Characterize Off-Gases	Valved Sample Point	Sampled Continuously	Chemical And Radiochemical Composition	External Facility

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

C. Wet particulates and sludges such as Feedstream 1C, 183H Basin Sludge, will be sampled using a "Core Sampler". It is assumed that the physical properties of these wastes will be such that it will be possible to simply push the sampler into the waste using the same robotic arm as used to take a sample with a Thief. The "Core Sampler" containing the sampled material shall be placed in a container and posted out of the enclosure. The sampled material will be removed from the "Core Sampler" in one of the sample fume hoods and repackaged in a bar coded sample container and logged onto the data record system prior to transfer to an external facility for analysis. The "Core Sampler" will be cleaned and then posted back into the enclosure for reuse.

D. Solid loose items will be sampled using a mechanical grab. The robotic arm used to take samples of dry particulates and sludges will be designed to take the grab sample from the drum. This will remove the need for a manipulator specifically to take this sample and hence minimizing equipment requirements in the sample enclosure. The sample will be placed in a sample container and posted out of the enclosure for bar coding and logging onto the data record system.The sample will then be transferred to an external facility for analysis.

E. Solidified Liquids such as Feedstream 1A, 183H Basin Solidified Liquid, will be sampled using a Core Sampler. For these wastes the Core Sampler will be designed with a cutting edge and will be drilled into the waste. The Core Sampler will be lubricated with air hence it will be necessary to place the equipment for taking core samples from solidified wastes in a booth to contain any dust generated and prevent contamination of other equipment in the sample enclosure. The Core Sampler containing the sampled material shall be placed in a container and posted out of the enclosure. The sampled material will be removed from the Core Sampler in one of the sample fume hoods and repackaged in a bar coded sample container and logged onto the data record system prior to transfer to an external facility for analysis. The Core Sampler will be cleaned and then posted back into the enclosure for reuse.

3.3 Sample Management Area: Sample No. 1(b) - Outgoing Product Drums

A. Macroencapsulated products will be sampled using a Core Sampler. For these wastes the Core Sampler will be designed with a cutting edge and will be drilled into the waste. The Core Sampler will be lubricated with air hence it will be necessary to place the equipment for taking core samples from solidified wastes in a booth to contain any dust generated and prevent contamination of other equipment in the sample enclosure. The Core Sampler containing the sampled material shall be placed in a container and posted out of the enclosure. The sampled material will be removed from the Core Sampler in one of the sample fume hoods and repackaged in a bar coded sample container and logged onto the data record system prior to transfer to an external facility for analysis. The Core Sampler will be cleaned and then posted back into the enclosure for reuse.

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

3.4 Polymer Encapsulation Samples: Sample No.1 - Mixed VES Polymer

A. This sample will be required to confirm that correct levels of ingredients such as VES resin, styrene and promoter are present. The sample will be taken from a valve in the process pipework as the polymer mix is being transferred to the drum. The sample will not normally be taken for every batch of polymer made. However, during commissioning and infrequently during operation of the plant it will be possible to take samples to confirm that the correct quantities of each binder material are being mixed in the tank. A reduction in quantity of one of the constituents could indicate that one of the feed lines to the tank is becoming blocked and hence reducing the flow of that material to the tank. The sample will be collected in a sample container and taken to the SMA for bar coding and logging onto the data record system and viscosity analysis.

3.5 Polymer Encapsulation Samples: Sample No.2 - Hydrocarbon Wastes

A. This sample is required to allow the chemical composition to be determined. The waste will be a dilute solution of polymer components in an organic solvent. Information on the chemical composition will be required by the disposal facility prior to accepting the waste. The sample will be taken from a valve in the process pipework. The stream will be sampled prior to discharging the tank contents and feeds to the tank will be interlocked closed during taking of the sample and will remain closed until the tank has been emptied and is ready to accept waste. The sample will be collected in a sample container and taken to the SMA for bar coding and logging onto the data record system. The sample will then be transferred to an external facility for analysis.

3.6 Polymer Encapsulation Samples: Sample No.3 - Mixed VES Polymer And Catalyst

A. This sample is required to confirm that complete mixing of the VES polymer and catalyst is occurring in the in-line mixers. The sample will be taken from a valve on the discharge of the in-line mixers. The sample container shall act as a mould in which the polymer will be allowed to cure. Once cured the sample will be posted out of the encapsulation area and taken to the SMA for analysis. Analysis will be simply a visual check on a section through the sample. The sample will not normally be taken for every drum of product. However, during commissioning and infrequently during operation of the plant it will be possible to take samples to confirm that mixing process for the polymer and catalyst is working as designed.

3.7 Polymer Encapsulation Samples: Sample No.4 - Bleed Liquor

A. This sample is required to determine the composition of the bleed liquor. This does not need to be a detailed analysis as it will only be used to determine the routing of the liquor i.e. either to the Hydrocarbon Waste Tank or to the Active Liquor Collection Tank. Sample analysis will consist of simply allowing the aqueous and organic phases to separate and the determining the relative volumes of each phase. This analysis will be performed in the SMA. The sample will be taken from a valve in the process pipework. The sample will be taken whenever bleed liquor is detected on the surface of a product drum.

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

3.8 Polymer Encapsulation Samples: Sample No.5 - VES/Waste Product

A. This sample is taken for certification purposes. The sample will be tested for one or more of the following criteria:

- Compressive Strength
- Leachability Index
- Biodegradation
- Thermal Cycling
- Radiation Stability
- Immersion
- Free Liquids
- Hazardous Characteristics
- Toxicity Characteristics

Within Wrap 2A there shall be the capability to extract a representative sample from at least one container in each lot or 10 % of the exiting lot of drums, whichever is greater.

B. Prior to the mix being allowed to cure a Sleeve-in-Sleeve Sampler will be inserted into the product. Once cured the sample will be withdrawn from the drum and posted out of the Polymer Encapsulation Area and taken to the SMA where it will be repackaged in a bar coded sample container and logged onto the data record system. The sample will then be transferred to an external facility for analysis.

C. Samples of vibro-infilled product drums can only be obtained from the product after it has cured. In order to do this the cured product drum will be transferred to the Sample Management Area for Core Sampling. Handling of these samples are discussed under SMA Sample 1(b).

3.9 Polymer Encapsulation Samples: Sample No.6 - VES Promoter
Sample No.7 - VES Catalyst

A. Both these materials have long shelf lives if kept at the correct temperature and are unlikely to start to decompose in the timeframe that they are held in WRAP 2A, however, samples may be taken in order to produce a test VES product and confirm that the promoter and catalyst have not started to decompose. The sample will be taken from a valve in the process pipework for each tank. Test products from the samples will be prepared in one of the fume hoods in the SMA to confirm that the promoter has not started to decompose. The product will be tested for compressive strength. A titration method will be used to determine the active oxygen content of the catalyst to confirm that it has not started to decompose.

3.10 Polymer Encapsulation Samples: Sample No.8 - VES Resin

A. VES resin also has a reasonable shelf life if kept at the correct temperature and is unlikely to start to polymerize in the timeframe that it is held as a raw material in WRAP 2A. However, it will be possible to do a visual check if polymerization has started to occur as polymer strands will form in the liquid. A viscosity check will also be performed as further confirmation that the VES has not started to polymerize. The sample will be taken from a valve in the process pipework for the tank. The sample will be examined in the SMA.

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

3.11 Grout Immobilization Samples: Sample No.1 - Grout Powders

A. Samples of grout powders will be analyzed to confirm that they comply with the purchasing requisition specifications and the following ASTM specifications:

- C989 - Ground Granulated Blast Furnace Slag
- C618 - Pulverized Fly Ash
- C150 - Type I/II Portland Cement

The grout powders have a long shelf life unless exposed to moisture. Hence this will be a non-routine sample which will only be taken if it is suspected that the stored powders are not to specification. The samples will be taken from tap-in points on the screwfeeders at the base of each silo. The sample will be collected in a sample container and taken to the SMA for bar coding and logging onto the data record system. The sample will then be transferred to an external facility for analysis.

3.12 Grout Immobilization Samples: Sample No.2 - Polymer Additive

A. It is assumed that this material will be similar in nature to VES resin (Polymer Encapsulation Sample No. 8) and therefore will be sampled in the same manner and will require the same analytical techniques.

3.13 Grout Immobilization Samples: Sample No.4 - Liquid Grout

A. These samples are required to confirm that complete mixing of the grout is occurring in the in-line mixers. The samples will be taken from a valve in the process pipework for the Wet Grout Mixing Tank. The first sample will be tested for viscosity at source to confirm that the fluidity of the grout is within the required parameters for vibro-infilling. A second sample may then be allowed to cure if required. Once cured this sample will be taken to the SMA for compressive strength analysis. A sample will not be kept and allowed to cure for every batch of grout prepared. However, during commissioning and infrequently during operation of the plant it will be possible to take samples to confirm that mixing process for liquid grout is working as designed.

3.14 Grout Immobilization Samples: Sample No.6 - Agitated Grout Product

A. This sample is taken for certification purposes. The sample will be tested for one or more of the following criteria:

- Compressive Strength
- Leachability Index
- Biodegradation
- Thermal Cycling
- Radiation Stability
- Immersion
- Free Liquids
- Hazardous Characteristics
- Toxicity Characteristics

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

Within WRAP 2A there shall be the capability to extract a representative sample from at least one container in each lot or 10 % of the exiting lot of drums, whichever is greater.

B. Prior to the mix being allowed to cure a Sleeve-in-Sleeve Sampler will be inserted into the product. Once cured the sample will be withdrawn from the drum and posted out of the Grout Immobilization Area and taken to the SMA where it will be repackaged in a bar coded sample container and logged onto the data record system. The sample will then be transferred to an external facility for analysis.

3.15 Secondary Waste Samples: Sample No.1 - Non-active Aqueous Waste

A. This waste will be sampled to determine if it is contaminated with any hazardous material. Potential contaminants of this waste stream have yet to be identified. The sample will be taken from a valve in the process pipework of the Non-active Aqueous Waste Tank. This waste stream will be sampled prior to discharging the tank contents and feeds to the tank will be interlocked closed during taking of the sample and will remain closed until the tank has been emptied and is ready to accept waste. The sample will be collected in a sample container and taken to the SMA for bar coding, logging onto the data record system and analyzed for pH level to allow the pH to be adjusted for eventual immobilization with grout. The sample will then be transferred to an external facility for analysis.

3.16 Secondary Waste Samples: Sample No.3 - Treated Active Waste

A. This sample will be taken to fully characterize the waste and to confirm that the pH is within acceptable limits for immobilization in grout. The waste will be analyzed for both its chemical and radiochemical compositions. The sample will be taken from a valve in the process pipework of the Treated Active Waste Collection Tank. This waste stream will be sampled each time the tank is filled from the Active Waste Collection Tank. Feeds to the tank will be interlocked closed during taking of the sample and will remain closed until the tank has been emptied and is ready to accept waste.The sample will be collected in a sample container and taken to the SMA for bar coding and logging onto the data record system. The sample will be tested for pH and then transferred to an external facility for analysis. When details of the chemical and radiochemical composition are known the routing of the waste will be determined. If the waste is to be immobilized in grout its pH will be adjusted and then the tank contents re-sampled to confirm that the pH is within prescribed limits. This analysis will be undertaken in the SMA.

3.17 Box Breakdown Samples: Sample No.2 - Lead, 183H Basin Misc. Clean-up Waste and HEPA Filters

A. The Box Breakdown Area shall have the capability to extract a representative sample from at least one drum of a lot of incoming waste or 20 % of the waste containers of a lot whichever is greater. However, these samples will normally only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. In either case a full characterization of the waste will be required including: chemical and physical properties. Only one sample technique has been identified for this area

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

and that is to use manipulators to place pieces of solid waste into a sample container and transfer out of the area using a purge port bagless transfer system. The sample container will then be transferred to the SMA for bar coding and logging onto the data record system. The sample will then be transferred to an external facility for analysis.

B. The Box Breakdown Area shall also have the capability to extract a representative sample from at least one container in each lot of solidified vibro-infilled product drums or 10 % of the exiting lot of drums, whichever is greater. The drums will be broken up using tools in the Box Breakdown Area and then a sample taken and routed for analysis as described above for incoming waste drums/boxes.

3.18 Size Reduction and Repack Samples: Sample No.1 - Shreddable Wastes
Sample No.3 - Wastes For Direct Repack

A. The Size Reduction and Repack Area shall have the capability to extract a representative sample from at least one drum of a lot of incoming waste or 20 % of the waste containers of a lot whichever is greater. However, these samples will normally only be taken if there is uncertainty about the waste characterization of particular drums being routed to WRAP 2A, or if, when visually inspected, the drum contents are not consistent with the waste characterization documentation which accompanies the drum. In either case a full characterization of the waste will be required including: chemical and physical properties. Only one sample technique has been identified for these wastes and that is to use manipulators to place pieces of solid waste into a sample container and transfer out of the area using a purge port bagless transfer system. The sample container will be transferred to the SMA for bar coding and logging onto the data record system. The sample will then be transferred to an external facility for analysis.

3.19 Size Reduction and Repack Samples: Sample No.2 - Wastes For Pug Mill Processing

A. This sample is also for lot verification of incoming waste and as such will be handled as described for the above Size Reduction and Repack Samples. The only difference will be that this sample will be taken with a scoop held by a manipulator.

3.20 HVAC Samples: Sample No.1 - Exhaust Gases

A. This sample point will collect particulates carried in the exhaust off-gases. The particulates will be analyzed for their chemical and radiochemical compositions. Exhaust gases from the ventilation stack will be sampled continuously and the gas flowrate recorded so that the average discharge rate over a fixed time period can be calculated. The exhaust gases will be sampled by pulling a known flowrate out of the stack via a series of pitot tubes and through a filter medium to remove components of interest. Routinely the filters will be replaced and placed into sample containers. The sample containers will be transferred to the SMA for bar coding and logging onto the data record system. The samples will then be transferred to an external facility for analysis.

TABLE 1 (CONTINUED)
WRAP 2A SAMPLE REQUIREMENTS

4. SMA Operation

A. The Sample Management Area consists principally of a sample enclosure and a laboratory area. The sample enclosure will be equipped to lift a 55 gallon drum into the area, de-lid the drum, take a sample of the waste, re-lid the sampled drum, place the drum into an empty 83 gallon drum and relid the 83 gallon drum so that it can be returned to storage. The laboratory area will be where samples are bar coded and logged onto the data record system. The area will also have four sample fume hoods, two for the handling of active samples and two for the handling of inactive samples. The sample fume hoods will be equipped to perform any simple analysis work required or to be used for repacking samples for transfer out of WRAP 2A.

4.1 Drum Sampling

A. The drum to be sampled will be placed on a lift table below the 55 gallon drum entry port in the sample enclosure. The simple double lid port above the drum is opened and the drum raised partly into the enclosure using the lift table. The drum hoist picks up the drum and places it on the drum band removal, de-lidding and sample extraction station. The enclosure simple double lid entry port is then closed and the drum lid removed. A sphincter port is opened to allow the sample container to be posted into the enclosure. A sample of the waste is extracted and the sample container posted back out of the enclosure for transfer to an external analytical facility. The 55 gallon drum is re-lidded and then an empty 85 gallon drum is placed below the enclosure simple double lid entry port. The 85 gallon drum is de-lidded and the 55 gallon drum is placed in the 85 gallon drum using the enclosure hoist. The 85 gallon drum is then re-lidded and the overpacked 55 gallon drum is returned to the external storage facility.

4.2 Sample Handling

A. Non-radioactive samples will be transported to the SMA in standard sample containers. Radioactive samples taken out of Zone 1 areas will be transported to the SMA in shielded sample pigs. These will be collected in racks and will be delivered by manual powered hand cart. Samples which require analysis by external analytical facilities but which do not require repackaging will be bar coded and logged onto the data record system prior to dispatch. Samples which require repackaging or analysis within the SMA will be placed in the designated sample fume hood. The fume hoods will be positioned and labelled so that there is a clear distinction between the active and inactive fume hoods. In addition the inactive fume hoods will not be equipped to handle shielded sample pigs. The SMA will be manned by competent laboratory personnel and therefore further physical methods of preventing samples being treated in the wrong fume hood will not be necessary.

WASTE RECEIVING AND PROCESSING FACILITY

TITLE: **STUDY 1604-3**
WASTE MIXING TECHNIQUE EVALUATION

Revision: 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A **Raytheon** Company
Western Operations

STUDY 1604-3
WASTE MIXING TECHNIQUE EVALUATION

Prepared by: _____ Date: 5/12/93

Reviewed by: _____ Date: 5/14/93

Approved by: _____ Date: 1/7/94

Approved by: _____ Date: 1/7/94
Project Manager

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APPENDIX A VENDOR CONTACTS

GLOSSARY

Blending: The intermingling of miscible fluids to produce some degree of uniformity.

Coating: Layering of one material to cover another.

Emulsification: The creation of a mixture consisting of a liquid dispersed in an immiscible liquid in droplets of larger than colloidal size.

Homogeneity: A measure of the uniformity of structure or composition throughout the sampled material.

Impeller: The terms paddle, impeller and agitator are used interchangeably in this study to describe wetted portions of the mixer in contact with waste and binder.

Laminar (Viscous) Flow: Condition or Flow in which particles of the liquid follow separate non-intersecting paths with little or no eddying or turbulence.

Mixing: The production of uniformity between materials that may or may not be miscible.

Mixing Horsepower: Measures actual power transmitted from impeller to fluid.

Mixing Intensity: For the purposes of this study it is a measure of energy per unit volume of mixed materials.

Mixing Time: Time required to perform mixing operation to obtain an acceptable product, i.e. process objectives achieved.

Particle Dispersion: The state of a mixing process which relates to the degree of diffusion of solids throughout the mixing tank. (i.e. measure of radial dispersion of solids.)

Particle Suspension: The state of a mixing process which at a minimum lifts solids off the bottom of the mixing tank. (i.e. measure of axial dispersion of solids.)

Pumping Capacity: Volume flow rate of material to be mixed measured normal to the face of the impeller.

Residence Time: Time required to vibrate size reduced solids in a binder matrix to achieve process objectives, i.e. eliminate voids.

Shear Rate: Instantaneous rate of change of velocity at a particular point in the fluid measured as the slope of the velocity gradient.

Transition Flow: Intermediate flow regime which displays properties of laminar and turbulent flow.

Turbulent Flow: Condition of flow in which particles of liquid follow randomly intersecting paths. In addition to the main flow path eddy flows and independent flow streams may break off eddy and/or return to the main flow.

1.0 OBJECTIVE

This study will evaluate screened methods to mix waste with an immobilization binder. Various in-drum and out-of-drum mixing techniques will be studied to determine advantages and disadvantages of each. The study will recommend mixing option(s) which will handle all waste feedstreams currently identified for WRAP 2A.

1.1 Scope

A. Perform literature search of equipment/technologies relating to stirred, vibro and tumbling mixing and other methods.

B. Review work at industrial sites and other DOE facilities.

C. Contact and research equipment vendors.

D. Establish a file source for vendor and DOE facility data. (Includes performance/cost/configuration).

E. Identify general requirements for mixing process variables and describe ranges of mixer operation related to waste/binder physical properties to allow initial screening of each identified mixing option.

F. Evaluate each screened equipment option based upon standardized criteria.

G. Identify potential modifications to drum holder/liners, mixer blades, blade attachment, anti-flotation and anti-vortex devices, etc. for the selected alternatives.

H. Evaluate the relative merit of in-drum vs. out-of-drum mixing.

1.2 Background

A. Due to the diversity of waste feedstreams processed in WRAP 2A, techniques to mix these wastes in an immobilization binder that meets disposal criteria is critical in the overall processing scheme. The WRAP 2A CDR proposes two types of in-drum mixing techniques to mix grout or polymer binder with the various feedstreams. Finely divided particulates in dry or wet sludge form are to be mixed with grout or polymer using agitated or stirred techniques. Large particulates (greater than 2" x 2") from shredding operations or other large forms such as lead bricks or crushed HEPA filters are to be encapsulated in binder using in-drum vibratory techniques. The purpose of vibratory mixing techniques is to eliminate air pockets or void spaces in the monolith during macro encapsulation of the waste.

B. This study will address an array of other mixing options which would allow micro or macro encapsulation of WRAP 2A feedstreams to meet waste disposal requirements. The advantages and disadvantages of each technique will be weighed with respect to developmental status, flexibility to exceed waste performance specifications waste minimization, systems throughput, design construction impacts, safety, operations, maintenance, and capital cost. A recommendation will be proposed for a preferred mixing alternative, including mixer blades/agitator design recommendations.

C. This study will investigate mixing alternatives for three immobilization binders:

1. Grout

2. Thermoset Polymers

3. Thermoplastic Polymers

D. Each binder will be evaluated with respect to appropriate in-drum or out-of-drum mixing techniques. This study will interface closely with the single immobilization option (Study #1) and the Waste Form Qualification (WFQ) treatability study impacts (Study #2) to assess the feasibility of each immobilization option. The Open/Sort/Size Reduction study will provide input to this study for Size Reduced Waste Feedstream particle size and geometry. This study will also interface with equipment demonstration/testing programs.

E. The following CDR Design Review comments will be addressed in this study:

Comment #	Comment
25	Studies required to determine the relative merits of in-drum vs. out-of-drum mixing
206	Evaluate In-drum vs. out-of-drum mixing for immobilization

1.3 Purpose and Need

A. The waste mixing techniques evaluation study is necessary to define mixing operation as a function of waste type and immobilization binder. Until a final immobilization option or options are selected that is capable of handling all WRAP 2A waste feedstreams, the waste mixing evaluation will cover a broad spectrum that identifies current commercialized techniques for each binder type. This study, in combination with the WFQ treatability work, will have specific input into the single immobilization option binder study for all waste feedstreams. Also, in combination with the single immobilization study, an integrated waste treatment system employing mixing techniques recommended in this study will be developed.

B. Issues related to waste mixing which require further definition in the study are listed below. The effects of, and potential resolution of these issues will be addressed in Section 7.4.

1. Container configuration (free board, joints, etc.).

2. Mixer blade and blade attachment design details.

3. Use of drum liners.

4. Preload sequence (waste, binder, or mixer paddle). Reference Section 5.1.1.A.3 and .7.

5. Dealing with "Sinkers" or "Floaters".

2.0 SUMMARY

2.1 Purpose of Study

A. This waste mixing technique evaluation study is necessary to define the preferred mixing operation (equipment and procedures), as a function of waste type and immobilization binder, to be utilized to initiate WRAP 2A Title Design.

2.2 Preferred Alternative and Basis for its Selection

A. The study has developed mixing techniques which must be related to binder and waste stream. It was determined that no single technique is acceptable for all feedstreams regardless of the binder utilized. The basis for the selection of the preferred alternatives was, primarily, accumulated scoring on the following evaluation criteria: Potential hazards, operability, maintainability/reliability, demonstrated technology/development requirements, capital cost, process flexibility, waste mixing effectiveness, and waste minimization. This was ultimately supplemented by the requirement to accommodate all waste feedstreams. Approximately 19 volume % of WRAP 2A feedstreams are size reduced materials which cannot be treated by any of the evaluated techniques. To treat these streams it was necessary to re-introduce vibratory mixing which had earlier been screened from evaluation due to limited application to the population of all waste feedstreams.

B. The technical changes to the CDR baseline which are recommended based upon evaluation findings are summarized as follows:

1. The vacuum draw system will not be utilized as a mixing option. However, it will be retained for potential use in free water removal from the top of treated polymer drums.

2. The five existing single shaft agitators will be increased in horsepower as identified in the study. Additionally one will be revised for use as a high speed disperser.

3. The vibratory mixers will be utilized as identified in the CDR baseline without change.

4. Impeller configurations will be adapted as identified in the evaluation.

C. Table 2-1 provides the summary matrix of preferred alternative mixing techniques as selected by this study.

TABLE 2-1
PREFERRED MIXING TECHNIQUE ALTERNATIVES

PREFERRED ALTERNATIVE WITH GROUT BINDER						
EQUIPMENT TYPE/WASTE FORMS		DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
CONFIGURATION:	Single Shaft Agitator Mixer (In Drum)	■ Preferred feedstream #'s 7 & 8 Potential feedstream #'s 1B, 2A, 5B, 6	■ Preferred feedstream #'s 2C Potential feedstream #'s 1C			■ Potential feedstream # 2B
SPEED RANGE:	0-350 RPM Infinitely Variable					
MOTOR:	3 Hp - Air Motor Drive					
DRIVE:	Gear Driven					
SHAFT:	7/8" Diameter, Stainless Steel Drive Shaft with Quick Release Coupling					
AGITATOR:	BNFL Style or Open Bow Tie Type or Double Blade Impeller Disposable (Lost) Paddles					
SYSTEM COST:	$3,000 (per unit)					
CONFIGURATION:	Vibrating Table (Waste In Drum)			■ Preferred feedstream #'s 1D, 3, 4 & 5D Potential feedstreams 5A & 5C	■ Preferred feedstream #'s 1D & 2D Potential feedstream #1A	
SPEED RANGE:	0-1200 RPM					
MOTOR:	Two (2) 0.8 Hp Counter Rotating Motors					
FREQUENCY:	2,400 CPM					
SYSTEM COST:	$15,000 (includes all controls) (per unit)					

Note: The preferred and potentially treatable feedstreams are distinguished for information.

Costs do not include consumables.

TABLE 2-1 (CONTINUED)
PREFERRED MIXING TECHNIQUE ALTERNATIVES

PREFERRED ALTERNATIVE WITH THERMOSET POLYMER BINDER						
EQUIPMENT TYPE/WASTE FORMS		DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
CONFIGURATION:	Single Shaft Agitator Mixer (In Drum)		■ Preferred feedstream # (1C) Potential feedstream # 2C			■ Preferred feedstream # (2B)
SPEED RANGE:	650-3200 RPM					
MOTOR:	15 Hp, 1800 RPM					
DRIVE:	Variable Speed Belt					
SHAFT:	1-3/4" Diameter, Stainless Steel Drive Shaft with Quick Release Coupling					
AGITATOR:	High Speed Disperser Type Blade in a Disposable (Lost) Configuration					
SYSTEM COST:	$6,300 (per unit)					
CONFIGURATION:	Vibrating Table (Waste In Drum)			■ Preferred feedstream # 5A & 5C Potential feedstream # 1D, 3, 4, 5D	■ Preferred feedstream # (1A) Potential feedstream # 1D, 2D	
SPEED RANGE:	0-1200 RPM					
MOTOR:	Two (2) 0.8 Hp Counter Rotating Motors					
FREQUENCY:	2,400 CPM					
SYSTEM COST:	$15,000 (includes all controls) (per unit)					
CONFIGURATION:	Single Shaft Agitator Mixer (In Drum)	■ Preferred feedstream # (1B, 2A, 5B, 6) Potential feedstream 7 & 8				
SPEED RANGE:	0-350 RPM Infinitely Variable					
MOTOR:	3 Hp - Air Motor Drive					
DRIVE:	Gear Driven					
SHAFT:	7/8" Diameter, Stainless Steel Drive Shaft with Quick Release Coupling					
AGITATOR:	BNFL Style or Open Bow Tie Type or Double Blade Impeller Disposable (Lost) Paddles					
SYSTEM COST:	$3,000 (per unit)					

Note: The preferred and potentially treatable feedstreams are distinguished for information.

Costs do not include consumables.

TABLE 2-1 (CONTINUED)
PREFERRED MIXING TECHNIQUE ALTERNATIVES

PREFERRED ALTERNATE WITH THERMOPLASTIC POLYMER BINDER						
EQUIPMENT TYPE/WASTE FORMS		DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
CONFIGURATION:	Twin - Counter Rotating Shaft Extruder	■ Potential feedstreams # (1B, 2A, 5B, 6, 7, 8)	■ Potential feedstreams # (1C, 2C)			■ Potential feedstream # 2B
THROUGHPUT:	1500 lbs/hr					
MOTOR:	250 Hp DC					
SHAFT:	Stainless Steel					
AGITATOR:	Combination Mix/Extrude Screw Flights					
SYSTEM COST:	$420,000 - 530,000 (per unit) (dependent upon options)					
CONFIGURATION:	Vibrating Table (Waste In Drum)			■ Potential feedstream # 1D, 1D, 3, 4, 5A, 5C, 5D	■ Potential feedstreams # 1A, 1D, 2D	
SPEED RANGE:	0-1200 RPM					
MOTOR:	Two (2) 0.8 Hp Counter Rotating Motors					
FREQUENCY:	2,400 CPM					
SYSTEM COST:	$15,000 (includes all controls) (per unit)					

Note: The preferred and potentially treatable feedstreams are distinguished for information.

Costs do not include consumables.

2.3 Impact to CDR Capital Cost

A. In order to develop this cost data it must be assumed that the current process configuration and binder selections are applicable. In the current CDR 65 volume % of the waste feed is treated with thermoset polymer and the remaining 35 volume % are treated with grout. The CDR capital cost impacts are as follows:

Thermoset Polymer Process

• Upgrade 3 mixers to 3 Hp assuming low speed agitation at high viscosities. (0-350 RPM @ 120,000 cp)	$ 2625
• Upgrade 1 mixer to 15 Hp assuming slurried ion exchange resins which requires use of high speed disperser at high viscosities. (650-3200 rpm @ 120,000 cp)	$ 4425
Subtotal Thermoset Polymer	$ 7050

Grout Process

• Upgrade the mixer to 3 Hp low speed agitation. (0-350 rpm)	$ 1000
Subtotal Grout Process	$ 1000
Total CDR Capital Cost Impact	$ 8050

B. It should be noted that if a thermoplastic polymer binder is added to the process the impact to CDR capital costs must be re-evaluated in detail to account for all spinoff facility modifications. In very rough terms it requires basic mixing equipment outlays of up to $530,000. Also, since it cannot treat all waste streams, at least one other binder and its associated equipment must remain in the facility in a scaled version from the CDR baseline. This detailed analysis is not within the scope of this study. It will be addressed in the single immobilization study which will address additional material handling equipment and other associated requirements.

C. Disposable paddle costs are estimated to be from $200.00 to $500.00 per drum depending upon impeller and closure lid configurations. This data is based solely upon preliminary manufacturer's estimates. These consumable costs are not included in capital cost estimates.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Recommendations for Current Design Basis

A. The waste mixing techniques and process configurations as detailed in the CDR are to be finalized for initiation of title design with the following changes incorporated.

1. For the thermoset polymer process it is recommended that the vacuum draw system be maintained for the potential removal of free water only. It will not be utilized as a mixing option. This was based upon the systematic evaluation of the process. Three of the existing 0.5 horsepower single shaft mixers are to be upgraded to 3 horsepower and the fourth is to be replaced with a 15 horsepower high speed disperser.

2. For the grout process the existing single shaft mixer is to be upgraded from 1 horsepower to 3 horsepower.

3. All stirred mixers will incorporate lost paddle systems.

4. The impeller configurations will be: BNFL paddle, open bow tie, or double impeller type for low RPM use and disperser type for the high RPM machine.

5. The vibratory mixers identified in the CDR baseline are acceptable as is.

6. If the CDR baseline is modified to include thermoplastic polymers a counter rotating twin screw extruder is recommended for the waste forms identified in **Table 2-1**.

7. The required horsepowers are provided by vendors based upon test data for their impellers and the estimated material physical properties provided. Data for the BNFL anchor style impeller is not available and estimated horsepowers which are derived from previous BNFL experience must be verified by testing.

B. Recommendations for supporting work.

1. Testing of surrogate wastes with various agitator configurations is imperative to finalize agitator selection and mixer motor sizing and to initiate details of drum/agitator interface.

2. Additional tests of surrogate wastes and binder formulations should be performed utilizing vibratory techniques to assess required binder viscosities.

3.2 Conclusions

A. In general, the CDR baseline has been validated by this study The proposed systems performed acceptably in the following eight evaluation areas:

1. Potential Hazards - Potential for operator dose uptake or injury.

2. Operability - Ease of operation, clean-up, set up, and adjustment of mixing parameters.

3. Maintainability/Reliability - Evaluation of maintenance frequency and difficulty.

4. Demonstrated Technology/Development Requirements - Demonstrated experience within commercial or DOE arena.

5. Capital Cost - Relative ranking of estimated capital cost.

6. Process Flexibility - Capability to use equipment with multiple binders or waste forms.

7. Waste Mixing Effectiveness - Ability to meet or exceed current waste performance specification.

8. Waste Minimization - Minimization of secondary waste volumes.

A detailed discussion of the evaluation process is provided in Section 6.4. The summary of relative scoring is provided, by binder, in Tables 6-5, 6-6 and 6-7, and is accompanied by Detailed Discussion as appropriate.

B. The following specific conclusions have also been demonstrated:

1. Stirred Techniques: Based upon the subject evaluations the stirred mixing technique utilizing a single shaft agitator and lost paddle generated the highest combined score for grout and thermoset polymer binders. However, it was eliminated for use with thermoplastic polymer binders. This technique scored as high or highest in all areas of evaluation except for technology development and waste mixing effectiveness. The lower technology development score was due to the limited use of lost paddle techniques in the states. However, the method has been researched extensively and used successfully by BNFL. The lower score on mixing effectiveness resulted from comparison to extremely intensive mixers such as double planetary types. The use of single shaft mixers with disposable or lost paddles is clearly demonstrated as being the most simplistic, adaptable and operationally effective means to provide waste/binder mixing in WRAP 2A for all waste feedstreams except size reduced materials. The preloaded waste and lost paddle is the most effective means possible for limiting equipment contamination. The single shaft agitation equipment has been widely used and is easily understood, operated, and maintained. Continued testing and refinement of waste feedstream unknowns and waste/binder formulations will allow development of one or more impeller (paddle) configurations and further optimization of the process.

2. Vibratory Techniques: As noted earlier, vibratory techniques provide the only acceptable means of disposing of size reduced wastes in grout or thermoset polymer binders. It is acceptable, but not preferred, for use with thermoplastic polymer binders. This technique had been screened prior to evaluation because of its limited potential waste feed volumes. However, subsequent to the evaluation process it was reintroduced to accommodate feedstreams for which no other acceptable treatment process had been identified (see section 7.1). The vibratory process identified in the CDR baseline is acceptable.

3. Extrusion Techniques: If thermoplastic polymer binders are added to the CDR baseline, they very likely must be utilized in conjunction with other binders due to their limited waste feedstream capabilities. The acceptable waste mixing technique for particulate wastes is a counter rotating twin screw extruder. It is possible but not desirable to use vibratory techniques for oversize materials.

4.0 UNCERTAINTIES

A. This section details certain assumptions, made in support of this study, which may be questioned in the future. For the purposes of discussion they are broken down into broad categories which are intended to envelope several related topics. The categories include: Plant throughput and capital costs.

4.1 Plant Throughput

A. The assumed waste feedstream physical characteristics are listed below. Section 5.1.3 summarizes the assumptions regarding waste feedstreams volume percentages and process variables utilized in the mixing technique evaluation.

B. Other assumed waste feedstream physical properties as detailed in Section 5.2.2B.

1. Assumed viscosity range 130 - 120,000 cp.

2. Density up to 100 lbs/ft^3.

3. Ion exchange resins are to be provided in slurried form.

C. Binder Selection

1. The current CDR configuration and binder selections are assumed as correct (refer to summary in Table 2-1).

2. Thermoplastic polymer will not be utilized unless the single immobilization or waste form qualification studies indicate that grout or thermoset polymer binders cannot reliably or economically be used for all waste feedstream forms.

4.2 Capital Costs

A. Operating Expenses Using Lost Paddle: The expenses related to impeller consumption have been estimated on a per drum basis for reference only. These costs have not been included in the capital cost evaluation because they are part of the consumable costs for plant operation.

B. Operating Expenses Using Fixed Paddle: The cost of repair or replacement of reusable paddle systems have not been included in the capital cost evaluation.

4.3 Summary of Uncertainties

A. It should be noted that, aside from incorporation of thermoplastic polymers in the facility design, the final waste/binder mixture viscosity (assumed value is noted above) is the greatest uncertainty at this point. This may impact mixer motor-sizing, mixer effectiveness and, potentially, impeller sizing. Testing performed on surrogate wastes with various impeller configurations will provide the data needed to finalize these design details.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC Requirements

A. The criteria for developing waste mixing techniques for immobilization of pretreated waste in an appropriate immobilization binder shall be subject to the following FDC requirements.

1. The system must be capable of adapting to changing immobilization formulations.

2. Treated waste shall be packaged into new 55 gallon drums.

3. Feeding of dry waste materials to the mixing process shall be by conveyance system.

4. Capability shall be available for extracting samples for verification of successful treatment.

5. Capability to allow tracking of waste container contents entering the treatment areas to the exiting containers shall be provided as required per the regulations.

6. Provisions to accommodate controlled delivery systems for dry and liquid agents to support treatment shall be provided.

7. The capability to determine and control the weight of the containers of waste for disposal during treatment and addition of volume fillers as needed shall be provided.

5.1.2 Study Criteria

5.1.2.1 Immobilization Binders

A. The study will be directed at evaluating techniques for mixing pretreated waste with immobilization binders. The immobilization binders assumed to be used in this study are as follows:

1. Grout or modified cements.

2. Thermoset polymers.

3. Thermoplastic polymers.

5.1.2.2 Waste Types

A. Each type of binder and the corresponding type of waste feedstream which is solidified with a given binder will dictate the range of waste mixing techniques to be evaluated. The following types of waste feedstreams which represent, in physical terms, those to be processed in WRAP 2A will be evaluated in the study:

1. Dry particulate (powder or crystalline solids, contributing feedstreams: 1B, 2A, 5B, 6, 7, 8).

2. Wet particulate (sludge, contributing feedstreams: 1C, 2C).

3. Dry oversize or size reduced solids (2" x 2"). (Contributing feedstreams: 1D, 3, 4, 5A, 5C, 5D)

4. Wet oversize or size reduced solids (2" x 2"). (Contributing feedstreams: 1A, 1D, 2D)

5. Wet ion exchange resin beads. (Contributing feedstreams: 2B)

5.1.2.3 Mixing Techniques

A. Mixing techniques evaluated will be specific to the type of waste and the type of immobilization binder used to solidify the waste. In general, the mixing techniques can be separated into one of two general mixing philosophies:

1. In-drum mixing.

2. Out-of-drum mixing.

B. In-drum mixing is defined to be mixing that takes place in a new standard 55 gallon drum. This type of mixing can be further divided into mixing where waste is preloaded into drums and/or binder is preloaded. The method by which the waste or binder is delivered to the 55 gallon drum will depend on the sequence of addition.

C. Out-of-drum mixing is defined as mixing that takes place outside of the 55 gallon drum which is used as the final disposal package for the solidified and immobilized waste feedstream. Out-of-drum mixing will be specific to the type of waste and immobilization binder employed (e.g., use of heated extruders for mixing of waste and thermoplastic polymer binder).

5.1.2.4 Mixing Alternative Study Matrix

A. The following matrix gives the mixing options considered for this study as a function of type of waste and type of immobilization binder.

In-Drum Mixing Techniques X Out-of-Drum Mixing Techniques O			
Immobilization Binder	**Grout**	**Thermoset Polymer**	**Thermoplastic Polymer**
Waste Type			
1. Dry particulate	X,O	X,O	X,O
2. Wet particulate	X,O	X,O	X,O
3. Dry size reduced/oversized	X,O	X (Note 1)	X (Note 1)
4. Wet size reduced/oversized	X,O	X (Note 1)	X (Note 1)
5. Wet ion exchange resin (slurried)	X,O	X,O	X,O

Note 1: Out of drum mixing techniques for dry or wet size reduced/oversized solids with polymer binders was not considered due to an inability to identify specific applicable equipment types from vendor and literature sources.

5.1.2.5 Mixing Process Objectives

A. The overall objective of the mixing system is to provide a homogeneous mixture of waste and binder. The mechanisms used to obtain this overall objective can be broken down into six distinct mixing process objectives:

1. Blending of Waste and Binder: This objective is required for all wastes and binders where the ingredients must be uniformly mixed to the extent required to allow any chemical reactions required for solidification of the binder or interaction between binder and waste to allow chemical stabilization of the waste. This objective is relevant only to grout or thermoset binders.

2. Coating of Waste with Binder: coating is a mixing mechanism that requires encapsulation of each waste particle. The coating may be microencapsulation, as in the case of small particulate waste, or macroencapsulation as required for large lead bricks. Coating is typically applicable only to physical encapsulation binders such as thermoset or thermoplastic binders.

3. Waste Particle Suspension in Binder: Waste particulates tend to settle and compact in the mixing vessel due to gravity. This objective attempts to provide the degree of mixing required to suspend the waste particles in the binder. The degree of particle suspension can vary from producing motion of all particles along the vessel bottom to having a uniform vertical suspension of all particles throughout the drum, irrespective of particle size. The former condition is required to set in motion preloaded waste in-drum and is, therefore, applicable to all in-drum stirred mixing applications where preloaded particulate waste is used. The particle suspension mixing objective (i.e. degree of axial dispersion of solids) will be applicable to all binders.

4. Waste Particle Dispersion in Binder: Particulate waste may tend to agglomerate after homogenization and repack of the waste for final solidification. This is particularly true of preloaded particulate waste in-drum. The mixing process must be capable of breaking up the agglomerated waste into its original particle constituents and dispersing the waste in the binder matrix (i.e. radial dispersion of solids). Particle dispersion is a process objective for any binder used to solidify waste that has potential particulate agglomerates.

5. Elimination of Free Water in Binder: In cases where the waste may contain excess or free water, the mixing process must be capable of dispersing the water throughout the matrix so that it can be encapsulated within the matrix or vaporized and removed as vapor. This mechanism is only applicable to thermoset or thermoplastic binders where water is not required for chemical reaction. Thermoset polymers will require a dispersion of water into an emulsion of fine water droplets which approach the waste particle size. Thermoplastic polymers require enough mixing to promote intimate contact between the hot binder and water to promote vaporization and offgassing of the water.

   The assumption that free liquids may be present in the waste prior to immobilization must be validated by further feedstream characterization data. Currently, this study assumes that Feedstream 2A, rinsed ion exchange resins, will be received as a 20 wt% solids slurry. This waste may be treated in several ways as is discussed in Section 6.4.1.8 waste minimization. The waste may be dewatered prior to or during immobilization which will produce a waste water stream which must be treated as a potential primary waste stream. The water could be absorbed onto an absorbant such as diatomaceous earth, but doing so will increase the primary waste volume considerably. The final option is to treat the water with the ion exchange resins in a single immobilization step where free water is emulsified in the polymer matrix.

   It is assumed in this study that any waste feedstream category that is designated as "wet" may potentially contain unabsorbed free water. Even if the sludge repack area uses additional absorbant to absorb free water during repack, there is always the potential for free water to separate during standing while the repacked drums await immobilization. This conservative assumption may be modified as additional feedstream characterization data becomes available.

6. Filling of Waste Void Space with Binder: Size reduced waste material may have large or irregular shapes which have significant void space. This type of material will be encapsulated using vibro-mixing techniques rather than stirred mixing. Generally, void space filling process objective requirements will be applicable to all three binders when used with vibro-mixing

B. The six mixing process objectives described above can be related to specific mixing variables for each combination of waste category and binder Two of the most critical mixing variables are mixing intensity and residence time. Residence time is stirring or vibrating time depending on the application. It is possible to have one or more mixing process objectives for each combination of waste and binder. **Table 5-1** is a matrix which indicates the primary mixing objectives for each combination as well as listing an estimated range of residence times and agitation or vibration intensities as provided by literature sources (Reference 9).

TABLE 5-1
MIXING PROCESS OBJECTIVES AND RANGES OF MIXING VARIABLES

WASTE CATEGORY	MIXING OBJECTIVES/ MIXING VARIABLES	GROUT	THERMOSET POLYMERS	THERMOPLASTIC POLYMERS
Dry Particulate	Objective*	1) 3) 4)	3) 2) 4)	3) 2) 4)
	Intensity (Hp/ft^3)	3)	2)	2)
	Agitation Time (Min)	2)	1)	1)
Wet Particulate	Objective*	1) 3) 4)	3) 2) 4) 5)	3) 2) 4) 5)
	Intensity (Hp/ft^3)	3)	2)	2)
	Agitation Time (Min)	2)	2)	3)
Dry Size Reduced/Oversized	Objective*	6)	6)	6)
	Intensity (Hp/ft^3)	1)	1)	1)
	Vibration Time (Min)	2)	2)	2)
Wet Size Reduced/Oversized	Objective*	6)	6) 5)	6) 5)
	Intensity (Hp/ft^3)	1)	2)	2)
	Vibration Time (Min)	2)	2)	3)
Ion Exchange Resins	Objective*	1) 3) 4)	5) 2) 3) 4)	5) 2) 3) 4)
	Intensity (Hp/ft^3)	3)	2)	2)
	Agitation Time (Min)	2)	2)	3)
Lead Bricks**	Objective*	2)	2)	2)
	Intensity (Hp/ft^3)	1)	1)	1)
	Vibration Time (Min)	1)	1)	1)

Objectives:
1) Blending
2) Coating
3) Particle Suspension
4) Particle Dispersion
5) Elimination of Free Water
6) Elimination of Void Space

Intensity Ranges:***
1) Low: Up to .03 Hp/ft^3
2) Med: .03 to .08 Hp/ft^3
3) High: >.08 Hp/ft^3

Agitation or Vibration: Time Requirement
1) Short: 0 - 10 Min
2) Med: 10 - 20 Min
3) Long: > 20 Min

Notes:

* Objectives listed in order of priority

** Lead bricks are considered part of dry size reduced/oversized waste type for physical characterization.

*** Mixing intensity ranges as taken from reference 9 are as follows:
1) Low: Low to moderate power, up to 0.6 Kw/m^3
2) Med: Moderate to high power, 0.6 to 2 Kw/M^3
3) High: High to very high power, > 2 Kw/M^3

5.1.3 Screening and Evaluation Criteria

5.1.3.1 Screening Criteria

A. The screening criteria are used to eliminate alternatives from further consideration or detailed evaluation. These criteria are defined as follows:

1. Functional Criteria ("Shalls")

   Existing FDC and other mandatory requirements should be identified in this section. In particular, relevant waste performance specifications should be detailed (eg. voidage, compressive strength, leachability, free liquids). These criteria are "go/no-go" criteria - they must be complied with to allow an option to go on to further (relative) assessment.

2. Preliminary Screening

   Mixing options will be screened initially from the many mixing techniques available industrially or commercially. This screening will judge the ability of the mixing equipment to handle solids with physical characteristics similar to that expected for the WRAP 2A feedstreams. The mixing systems will be screened based upon the following criteria:

   a. Demonstrated commercial or industrial use in a similar full scale or pilot application.

   b. Versatility of the mixing system to handle a moderately diverse range of waste form physical characteristics. This is defined to be at least three or more physical waste forms as identified in the study matrix.

   c. Ability of mixing system to process a minimum of 50% of the total WRAP 2A waste feedstream volume throughput as shown in attached Table 5-2.

   d. Refer to Section 6.0 for details of the preliminary screening process.

3. No Justification for Further Evaluation

   If a study identifies any alternatives which clearly using engineering judgement do not merit further evaluation, then these alternatives can be eliminated at this stage providing a full justification can be made to support the elimination.

   A screening on the basis of engineering judgement for selected mixing techniques is given in Section 6.3, List of Screened Alternatives. This screening judges potential use of an immobilization binder with each mixing technique. Matrixes showing the screened mixing techniques as a function of binder are given in Tables 6-2 and 6-3 in Section 6.1.

TABLE 5-2
WRAP 2A FEEDSTREAM PHYSICAL CHARACTERISTICS SUMMARY

WRAP 2A Feedstream		Dry Particulate	Wet Particulate	Dry Size Reduced/ Oversized	Wet Size Reduced/ Oversized	Ion Exchange Resins	Lead Bricks[2]
1A	183 H Solidified Liquid				20,625 (2.8%)		
1B	183 H Crystalline Solid	32,500 (4.5%)					
1C	183 H Sludge		35,000 (4.8%)				
1D	183 H Miscellaneous Cleanup			4,813 (0.7%)	4,813 (0.7%)		
2A	Ammonium Sulfate	261,500 (36.1%)					
2B	Ion Exchange Resins					53,500 (7.4%)	
2C	Metal Sludge		76,250 (10.5%)				
2D	RO Filter Elements				8,750 (1.2%)		
3	Dry Active Waste			52,500 (7.2%)			
4	Construction Debris			28,875 (4.0%)			
5A	Mercury/Mercury Contaminated Waste			12,900 (1.8%)			
5B	Reactive Metals	440 (<0.1%)					
5C	Lead/Lead Contaminated Waste			735 (0.1%)			11,764 (1.6%)
5D	Miscellaneous Metals			3,035 (0.4%)			
6	Absorbed Chemicals	42,500 (5.9%)					
7	Incinerator Ash	57,500 (7.9%)					
8	Contaminated Soils	17,000 (2.3%)					
TOTAL[1]		411,440 (56.8%)	111,250 (15.3%)	102,858 (14.2%)	34,188 (4.7%)	53,500 (7.4%)	11,764 (1.6%)

Notes:

1 Values are FT^3 volume
Values in ( ) are volume %

2 Lead bricks are considered part of the dry sized reduced/oversized waste type for physical characterization

3 _____ streams to be treated with grout per CDR baseline

5.1.3.2 Evaluation Criteria

A. All alternatives which are not eliminated by the first level evaluation, progress for further consideration using a predetermined list of evaluation criteria. Each individual evaluation criteria is given:

1. A weighting factor.

2. A range of raw scores reflecting the potential relative merits of the alternative.

B. Scoring is calculated by multiplying the raw score selected and the weighting factor.

C. Evaluation criteria, weighting, and scoring factors.

1. Potential Hazards

a. Weighting Factor: 10%

b. Scoring Factor:

All processes have some potential hazards to be considered during the evaluation, however, all processes must be acceptably safe. Factors to consider include operator dose exposure; potential for operator injury; potential for leaks, spills or uncontrolled releases; potential for dropping objects; and potential for flammable or hazardous gas generation.

Best	5
Good	4
Average	3
Below Average	2
Marginal	1

2. Operability

a. Weighting Factor: 10%

b. Scoring Factor:

Assessment of ease of operation and ability to adjust mixing parameters without excessive operator intervention. Also includes ability to clean-up equipment between batch operations or on a scheduled interval as well as ease of startup and shutdown of mixing equipment.

Best	5
Good	4
Average	3
Below Average	2
Marginal	1

3. Maintainability/Reliability

   a. Weighting Factor: 10%

   b. Scoring Factor:

Evaluation of the equipment maintenance requirements in terms of minor routine servicing or major equipment changeout due to equipment failure. The frequency of major equipment servicing or changeout will be related, to a large extent, to equipment reliability.

Best	5
Good	4
Average	3
Below Average	2
Marginal	1

4. Demonstrated Technology/Development Requirements

   a. Weighting Factor: 20%

   b. Scoring Factor:

Evaluation of the current status of technology development for a mixing configuration. Rating is based upon past experience in a similar application and potential for further development if significant uncertainties are identified. Similar experience is related to waste form, binder, and equipment type.

Nearly identical full scale production experience at a commercial or DOE facility	5
Similar Full Scale Production Experience at a Commercial or DOE Facility	4
Similar Pilot Scale Experience at a Commercial or DOE Facility	3
Bench Scale Experience Only	2
No Demonstrated Experience	1

5. Capital Cost

a. Weighting Factor: 10%

b. Scoring Factor:

Comparison of total estimated capital cost of proposed mixing equipment. This cost will exclude all support systems for mixing such as raw material or waste storage and feed systems as well as any secondary waste collection or treatment.

Least Capital Cost	5
Below Average Capital Cost	4
Average Capital Cost	3
Above Average Capital Cost	2
Greatest Capital Cost	1

6. Process Flexibility

a. Weighting Factor: 20%

b. Scoring Factor:

The percentage of time that the mixing equipment can operate with multiple binders and/or waste forms. This flexibility will allow a train of mixing equipment to be used more efficiently with less idle time during mixing operations.

Total Percentage of Time Equipment Can Be Used

Highest	5
Next Highest	4
Average	3
Below Average	2
Lowest	1

7. Waste Mixing Effectiveness

   a. Weighting Factor: 10%

   b. Scoring Factor:

   The capability to provide an overall homogeneous mixture by utilizing one or more of the six mixing process objectives (blending, coating, particle suspension, particle dispersion, elimination of free water, and elimination of void space).

   The ability to meet or exceed current or future anticipated waste performance specifications for product homogeneity.

Best	5
Good	4
Average	3
Below Average	2
Marginal	1

8. Waste Minimization

   a. Weighting Factor: 10%

   b. Scoring Factor:

   The overall minimization of secondary waste volume for an equivalent process system. Factors such as primary waste loadings and generation of secondary waste treatable within or outside of WRAP 2A will be considered.

Least amount of secondary waste volume	5
Below average amount of secondary waste volume	4
Average amount of secondary waste volume	3
Above average amount of secondary waste volume	2
Greatest amount of secondary waste volume	1

5.2 Assumptions

5.2.1 Study Prerequisites

A. There are no prerequisites to initiate the vendor and literature search for mixing techniques as a function of general waste type and immobilization binder.

5.2.2 Study Assumptions

A. Mixing technique evaluation will be limited to the following immobilization binders:

   1. Cement/Grout.

   2. Thermoset Polymer.

   3. Thermoplastic Polymer.

B. Waste feedstream types will be generic physical representations of the specific feedstreams identified in the CDR issued July 1992. These waste types and their physical properties will be:

1. Dry or wet particulates.

2. Dry or wet size reduced solids. (Includes solid lead bricks)

3. Wet ion exchange resins (slurried).

4. Material densities up to 90-100 lbs/ft^3 (S.G. up to 1.5)

5. Viscosities from 130 to 120,000 cp.

6. Maximum batch size 25 ft^3. This was selected based upon engineering judgement and a review of the limiting conditions of the polymer line. In order to provide a basis for review out of drum mixing must accommodate larger batch sizes than a single drum. Based upon a review of the polymer line up to three mixers could be replaced by one batch mixer.

C. Waste mixing techniques evaluated will be in-drum or out-of-drum depending on the waste type and immobilization binder. The sequence of binder, additive, or waste addition may vary depending on mixing technique. Further, it is assumed that all waste will be preloaded in drum for the in-drum mixing techniques.

D. Immobilized waste in any of the three binders must satisfy appropriate waste performance specification for disposal. This includes compliance with the following regulations:

1. Washington Administrative Code (173-303) which defines treatment and packaging of hazardous waste.

2. Hanford Site Radioactive Solid Waste Acceptance Criteria (WHC-EP-0063) which defines site specific disposal criteria. For example, internal void spaces in the solidified waste shall not exceed 10% of the final container volume.

3. EPA Land Disposal Restrictions.

E. Free liquids in the solidified waste shall not exceed 0.5% (40 CFR 265.314).

F. Results of the Waste Form Qualification test program may allow elimination of one or more immobilization binders, and corresponding mixing techniques, if test results do not meet waste performance specifications.

6.0 DESCRIPTION OF ALTERNATIVE AND SOLUTIONS

6.1 Screening of Alternatives

A. A preliminary screening of waste mixing alternatives was accomplished using the preliminary screening criteria listed in Section 5.1.3.1. The methodology used for this preliminary screening is shown in **Figure 6-1** Waste Mixing Technique Screening Logic Diagram. Listing of all potential mixing techniques available from a literature search is shown in **Table 6-1**. **Table 6-2A** is a matrix which identifies the mixing techniques which were considered for further screening as a result of the literature search. The initial screening criteria was demonstrated experience in commercial full scale or pilot operations with similar waste feedstreams as predicted for WRAP 2A. **Table 6-2B** entitled Equipment Manufacturer's capabilities and cost provides detailed information for all techniques identified in **Table 6-2A**. **Table 6-3** gives the results of the first screening.

B. The mixing techniques screened using the demonstrated experience criteria were further screened using an assessment of waste form versatility. A mixing technique passed this second screening if it was capable of use with a minimum of three or more waste types. Another criteria for this second screening was that a candidate mixing technique be capable of mixing at least 50 vol % of the total WRAP 2A feed as earlier shown on **Table 5-1**. **Table 6-4** gives the results of the final screening. The results yielded four mixing options per binder for both in-drum and out-of-drum operations. The single shaft agitator for in-drum mixing was further broken down into "with" and "without" lost paddle mixing techniques due to potential variations in the final evaluation. This gave a final result of five mixing options for grout and thermoset binders and four mixing options for thermoplastic binders that will be formally evaluated. **Table 6-4B** summarizes remaining equipment capabilities and costs.

6.2 Description of Alternatives Considered

6.2.1 Mixing Options with Grout Binder

6.2.1.1 Potential Options for In-Drum Mixing

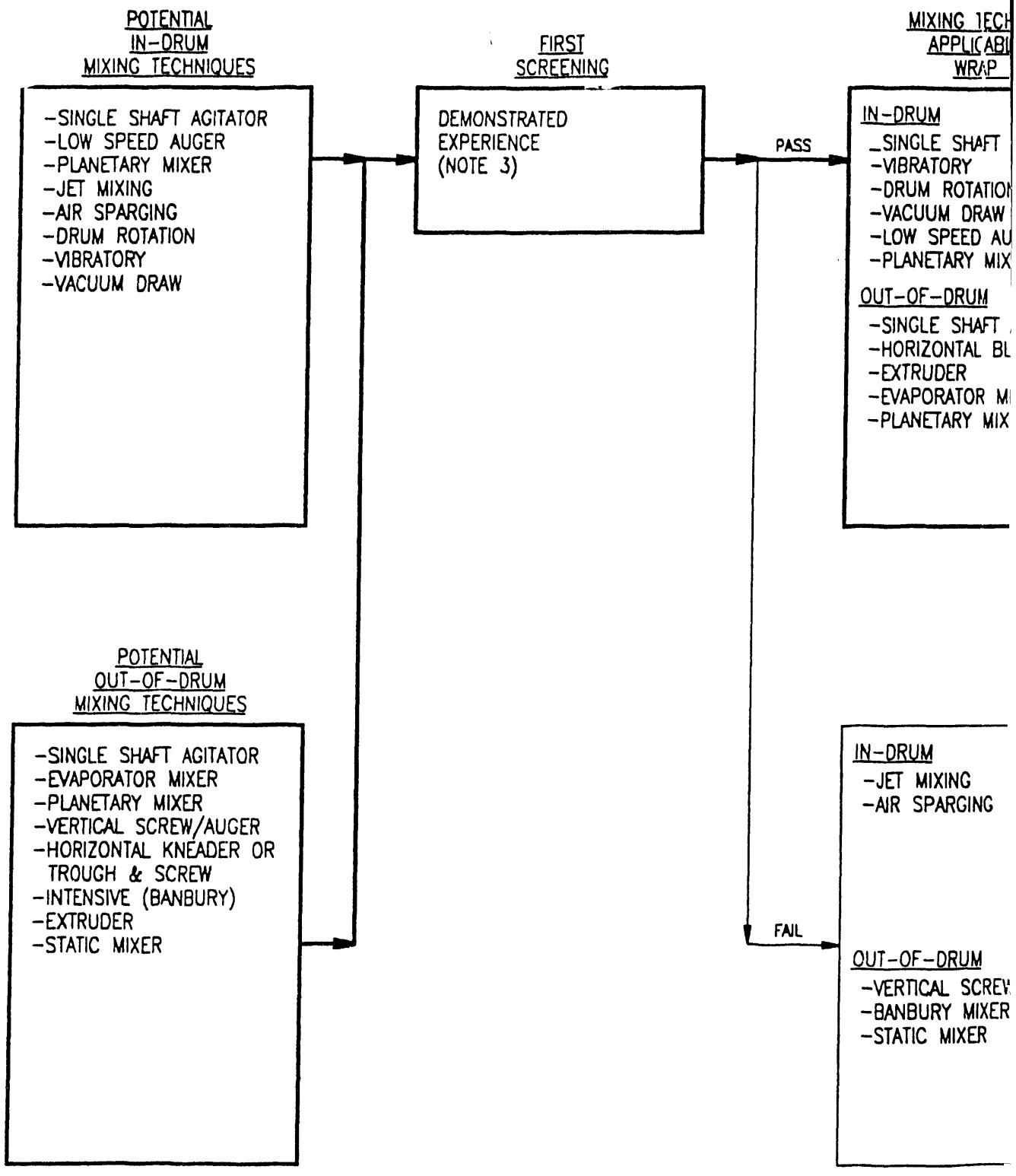
A. Agitated Mixing (Single Shaft)

<u>Description</u> (See **Figure 6-2**)

1. Based upon vendor discussions and other reviews of equipment performance this method of mixing has been most widely used at DOE sites to treat dry or wet particulate waste and ion exchange resins with grout.

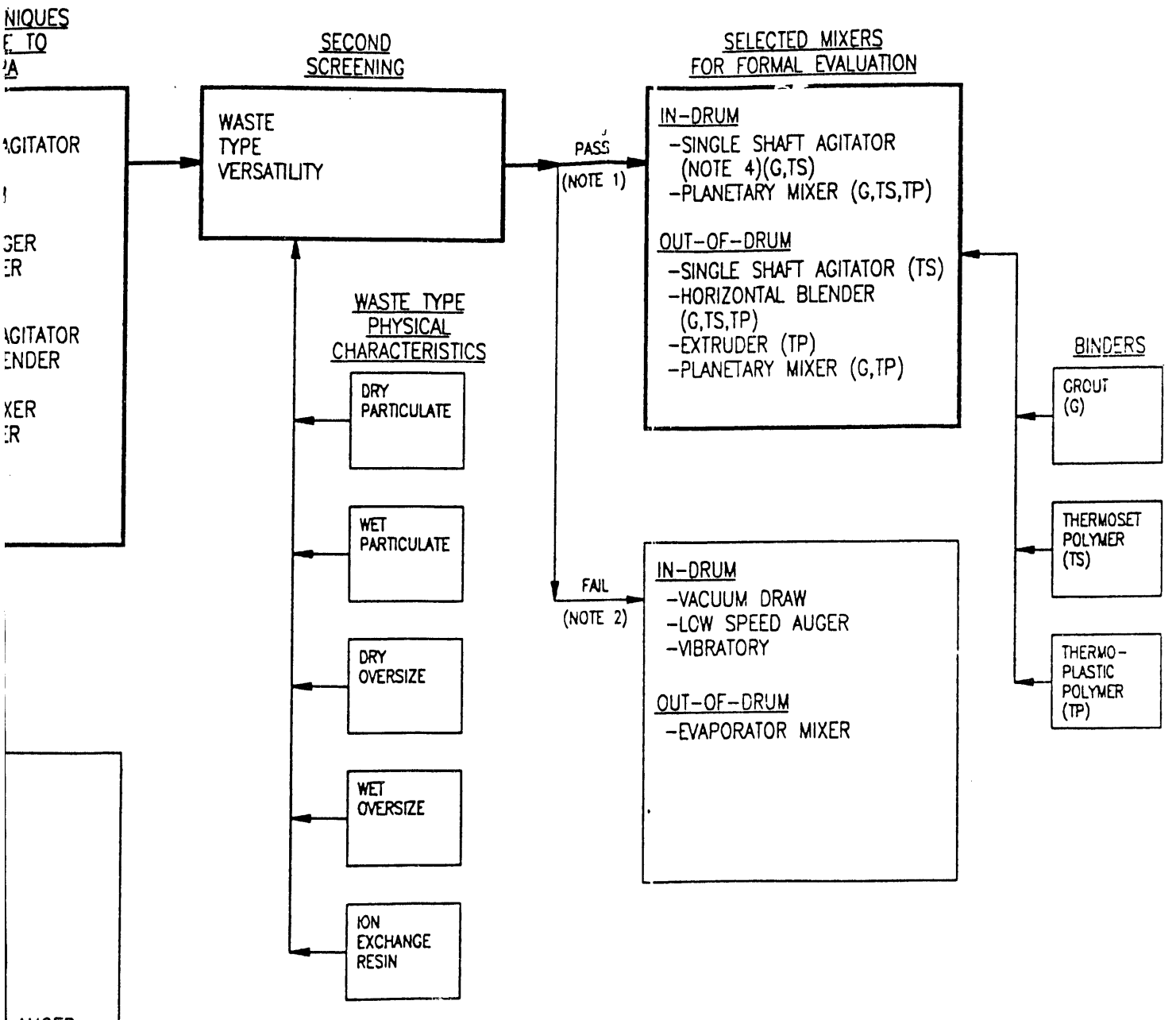
2. The agitated mixer is assembled in modular form, and consists of four major components:

   a. The drive assembly, this can be either electric or pneumatic dependent on the speed and torque requirement.



Figure

WASTE MIXING TECHNIQUE SC



NOTES

1. PASSES WASTE FORM VERSATILITY IF MIXER CAN BE USED ITH 3 OR MORE WASTE TYPES AND IS CAPABLE OF MIXING GREATER THAN 50% OF THE TOTAL WRAP 2A FEEDSTREAM VOLUME.
2. FAILS WASTE FORM VERSATILITY IF MIXER CAN BE USED WITH ONLY 2 OR LESS WASTE TYPES OR CAN NOT MIX AT LEAST 50% OF TOTAL WRAP 2A FEEDSTREAM VOLUME.
3. DEMONSTRATED EXPERIENCE WITH SIMILAR WASTE TYPES AS USED IN WRAP 2A.
4. WITH AND WITHOUT LOST PADDLE.

6-1

REENING LOGIC DIAGRAM

TABLE 6-1

POTENTIAL IN-DRUM AND OUT-OF-DRUM MIXING TECHNIQUES FOR INITIAL SCREENING

	IN-DRUM	OUT-OF-DRUM	COMMENTS
Single Shaft Impeller			
• Radial-Flow Impeller			Flow away from shaft. Baffles generally used.
- Flat Blade Turbine	P(WP,IER)	P(WP,IER)	High shear rate and turbulence i.e. gas-liquid and liquid-liquid contacting.
- Bar Turbine	P(WP,IER)	P(WP,IER)	High speed, highest shear rate.
- Anchor Impeller	P(DP,WP,IER)	P(DP,WP,IER)	High-viscosity (5000 to 50,000 cP) blending and heat transfer applications. Close radial clearances (<5% of I.D.). Crossbars used without power penalty.
• Axial-Flow Impeller			Flow parallel to shaft. Solids suspension, blending and heat transfer. Baffles may be used.
- Marine Impeller			Produces downward flow. Maximum viscosity 5000 cP for small batches (<100 gal).
- Axial-Flow Pitched Blade	P(DP,WP,IER)	P(DP,WP,IER)	Four blades @ 45 degrees. Wide range of use.
	P(DP,WP,IER)	P(DP,WP,IER)	
- Axial-Flow Variable Blade	F	P(DP,WP,IER)	Three blades, blade angle and width decrease from hub to tip. Used in large tanks.
- Double Spiral	P(DP,WP,IER)	P(DP,WP,IER)	Very high viscosity (>75,000 cP). Inner flight pumps up, outer flight pumps down.
Planetary Mixer	P(DP,WP,IER)	P(DP,WP,IER)	Two hollow blades sweep walls and wipe each other. Used for mixing thick pastes and viscous materials in laminar flow regime.
Horizontal Mixer/Blender			These are all used for mixing or processing thick pastes and viscous materials in laminar flow regime.
• Double-Arm Kneader		F	Used to mix pastes. Close clearances between blades.
• Trough and Screw		F	Used primarily for heat transfer of solids.
• Ribbon Blender		P(DP,WP,IER)	Usually used to wet out or coat a powder.
• Plow Mixer		F	High speed shaft rotation. Used to break up solids in a paste or slurry (solids dispersion).
• Pug Mill		F	Used to mix mineral and clay products.
Vertical Mixer/Blender			Generally used in laminar and transition flow regimes.
• Cone and Screw		P(DP,WP,IER)	Orbiting helical screw. Excellent low-energy blending. Reversing screw aids discharge.
• Twin-Blade Conical Mixer		F	Used to mix pastes. Close clearances between blades.
• Helical Ribbon (Low Speed Auger)		P(DP,WP,IER)	Used in polymerization reactions to achieve uniform blending.
Intensive Mixer (Banbury)		F	Used in plastics and rubber industries. Close clearances. Laminar flow regime.
Horizontal Extruder		P(DP,WP,IER)	Used primarily to mix and melt polymers. High mixing intensity. Laminar flow regime.
Evaporator Mixer		P(DP,WP,IER)	Combines liquid evaporation and mixing on rotating heated drum generally with a vacuum.
Pump Assisted			
• Jet Mixing	F		Generally used in large volume (>1000 gal) and low viscosity (<30 cP) turbulent applications.
• Static Mixer		F	Primarily used in blending of low to medium viscosity liquids.
Air Sparging	F		Air used for solids suspension if particles are not free settling.
Drum Rotation	P(IER)		Drums are rotated on drum rollers or end-over-end. Used to mix lower viscosity materials.
Vibration	P(DSR,WSR,LB)		Drums are vibrated to "in-fill" void spaces around oversized solids.
Vacuum Draw	P(IER)		Binder displaces aqueous phase surrounding solids which is drawn off by vacuum.

P = Passes DP = Dry Particulate DSR = Dry Size Reduced IER = Ion Exchange Resins
F = Fails WP = Wet Particulate WSR = Wet Size Reduced LB = Lead Bricks

TABLE 6-2A

MIXING TECHNIQUE/BINDER MATRIX

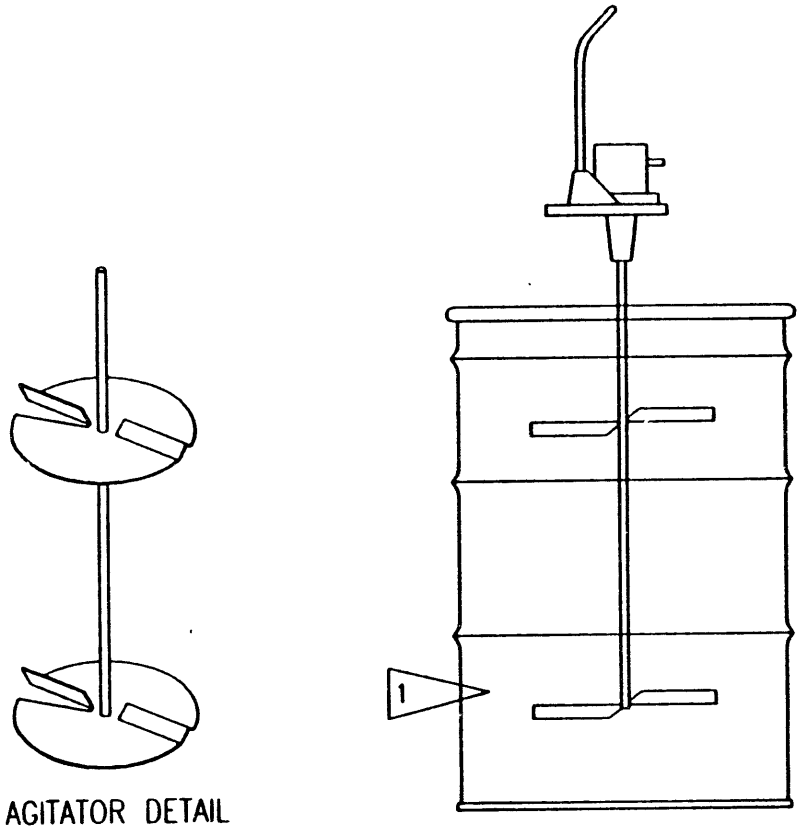
MIXING TECHNIQUE	GROUT BINDER	THERMOSET BINDER	THERMOPLASTIC BINDER
IN-DRUM			
A) Single Shaft Agitator Mixer	X	X	_
B1) Vibratory Pencil	X	_	_
B2) Vibratory Table	X	X	X
C) Drum Rotation	X	X	X
D) Planetary Mixer	X	X	X
E) Low Speed Auger	_	X	_
F) Vacuum Draw	_	X	_
OUT-OF-DRUM			
A) Single Shaft Agitator Mixer	_	X	_
B) Rotating Mixer	X	_	_
C) Horizontal Blender	X	X	X
D) Planetary Mixer	X	_	X
E) Extrusion Mixer	_	_	X
F) Thin Film Evaporator	_	_	X

X Considered for Further Evaluation (see Section 6.2)
_ Screened from Further Evaluation (see Section 6.3)

TABLE 6-2B

EQUIPMENT: MANUFACTURERS, CAPABILITY, AND COST

Manufacturer/ Equipment	Mix Method	Batch Size	Physical Properties	Equipment Capabilities	Estimated Cost	Notes
Best Model GD-0-2338-1980-6-(2) Electric Powered Vibratory Grid Deck Table	Vibratory Table	In Drum	1,000 lb. total load limit. Binder Material must flow.	2.4 CPM. 1.6 Hp. 1,000 lb. load max.	$15,000	This system is not viscosity dependent. However, binder must be able to flow.
Cleveland Vibratory	Vibratory Pencil	In Drum	Binder material must flow.	7,500 - 15,000 VPM. Up to 3 Hp. Diameter of influence up to 72". Input force up to 4,220 lbs.	$3,000	Wide range of components available.
Lightnin Model #XJA300 Air Driven Gear Drive Single Shaft Mixer	Low Speed Agitation	In Drum	Up to 120,000 CP. Up to 1.5 S.G.	0-350 RPM. Double blade impeller. 3 Hp air driven.	$3,000	Wide range of horsepower and propeller/impeller designs available.
Munson Model XHD-2-1/2-555 Horizontal Paddle Blender	Horizontal Blending	Out-of-drum 25 ft^3 SS vessel with sanitary finish	Up to 2,500 lb. batch size. 100 lb/ft^3 density. In excess of 120,000 CP.	40 RPM. 15 Hp.	$40,315	Paddle type discharge gate.
Ross HDM-55	Double planetary mixer.	Option (A) In-Drum Option (B) Out-of-Drum 25 ft^3 SS vessel	In excess of 200,000 CP. 100 lbs/ft^3	15 Hp. 3 to 1 speed. Range up to 40 RPM. Air/oil hydraulic lift.	(A) $71,143 (B) $79,211	Includes a significant number of optional items - controls and lift mechanisms.
Hayes & Stolz Belt Driven Horizontal Paddle Mixer	Horizontal Blending	Out of Drum 25 Cu Ft. Batch	Up to 2,700 lbs. 90-100 lbs. ft^3 200-120,000 CP	30 Hp.	$5,714	
Hockmeyer HV-15 High Speed Single Shaft Disperser	High Speed Agitation	In Drum	Up to 150,000 CP Up to 1.5 S.G. Densities up to 12.5 lbs/gallon	15 Hp. Variable belt drive. 600-3200 RPM. Explosion proof motor.	$6,350	Intended for use with high speed disperser blade.
Berstorff Extruder Mixer	Counter rotating twin screw extrusion.	1500 lbs/hr continuous	Up to 120,000 CP. 25-30 wt% solids max.	250 HP.D.C.	500,000 to 1,000,000	Cost is dependent upon control options.



NOTES :

1. A TWIN BLADE AXIAL FLOW IMPELLER IS SHOWN FOR REFERENCE. THE MIXER CAN BE CONFIGURED WITH MANY DIFFERENT IMPELLERS.
2. AIR DRIVE MOTOR (0-350 RPM) SHOWN.
3. 12" DIAMETER IMPELLERS ARE RECOMMENDED FOR GROUT AT A MAXIMUM.
4. 8"-10" DIAMETER IMPELLERS ARE RECOMMENDED FOR POLYMER.
5. FINAL IMPELLER DIAMETERS CAN BE OPTIMIZED WITH TESTING.

FIGURE 6-2

IN-DRUM SINGLE SHAFT AGITATOR

b. The impeller is attached to a single shaft which can be designed to cope with a large range of mixing speeds. The impellers can be interchangeable to deal with differing flow requirements.

c. The drive coupling which automatically couples and decouples to the agitator shaft in the case of "Lost Paddle" agitation. The coupling must be easily accessed for removal and cleaning of impellers if they are to be reusable.

d. The agitator mount which is designed to accommodate raising and lowering of the agitator or drum assembly. The mounting arrangement in the CDR is a fixed mixer mount which the drum is elevated to meet.

3. Equipment Specifications

a. For the purposes of discussion and costing a baseline mixer has been established which is equivalent to the CDR design basis. This mixer is a lightnin type single shaft fixed mount mixer. It is gear driven and speed is infinitely variable from 0 to 350 rpm. The manufacturer recommends an air motor because of ease of operation, simplicity and durability. This motor can be run to stall without damage.

b. This baseline equipment equipped with a 3 Hp motor and a twin blade impeller, or open bow tie impeller, can easily accommodate viscosities in excess of 120,000 centipoise, and densities of 100 lbs/ft^3. However, complete data is not available for the BNFL impeller and will have to be developed during testing to establish a relationship between the variables of horsepower, rpm, viscosity, and specific gravity.

c. The equipments' capability of dealing with size reduced materials is primarily a function of how much damage the impeller can sustain before failure and available clearance around the impeller.

d. Adequate mixing of materials which have been plated out on drum surfaces or are compacted into the corners of drum base/side intersections are difficult to quantify without direct observation. The failure to achieve complete mixing in these situations has been observed on other DOE sites. These problems can be mitigated with the use of disperser type agitators which have higher speeds and pumping capacities at the cost of higher horsepower requirements. Optionally, the process objectives may be achieved by use of an open Bow Tie or BNFL type impeller which has been designed with extremely close clearances or flexible wipers to achieve a scraping effect near the container surface. This will aid in particle suspension and ultimately particle dispersion.

e. In a limited number of situations (e.g. thermoset polymer binder with wet particulate or ion exchange resin wastes) a high speed (650-3200 RPM) mixer with an 8" diameter disperser impeller is required in order to emulsify free water and achieve complete encapsulation in the polymer. At viscosities up to 120,000 centipoise this requires a 15 horsepower motor.

f. Motor horsepowers have been increased over estimates in CDR because of current conservative assumptions with respect to viscosities. We are now using very conservative viscosities of up to 120,000 (based up WVNS data) as opposed to the original CDR estimates of 200-300 cp based upon vendor's polymer viscosities and BNFL's grout viscosities.

B. Vibratory Mixing (Referred to as mixing though actually only eliminates voids in waste form)

Description (Pencil Type see Figure 6-3A)

1. This type of vibratory mixer is inserted in the drum and directly contacts the mixing ingredients. The mixer is suitable for size reduced, oversized, and resin wastes.

2. The air powered vibrator has only one moving part, a precision ground hard chrome piston, the external vibration transmitter is an alloy steel stud that protrudes from the hand sized piece of equipment. This can be inserted into sacrificial transmission tubes that will stay with the finished product.

3. Equipment Specifications

   a. The vibrators reviewed for this study are extremely simplistic and can be provided as air or electric driven units.

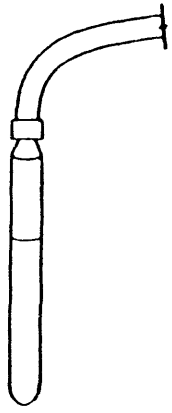
   b. Motors are available up to three horsepower.

   c. Frequencies of vibration from 7,500 to 15,000 V.P.M. are available.

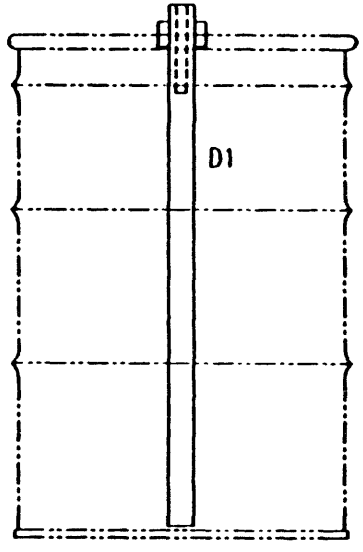
   d. Manufacturers describe the units as achieving "diameters of influence" in concrete from 14" to 72" and output or centrifugal forces from 800 to 4,220 lbs.

Description (Table Type, see Figure 6-3B)

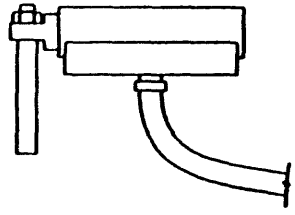
1. Vibratory tables provide external indirect mixing energy input into the drum contents and are suitable for eliminating air pockets or void spaces and limited mixing. Therefore they are more suitable for distributing grout throughout oversize or size reduced solids than intimate mixing of particulate waste.



OPTION 1



DISPOSABLE ROD

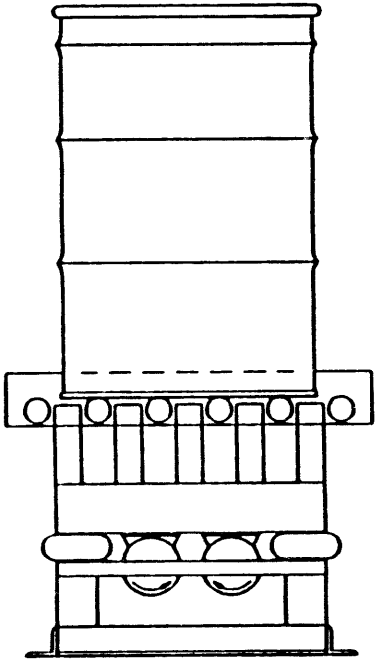


OPTION 2

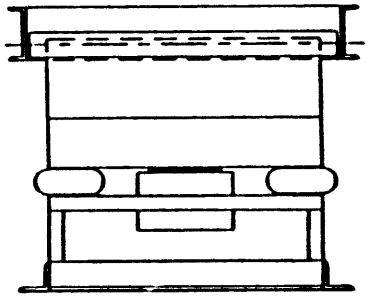
NOTE
1. OPTIONS 1 AND 2 DEPICT TWO VIBRATOR CONFIGURATION OPTIONS.

FIGURE 6-3A

PENCIL TYPE VIBRATORS



SIDE VIEW



END VIEW

NOTES :

1. TABLE USES AIR DRIVEN ECCENTRICLY WEIGHTED MOTORS

FIGURE 6-3B

IN-DRUM VIBRATING MIXING TABLE

2. A vibrating table consists of two steel fabrications; the upper component is the table, this is attached to the lower fabrication by four anti-vibration mounts. The motion is generated by two opposing motors, located on the upper fabrication. The motor shafts are fitted with adjustable concentric weights. The speed of the motor and the size of the weights determines the frequency of vibration required. The waste drum will be anchored to the surface of the table during operation.

3. Equipment Specifications

   a. For purposes of discussion and costing the mixer identified in the CDR design basis is described. The mixer is rated for a full 1,000 lb. load. It is powered by two 1,200 rpm, 0.8 horsepower each, (total 1.6 horsepower) fully adjustable counter rotating motors. The vibration frequency from each motor is approximately 2,400 cpm.

   b. It is not possible to determine viscosity ranges which can be acceptably accommodated by the equipment without direct observation. The required duration of vibration (residence time) is expected to increase as viscosities increase.

   c. The process can handle solids of all sizes which can be fit into the drum provided that they do not wedge against drum interior and prohibit binder circulation. This can be controlled by use of an inner basket to suspend material in the drum.

C. Drum Rotation

<u>Description</u>

1. Drum rotation can be used for mixing of oversize, size reduced, and other non-homogeneous waste forms. Because there is no direct mixing energy input, drum rotation is not normally suitable for mixing finely divided particulates. Additionally, it completely coats the drum interior surfaces and would plug any drum vent/filter system that may be utilized.

2. The drum rotator would initially start from a vertical position possibly receiving the drum from a conveyor system, it would than pivot through 90° to the horizontal mixing position. The preloaded drum will lie horizontally on rubber faced steel rollers. The drum may be rotated in either direction to achieve total void filling. The in-drum mixing mechanism could simply be a short length of I section steel beam.

3. Equipment Capabilities

   a. This equipment can be constructed in a variety of rpm ranges and directions of rotation.

   b. Various tests have been performed, including tests at West Valley which incorporated the use of mixing weights (angle iron) inside the drum. Various internal weldments can also be used to modify the material flow patterns while the drum is rotated. However, due to the nature of the mixing action the system is inhibited by viscosity and the level of drum fill. In extreme instances, centrifugal force rotates the contents with the drum and very little mixing is achieved.

D. Agitated Mixing (Low Speed Planetary)

<u>Description (See Figure 6-4)</u>

1. Planetary mixers were developed for highly viscous fluids and are best suited for blending dry or wet particulates or resins at relatively high waste loadings. Due to the nearly complete coverage of the drum volume with mixing agitators and close wall tolerance in the drum, this technique is an excellent prospect for mixing preloaded waste with grout.

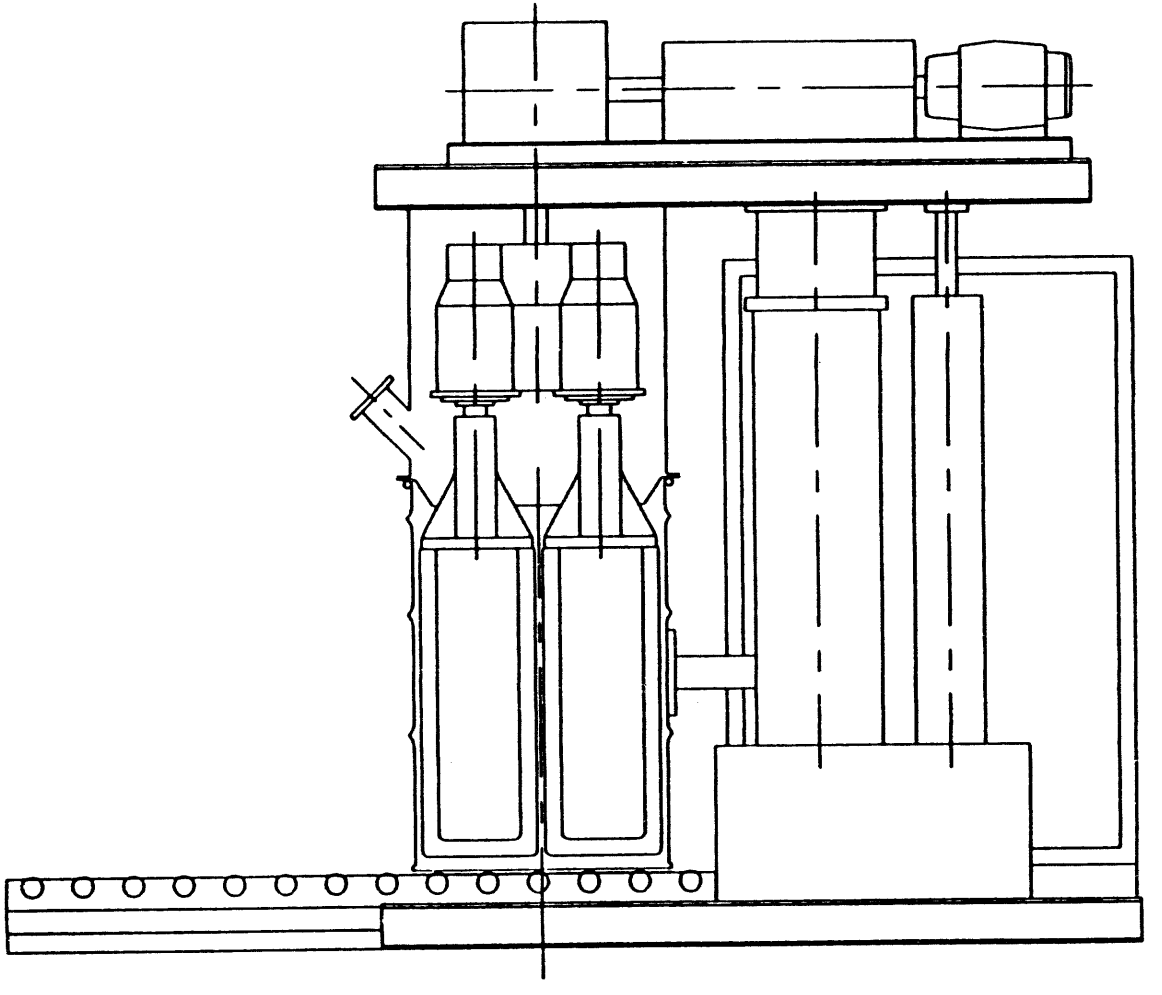
2. The planetary mixer consists of a mixing vessel which in this case will be a DOT 55 gallon drum. The double planetary mixer consists of two agitators that revolve around a common axis, the blade advances along the vessel wall and transports the material to the center of the vessel for mixing. A containment tube will seal against the 55 gallon drum and the immobilization material can be added via an inclined nozzle on the containment tube sidewall.

3. Equipment Specifications

   a. The equipment reviewed for this study can handle viscosities up to 400,000 centipoise.

   b. Speed can be varied from 12 to 40 rpm utilizing an adjustable frequency controller.

   c. Because of the close agitator blade tolerances this equipment cannot handle size reduced materials which exceed the clearance dimensions of the paddles.



NOTES :

1. IN THIS CONFIGURATION PADDLES DO NOT OVERLAP DURING MIX CYCLE. THIS IS BECAUSE THE MACHINE HAS BEEN ADAPTED FROM STANDARD GEARBOX COMPONENTS WHICH HAVE FIXED CENTERLINE DIMENSIONS.

FIGURE 6-4

IN-DRUM PLANETARY MIXER

6.2.1.2 Potential Options for Out-Of-Drum Mixing

A. Horizontal Blending

Description (See Figure 6-5)

1. Blending of non-densely packed particulate waste with grout may be applicable to this type of operation. The shear rate is higher for a horizontal blender than a standard rotating mixer due to independent agitator rotation.

2. Most horizontal blenders consist of a rigidly constructed tank with a 2:1 length to diameter ratio. An agitator will rotate within the confines of the tank. The configuration of the blades vary from standard helical, plow to paddle style dependent on application. The blades are welded to a drive shaft or tube which penetrate the walls of the hold tank where shaft seals retain the mixing compounds within the tank. The drives are designed to specific requirements. There are several alternatives for discharge techniques, all of which can be remotely operated.

3. Equipment Specifications

   a. The equipment reviewed for this study can handle viscosities in excess of 200,000 centipoise.

   b. Batch size is 25 ft^3 (for purpose of study to obtain uniform data).

   c. RPM is fixed at 40, however, the drive can be modified with a frequency control to operate over a 3 to 1 speed range.

   d. This equipment can be purchased in any batch size, power range, and with a variety of agitator configurations.

   e. The ability to deal with size reduced material is limited by agitator to mix vessel clearances.

B. Rotating Mixing

Description

1. Rotating mixers with fixed blades using simple vessel rotation are commonly used to mix concrete or cement formulations. Therefore this technique is probably most applicable to large "aggregate" size particulates or shredded waste.

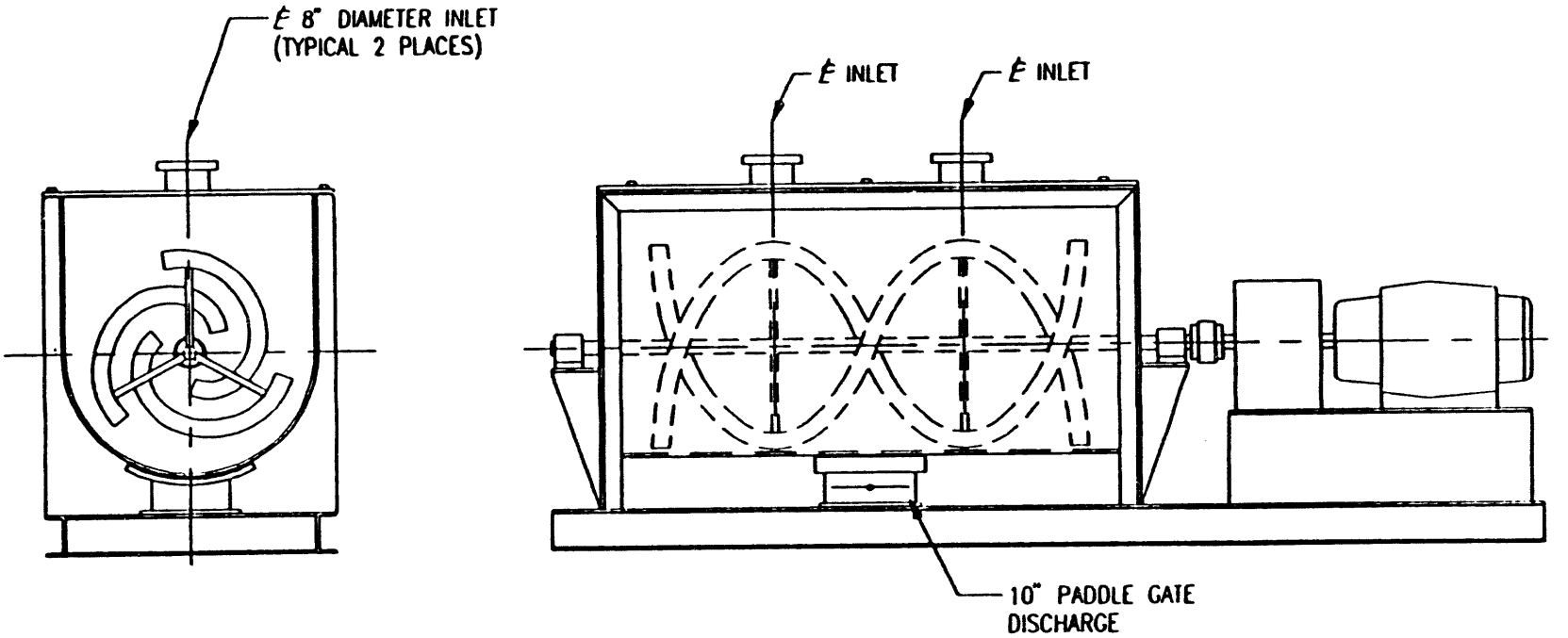


FIGURE 6-5

OUT-OF-DRUM HORIZONTAL BLENDER

2. The rotating mixer differs from the horizontal blender in that the blades and the vessel rotate together and it is the tumbling action that completes the mixing. The equipment is supported on a rigid frame, the rotating drum is held by adjustable journal roller assemblies. The feed spouts are positioned in the non-rotating component. The shape of the vessel ends promote directional flow into the main chamber. The mixer is driven by a conventional fan cooled motor with a chain drive to the mixing drum sprocket.

3. Equipment Capabilities

   a. This equipment can be configured to roll longitudinally or tumble.

   b. For the purposes of this study we assumed a batch capacity of approximately 25 ft^3.

   c. The effectiveness the mixing process can be facilitated by baffles or other internal weldments in the mixing vessel. It is possible to procure a rotating mixer with an independently driven internal agitator.

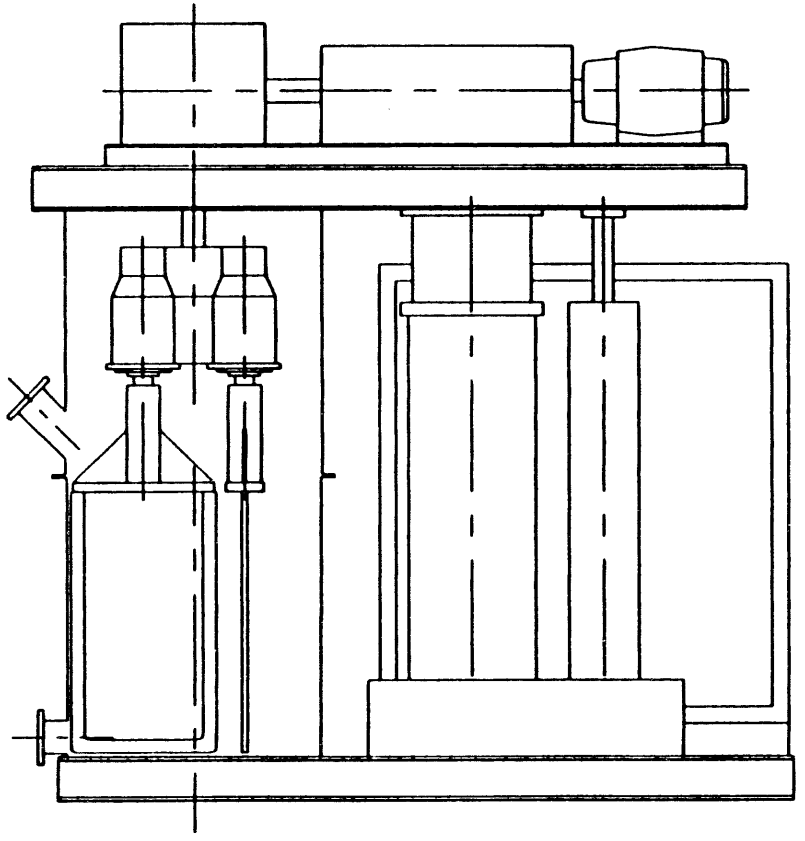
C. Agitated Mixing (Low Speed Planetary)

<u>Description (See Figure 6-6)</u>

1. Similar to in-drum planetary mixing system except that mixing vessel is a prefabricated container capable of holding custom mixing batches. Removal of grout/waste mixture can be accomplished by pumping or hydraulic ram assembly.

2. Equipment Specifications

   a. With this system the manufacturer can optimize the mixing vessel and mixing paddle configuration. The optimum configuration utilizes paddles that are roughly square ($l/d = 1$). This allows the use of standard gearing and components to achieve a design where the paddles overlap the vessel centerline with each pass. Therefore, the paddles wipe each other as they rotate and leave no undisturbed areas in the mixing vessel. Deviation from standard design may increase costs, lower efficiency and reduce reliability.



NOTES :

1. IN THIS CONFIGURATION PADDLES OVERLAP DURING MIX CYCLE.

FIGURE 6-6

OUT-OF-DRUM PLANETARY MIXER

6.2.2 Mixing Options with Thermoset Polymer Binder

6.2.2.1 Potential Options for In-Drum Methods

A. Agitated Mixing (Single Shaft)

Description

1. Similar to the agitated mixing system for grout. If utilized at high RPM's with a disperser type impeller it is well suited for mixing wastes with high water content with polymer such as wet sludge or ion exchange resin. This is due to the high shear rate emulsification of water into fine droplet sizes which are more efficiently encapsulated. Sequence of addition (i.e. fluidizing waste prior to binder addition) is more significant here due to polymer set times which are much shorter than grout.

2. Equipment Capabilities

   a. This equipment is similar to the agitated mixing equipment described for grouting operations. However, for use with thermoset binders it will probably be run at different RPM's and with different impeller configurations. The final RPM/impeller configuration requires direct observations of the mixing process to support equipment selection.

B. Vibratory Mixing (Table Type)

Description

1. Similar to vibrating table for grout. The oversize or size reduced waste is preloaded in-drum and catalyzed thermoset polymer is added during drum vibration to eliminate air pockets.

2. Equipment Specification

   a. There is no basis for equipment performance requirements that are any different than those established for grouting operations.

C. Drum Rotation

Description

1. Similar to grout drum rotation method except that the polymer catalyst may require segregation in the sealed drum. This could be done by loading the catalyst in friable capsules that would allow polymer activation after initiation of the drum rotation.

2. Equipment Capabilities

   a. Identical to grout binder equipment.

D. Agitated Mixing (Planetary)

Description

1. Identical to planetary mixing system proposed for grout. Low shear rate mixing is best applied to dry or slightly moist particulate waste at relatively high waste loadings providing a highly viscous mixture. This type of mixing operation will not emulsify large amounts of water and would not be suitable for high water content wastes such as ion exchange resins. We take this position assuming that ion exchange resins are received in a 20 wt% solids slurry form for treatment. Refer to mixing process objectives Section 5.1.2.5.

2. Equipment Specification

   a. Identical to grout binder equipment.

E. Agitated Mixing (Low Speed Auger)

Description

1. This mixing system, developed by Stock Equipment Co., has been used exclusively for mixing non-dense dry particulate waste such as incinerator ash with low viscosity VES polymer resin. The apparatus uses a low shear rate polymer coating technique and is not capable of emulsifying high water concentrations. All past mixing experience with this system has dealt with preloaded polymer resin in 55 gallon drums. The fragile construction of the mixer wiping blades is not designed for high viscosity binders or wastes.

2. The waste container is a standard DOT 17H 55 gallon drum which is preloaded with a mixer tube containing a fixed mixing helix. A wiper blade attached to the tube serves as an anchor and stirrer. Catalyst in friable capsules is preloaded into the agitator tube and the drum is prefilled with promoted VES resin. Waste is added through a filler nozzle in the drum lid center. After initiating mixing tube rotation catalyst is released. The waste is then fed through the rotating mixing tube and is forwarded out the bottom for mixing with catalyzed polymer.

F. Vacuum Dewatering

Description

1. The vacuum dewatering system, developed by Diversified Technologies, is designed specifically for dewatering and solidifying ion exchange resins with VES polymer resin. The system is capable of use with standard 55 gallon drums or large liners up to 200 ft^3 in volume. There is effectively no increase in treated waste volume since the polymer merely displaces water occupying the interstitial space between resin beads.

2. Premixed catalyzed polymer is distributed as a layer on top of the resin bed. As the polymer is added, a vacuum drawn from the vessel bottom pulls the polymer through the resin bed thoroughly coating all resin beads. Displaced water flows from the vessel to a collection drum for separate disposal.

6.2.2.2 Potential Options for Out-Of-Drum Methods

A. Agitated Mixing (Single Shaft)

Description

1. Dry or wet particulate wastes or wet ion exchange resins are mixed with thermoset polymer in a large capacity agitated mixing vessel. The polymer is not catalyzed during the bulk mixing with waste. The catalyst is added downstream of the primary mixing vessel. Potential methods for mixing catalyst with the polymer coated waste include another mixing vessel, static mixer, or in-line transfer pump. The downstream mixing vessel could be a disposable 55 gallon drum.

2. Equipment Capabilities

   a. This equipment is identical to grouting equipment except for differences in operating parameters as noted earlier. (i.e. Emulsification of water will require a combination of higher speeds, greater mixing intensity and/or longer residence time).

B. Horizontal Blender

Description

1. Similar to grout blending with particulate type waste or dewatered resins. However, due to the relatively low speed mixing provided by this type of equipment, there is little emulsification of water present in wet particulate waste.

2. Equipment Capabilities

   a. This equipment is identical to grouting equipment.

6.2.3 Mixing Options with Thermoplastic Polymer Binder

6.2.3.1 Potential Options for In-Drum Methods

A. Vibratory Mixing (Table Type)

Description

1. Heated thermoplastic polymer is added to a 55 gallon drum containing preloaded oversize or shredded waste. The vibratory device is exterior to the drum such as a vibratory table. Supplemental heat is added to the drum during the mixing process.

2. Equipment Specification.

   a. This equipment is identical to grouting equipment (excluding supplemental heating).

B. Agitated Mixing (Low Speed Planetary)

Description

1. Heated thermoplastic polymer is added to a 55 gallon drum for mixing with dry or moist particulate waste using stirring or agitation. The waste can be preloaded in-drum or added gradually with the binder to the drum. Supplemental heat is added to the drum during mixing.

2. Equipment Specification.

   a. This equipment is identical to grouting equipment (excluding supplemental heating).

C. In-Drum Rotation Mixing

Description

1. Heated thermoplastic polymer and dry particulate or size reduced waste are added to a 55 gallon drum. The drum is sealed and rotated on a mechanical device. Supplemental heat is added during mixing. Wet wastes cannot be processed due to the difficulty of removing water vapor.

2. Equipment Capabilities.

   a. This equipment is identical to grouting equipment (excluding supplemental heating).

6.2.3.2 Potential Options for Out-Of-Drum Methods

A. Extrusion Mixing

Description (See Figure 6-7)

1. Thermoplastic polymer and dry or wet particulate waste or ion exchange resins are mixed in a heated extruder. Single and twin screw (co-rotating or counter rotating) are available and provide a tradeoff of cost, mixing effectiveness and flexibility. Vented extruders provide removal of steam or other volatiles. The extruded polymer encapsulated waste is discharged to a 55 gallon for subsequent cooling and solidification as a monolith.

2. Equipment Specification: For the purposes of this study the following parameters were utilized:

   a. The extruder is provided with a 250 horsepower DC motor.

   b. 1500 lbs/hr maximum is the material discharge rate assuming approximately 40 weight % polyethylene.

   c. Large size reduced material cannot be accommodated beyond equipment clearances.

   d. The extruder was configured with twin - counter rotating screws.

   e. Cost estimates include integral screw feeders for input of waste and binder.

B. Thin Film Evaporation Mixing

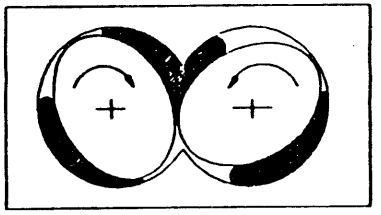
Description

1. Dilute waste (less than 25 to 30 wt% solids) and thermoplastic polymer are mixed in a thin film on the internal surface of a heated evaporated vessel. The large surface area of the vessel provides extensive heat transfer capabilities for vaporization of water. Mixing of the binder and waste occurs through use of a mechanical rotor which wipes the vessel surface. Encapsulated waste discharges by gravity flow to a 55 gallon drum for cooling and solidification.

C. Agitated Mixing (Low Speed Planetary)

Description

1. Particulate wastes and heated thermoplastic polymer is mixed in a large capacity agitated mixing vessel. The mixing vessel is heat jacketed and agitated by use of a high torque planetary type mixing impeller. Mixed polymer and waste are removed from the mixing vessel using gravity flow or a hydraulic ram assembly depending on viscosity.



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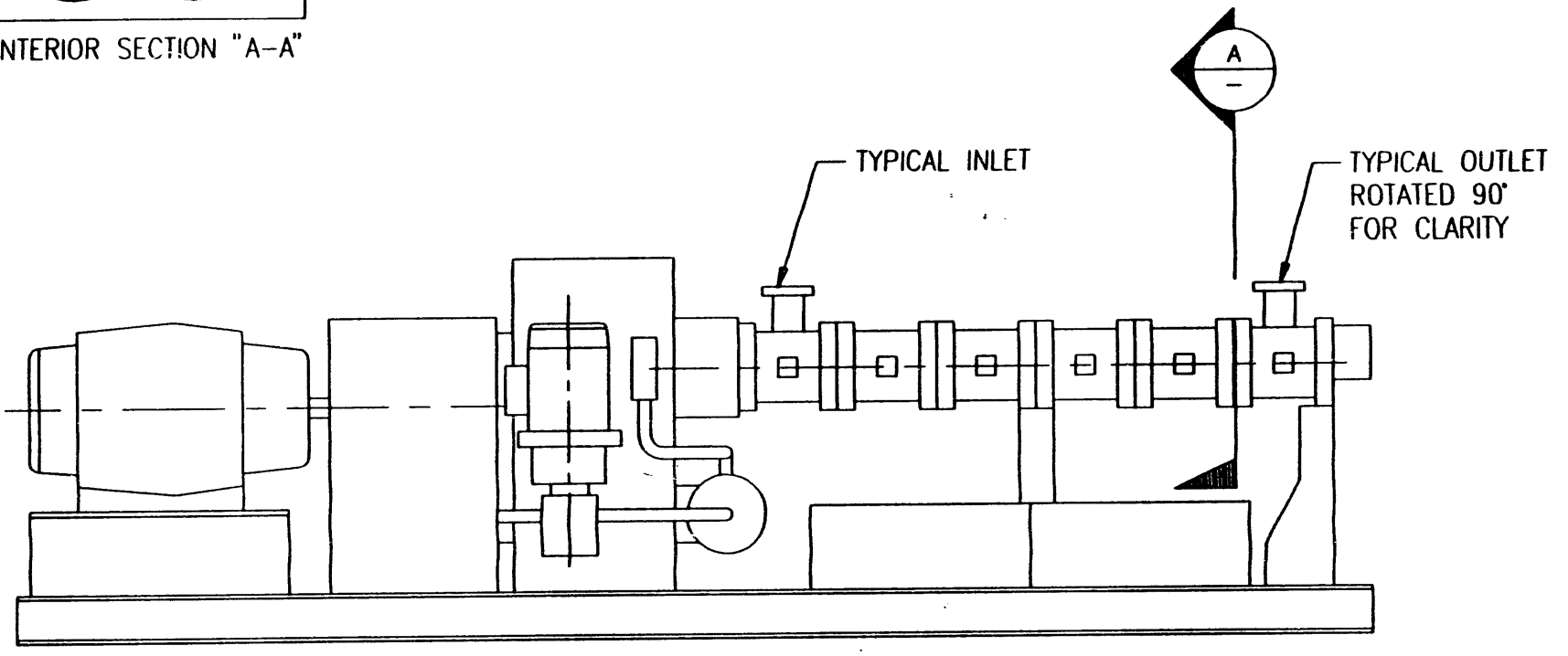

FIGURE 6–7

EXTRUDER/MIXER

2. Equipment Specifications.

   a. Identical to grouting equipment (excluding supplemental heating).

D. Horizontal Blender

Description

1. Similar to grout blending with particulate waste types. Horizontal blending tank can be heat jacketed as well as the agitator if it is of a spiral or helical design. Discharge to a 55 gallon drum could be accomplished by tilting of the blending tank and simultaneous operation of the agitator.

2. Equipment Capabilities.

   a. Identical to grouting equipment (excluding supplemental heating).

6.3 List of Screened Alternatives

6.3.1 Alternatives Screened Based Upon Demonstrated Technology

A. The following mixing alternatives were screened from further consideration based upon an engineering judgement and demonstrated technology assessment. This assessment judges the practicality of using selected mixing techniques with various binders. Refer to **Table 6-1** in Section 6.1 for a matrix of alternatives screened from further consideration as discussed in the following assessments.

6.3.1.1 Grout Mixing Options

6.3.1.1.1 In-Drum Options

A. Vacuum Draw

1. Not considered due to the inherent high viscosity of grout/water binder mixture and lack of any applicable experience.

B. Low Speed Auger

1. System designed specifically for low viscosity thermoset polymers and is not compatible with abrasive grout mixtures.

TABLE 6-3

MIXING OPTIONS FROM INITIAL SCREENING

MIXING OPTIONS WITH GROUT BINDER

EQUIPMENT TYPE/WASTE FORMS	DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
IN-DRUM					
SINGLE SHAFT AGITATOR MIXER	■	■			■
VIBRATORY TABLE			■	■	■
VIBRATORY PENCIL			■	■	■
DRUM ROTATION			■	■	
PLANETARY MIXER	■	■			■
OUT-OF-DRUM					
HORIZONTAL BLENDER	■	■			■
ROTATING MIXER			■	■	
PLANETARY MIXER	■	■			■

MIXING OPTIONS WITH THERMOSET POLYMER BINDER

EQUIPMENT TYPE/WASTE FORMS	DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
IN-DRUM					
SINGLE SHAFT AGITATOR MIXER	■	■			■
VIBRATORY TABLE			■	■	■
DRUM ROTATION			■	■	
PLANETARY MIXER	■	■			■
LOW SPEED AUGER	■				
VACUUM DRAW					■
OUT-OF-DRUM					
SINGLE SHAFT AGITATOR MIXER	■	■			■
HORIZONTAL BLENDER	■	■			■

MIXING OPTIONS WITH THERMOPLASTIC POLYMER BINDER

EQUIPMENT TYPE/WASTE FORMS	DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
IN-DRUM					
VIBRATORY MIXER			■	■	■
PLANETARY MIXER	■	■			■
DRUM ROTATION	■		■		
OUT-OF-DRUM					
EXTRUSION MIXER	■	■			■
THIN FILM EVAPORATOR		■			■
PLANETARY MIXER	■	■			■
HORIZONTAL BLENDER	■	■			■

Note: See process descriptions for each equipment type for further explanation of type of waste form applicable to a given mixing process.

6.3.1.1.2 Out-Of-Drum Options

A. Single Shaft Agitating Mixer

1. Not considered due to the difficulty of using this arrangement to mix high specific gravity slurries in large volumes without moving the mixer throughout the vessel or providing for a recirculation loop on the vessel.

B. Extrusion

1. Grout mixture is too coarse and abrasive for extruder mechanical tolerances.

C. Thin Film Evaporator

1. Water evaporation is not appropriate since water is required for grout hydration.

6.3.1.2 Thermoset Polymer Mixing Options

6.3.1.2.1 In-Drum Options

A. Vibratory Pencil

1. Not considered due to high potential for significant operational problems should resin contaminate vibrating mechanism. Additionally, there is no known use of the equipment in this manner and vibratory effects on polymer are entirely unknown.

6.3.1.2.2 Out-Of-Drum Options

A. Planetary Mixer

1. Ruled out due to the high surface area of the mixer paddles, shafts and other rotating elements which present a significant potential for polymer resin build up, and are quite difficult to clean. Also, planetary mixers are not capable of the free water emulsification, required for encapsulation in polymer.

B. Rotating Mixer

1. Not considered due to the high surface area of the mixer internals which present a significant potential for polymer resin buildup. Also, reliable mechanical sealing of polymer vapors would be difficult to attain.

C. Extrusion

1. Ruled out due to low viscosity of polymer resin and low likelihood of an extruder successfully feeding the liquid resin.

D. Thin Film Evaporator

1. Vaporization of volatiles in resin would occur during waste drying.

6.3.1.3 Thermoplastic Polymer Mixing Options

6.3.1.3.1 In-Drum Options

A. Vacuum Draw

1. Eliminated due to high temperature required to maintain polymer in molten form causing potential flashing of water and inability to maintain vacuum.

B. Low Speed Auger

1. This custom modified mixing system for thermoset polymers is not designed to operate in a high temperature, high viscosity mixing environment.

C. Single Shaft Agitating Mixer

1. Ruled out due to high inherent high viscosities of thermoplastic which is better suited for planetary agitated mixing.

D. Vibratory Pencil

1. Eliminated due to high potential for significant operation problems should thermoplastic contaminate vibrating mechanism. Additionally, there is no industry experience with this system.

6.3.1.3.2 Out-Of-Drum Options

A. Rotating Mixer

1. Not considered due to high surface area of the mixer internals surface area and potential for significant polymer buildup.

B. Single Shaft Agitating Mixer

1. Eliminated due to high thermoplastic viscosity better handled via planetary mixing.

6.3.2 Alternatives Screened Based Upon Waste Type Versatility

A. The following mixing techniques were screened out based upon the inability to handle at least three or more waste physical characteristics or were unable to mix at least 50 volume % of the total WRAP 2A throughput.

6.3.2.1 Grout Mixing Options

6.3.2.1.1 In-Drum Options

A. Vibratory Table and Pencil

1. Ruled out due to the limited capability of handling only 26.3 volume % of the WRAP 2A feed in the form of dry and wet size reduced solids and ion exchange resins.

B. Drum Rotation

1. Eliminated since this technique can handle only dry and wet size reduced solids which comprise only 18.9 volume % of the WRAP 2A waste feed.

6.3.2.1.2 Out-of-Drum Options

A. Rotating Mixer

1. Ruled out for the same reason as the in-drum drum rotation mixing method.

6.3.2.2 Thermoset Polymer Mixing Options

6.3.2.2.1 In-Drum Options

A. Vibratory Table

1. Ruled out due to the maximum throughput capability of only 26.3 volume % of total WRAP 2A feed.

B. Low Speed Auger

1. Eliminated due to demonstrated experience with only a single waste type, i.e. dry particulate solids. Also, no experience with preloaded waste in-drum.

C. Vacuum Drum

1. Ruled out for inability to handle more than one waste type, ion exchange resins, which comprise only 7.4 volume % of the total feed.

6.3.2.3 Thermoplastic Polymer Mixing Options

6.3.2.3.1 In-Drum Options

A. Drum Rotation

1. Not considered due to applicability to only two different waste physical characteristics comprising only 18.9 volume % of WRAP 2A waste feed.

6.3.2.3.2 Out-of-Drum Options

A. Thin Film Evaporation

1. Screened out since this technique is applicable to only dilute wet particulate or ion exchange waste forms.

6.4 Detailed Discussion

6.4.1 Evaluation of Alternatives

A. Those options which were recommended as a result of the preliminary screening process (**Table 6-4**) advanced to formal evaluation. This evaluation was performed using the evaluation criteria listed in Section 5.1.3.2. This criteria and the corresponding weighting factors are listed as follows:

		Weighting Factor
1.	Potential Hazards	10%
2.	Operability	10%
3.	Maintainability/Reliability	10%
4.	Demonstrated Technology	20%
5.	Capital Cost	10%
6.	Process Flexibility	20%
7.	Waste Mixing Effectiveness	10%
8.	Waste Minimization	10%

TABLE 6-4

MIXING OPTIONS FROM FINAL SCREENING

MIXING OPTIONS WITH GROUT BINDER

EQUIPMENT TYPE/WASTE FORMS	DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
IN-DRUM					
SINGLE SHAFT AGITATOR MIXER (1)	■	■			■
PLANETARY MIXER	■	■			■
OUT-OF-DRUM					
HORIZONTAL BLENDER	■	■			■
PLANETARY MIXER	■	■			■

MIXING OPTIONS WITH THERMOSET POLYMER BINDER

EQUIPMENT TYPE/WASTE FORMS	DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
IN-DRUM					
SINGLE SHAFT AGITATOR MIXER (1)	■	■			■
PLANETARY MIXER	■	■			■
OUT-OF-DRUM					
SINGLE SHAFT AGITATOR MIXER (2)	■	■			■
HORIZONTAL BLENDER	■	■			■

MIXING OPTIONS WITH THERMOPLASTIC POLYMER BINDER

EQUIPMENT TYPE/WASTE FORMS	DRY PARTICULATE	WET PARTICULATE	DRY SIZE REDUCED	WET SIZE REDUCED	ION EXCHANGE RESIN
IN-DRUM					
PLANETARY MIXER	■	■			■
OUT-OF-DRUM					
EXTRUSION MIXER	■	■			■
PLANETARY MIXER	■	■			■
HORIZONTAL BLENDER	■	■			■

NOTES: (1) With and without lost paddle
(2) Without lost paddle

C. **Tables 6-5, 6-6 and 6-7** summarize the waste mixing evaluation scoring comparison for grout, thermoset polymer, and thermoplastic polymer binders, respectively.

D. The following section gives a detailed description of the methods used to assign relative scores to each evaluation criteria. The scoring follows the scoring factors listed in Section 5.1.3.2.

6.4.1.1 Potential Hazards

In this evaluation, the five factors that describe the potential for hazardous operation are described in Section 5.1.3.2. Evaluation criteria are scored for each of the three binders using both in-drum and out-of-drum mixing devices. All five factors were weighted equally and the average score was "rounded" to the nearest whole number.

A. Grout Binder

1. The detailed evaluation of potential hazards for grout binder is shown in **Table 6-8.**

a. Grout Binder with In-Drum Mixing

1) Single Shaft Agitator with Lost Paddle: The "lost paddle" agitator includes the use of a prefitted lid with integral fill ports. Assuming that the waste is remotely preloaded into the drum and the drum is sealed prior to removal from confinement and transfer to the grouting area, this method minimizes operator exposure and the potential for operator injury, as well as the potential for leaks, spills or other gross contamination. This results in an average raw score of 5.

2) Single Shaft Agitator without lost Paddle: The reusable paddle may require cleaning and/or adjustment between uses. Also it implies the drum may be opened during and after mixing operations and a contaminated fill head/paddle assembly must be placed in the next drum. This increases potential for contamination and operator dose uptake. This results in an average raw score of 4.

3) Planetary Mixer: This mixer is similar to the single shaft reusable paddle mixer with respect to the potential for contamination when transferring a new drum to the mixer area. However, the operator dose exposure and potential for operator injury are greater than the reusable paddle. Therefore, the average raw score for the planetary mixer is 3.

TABLE 6-5

WASTE MIXING EVALUATION SCORING COMPARISON - GROUT BINDERS

	EVALUATION CRITERIA	POTENTIAL HAZARDS	OPERABILITY	MAINTAINABILITY /RELIABILITY	TECHNOLOGY DEVELOPMENT	CAPITAL COST	PROCESS FLEXIBILITY	WASTE MIXING EFFICIENCY	WASTE MINIMIZATION	TOTAL
	WEIGHTING FACTOR	10%	10%	10%	20%	10%	20%	10%	10%	100%
IN-DRUM MIXING EQUIPMENT	NOTE 1									
SINGLE SHAFT AGITATOR WITH LOST PADDLE	RAW SCORE	5	4	5	4	5	3	3	5	
	ADJUSTED SCORE	0.50	0.40	0.50	0.80	0.5	0.60	0.30	0.50	4.10
SINGLE SHAFT AGITATOR WITHOUT LOST PADDLE	RAW SCORE	2	3	4	5	5	3	3	4	
	ADJUSTED SCORE	0.20	0.30	0.40	1.00	0.50	0.60	0.30	0.40	3.70
PLANETARY MIXER	RAW SCORE	2	3	2	4	2	5	4	3	
	ADJUSTED SCORE	0.20	0.30	0.20	0.80	0.20	1.00	0.40	0.30	3.40
OUT-OF-DRUM MIXING EQUIPMENT	NOTE 2									
HORIZONTAL BLENDER	RAW SCORE	3	2	2	4	3	5	5	2	
	ADJUSTED SCORE	0.30	0.20	0.20	0.80	0.30	1.00	0.50	0.20	3.50
PLANETARY MIXER	RAW SCORE	3	3	2	2	2	3	5	2	
	ADJUSTED SCORE	0.30	0.30	0.20	0.40	0.20	0.60	0.50	0.20	2.70

NOTES: 1. ASSUMES WASTE PRELOADED IN DRUM
2. ASSUMES WASTE ADDED SIMULTANEOUSLY WITH OR AFTER BINDER

TABLE 6-6

WASTE MIXING EVALUATION SCORING COMPARISON - THERMOSET POLYMER BINDERS

	EVALUATION CRITERIA	POTENTIAL HAZARDS	OPERABILITY	MAINTAINABILITY /RELIABILITY	TECHNOLOGY DEVELOPMENT	CAPITAL COST	PROCESS FLEXIBILITY	WASTE MIXING EFFICIENCY	WASTE MINIMIZATION	TOTAL
	WEIGHTING FACTOR	10%	10%	10%	20%	10%	20%	10%	10%	100%
IN-DRUM MIXING EQUIPMENT	NOTE 1									
SINGLE SHAFT AGITATOR WITH LOST PADDLE	RAW SCORE	4	3	5	4	5	3	3	4	
	ADJUSTED SCORE	0.40	0.30	0.50	0.80	0.50	0.60	0.30	0.40	3.80
SINGLE SHAFT AGITATOR WITHOUT LOST PADDLE	RAW SCORE	2	2	4	3	5	3	3	3	
	ADJUSTED SCORE	0.20	0.20	0.40	0.60	0.50	0.60	0.30	0.30	3.10
PLANETARY MIXER	RAW SCORE	2	2	2	2	2	5	3	2	
	ADJUSTED SCORE	0.20	0.20	0.20	0.40	0.20	1.00	0.30	0.20	2.70
OUT-OF-DRUM MIXING EQUIPMENT	NOTE 2									
SINGLE SHAFT AGITATOR WITHOUT LOST PADDLE	RAW SCORE	2	1	4	4	5	2	5	1	
	ADJUSTED SCORE	0.20	0.10	0.40	0.80	0.50	0.40	0.50	0.10	3.00
HORIZONTAL BLENDER	RAW SCORE	2	1	2	1	3	5	4	1	
	ADJUSTED SCORE	0.20	0.10	0.20	0.20	0.30	1.00	0.40	0.10	2.50

NOTES: 1. ASSUMES WASTE PRELOADED IN DRUM
2. ASSUMES WASTE ADDED SIMULTANEOUSLY WITH OR AFTER BINDER

TABLE 6-7

WASTE MIXING EVALUATION SCORING COMPARISON - THERMOPLASTIC POLYMER BINDERS

	EVALUATION CRITERIA	POTENTIAL HAZARDS	OPERABILITY	MAINTAINABILITY /RELIABILITY	TECHNOLOGY DEVELOPMENT	CAPITAL COST	PROCESS FLEXIBILITY	WASTE MIXING EFFICIENCY	WASTE MINIMIZATION	TOTAL
	WEIGHTING FACTOR	10%	10%	10%	20%	10%	20%	10%	10%	100%
IN-DRUM MIXING EQUIPMENT	NOTE 1									
PLANETARY MIXER	RAW SCORE	2	2	2	1	2	5	3	3	
	ADJUSTED SCORE	0.20	0.20	0.20	0.20	0.20	1.00	0.30	0.30	2.60
OUT-OF-DRUM MIXING EQUIPMENT	NOTE 2									
HORIZONTAL BLENDER	RAW SCORE	2	1	2	4	3	5	4	2	
	ADJUSTED SCORE	0.20	0.10	0.20	0.80	0.30	1.00	0.40	0.20	3.20
PLANETARY MIXER	RAW SCORE	2	1	2	2	2	3	4	2	
	ADJUSTED SCORE	0.20	0.10	0.20	0.40	0.20	0.60	0.40	0.20	2.30
EXTRUSION MIXER	RAW SCORE	2	5	2	5	1	2	5	5	
	ADJUSTED SCORE	0.20	0.50	0.20	1.00	0.10	0.40	0.50	0.50	3.40

NOTES: 1. ASSUMES WASTE PRELOADED IN DRUM
2. ASSUMES WASTE ADDED SIMULTANEOUSLY WITH OR AFTER BINDER

TABLE 6-8

EVALUATION OF POTENTIAL HAZARDS FOR GROUT BINDER

	POTENTIAL HAZARDS FACTORS					
	Operator Dose Exposure	Potential for Operator Injury	Potential for Leaks, Spills or Uncontrolled Releases	Potential for Dropping Objects	Potential for Flammable or Hazardous Gas Generation	Average Score
In-Drum Mixing Equipment						
Single Shaft Agitator with Lost Paddle	5	5	5	5	5	5
Single Shaft Agitator without Lost Paddle	2	2	2	2	3	2
Planetary Mixer	2	2	2	2	3	2
Out-Of-Drum Mixing Equipment						
Horizontal Blender	2	3	3	3	3	3
Planetary Mixer	2	3	3	3	3	3

b. Grout Binder with Out-Of-Drum Mixing

1) Horizontal Blender: This blender must incorporate staged mixing and fill operations. It therefore has additional potential for leaking while transferring waste binder mix to the final drum. However, the system can use a fully enclosed mix chamber with remote fill and drain capability and therefore can be operated in a manner commensurate with single shaft reusable paddle. Because operator dose exposure risk is greater than the single shaft reusable paddle, this resulted in an average score of 2.

2) Planetary Mixer: This type of mixer is commensurate in potential hazards to the our-of-drum horizontal blender. The average score for this mixer is 2.

B. Thermoset Polymer Binder

1. The detailed evaluation of potential hazards for thermoset polymer binder is shown in **Table 6-9**.

a. Thermoset Polymer Binder with In-Drum Mixing:

1) Single Shaft Agitator with Lost Paddle: The potential for hazardous operation of this mixer with thermoset polymer binder is greater than with grout binder because of the increased potential for operation exposure to chemical fumes using thermoset polymer. Therefore, the average score for this mixer is 4.

2) Single Shaft Agitator without Lost Paddle: This mixing approach also increases the potential for operator exposure to more hazards than with a grout binder because of the potential for chemical fumes being released during drum changeover and during paddle cleaning. The average score for the agitator with reusable paddle is 3.

3) Planetary Mixer: This is very similar to the rating for planetary mixer used with grout binder except the potential for chemical fumes from using thermoset polymer decreases the average score from 3 to 2.

b. Thermoset Polymer Binder with Out-Of-Drum Mixing

1) Single Shaft Agitator without Lost Paddle: This is very similar in regards to potential hazards as the in-drum single shaft/reusable paddle. However, the larger tank and paddle has the potential for increased emissions of chemical fumes both during operating and cleaning periods. This results in an average score of 1 for this out-of-drum option.

TABLE 6-9

EVALUATION OF POTENTIAL HAZARDS FOR THERMOSET POLYMER BINDER

	POTENTIAL HAZARDS FACTORS					
	Operator Dose Exposure	Potential for Operator Injury	Potential for Leaks, Spills or Uncontrolled Releases	Potential for Dropping Objects	Potential for Flammable or Hazardous Gas Generation	Average Score
In-Drum Mixing Equipment						
Single Shaft Agitator with Lost Paddle	5	5	3	5	3	4
Single Shaft Agitator without Lost Paddle	2	2	1	2	1	2
Planetary Mixer	2	2	1	2	1	2
Out-Of-Drum Mixing Equipment						
Single Shaft Agitator without Lost Paddle	2	3	2	3	1	2
Horizontal Blender	2	3	2	3	1	2

2) Horizontal Blender: The horizontal blender is very similar to the out-of-drum single shaft agitator with reusable mixer and is also a more complicated and hazardous piece of equipment to operate than the horizontal blender used with grout binder. This produces an average score of 1 for this type of mixer.

C. Thermoplastic Polymer Binder

1. The detailed evaluation of potential hazards for thermoplastic binder is shown in **Table 6-10.**

a. Thermoplastic Polymer Binder with In-Drum Mixing

1) Planetary Mixer: The hazardous aspects of operating a planetary mixer with thermoplastic polymer are considered to be greater to those operating a planetary mixer with grout binder because molten polymer is used with a heated polymer tank, heated polymer lines and external clamp-on drum heater. This gives an average score of 3 for a planetary mixer with thermoplastic polymer binder.

b. Thermoplastic Polymer Binder with Out-Of-Drum Mixing

1) Horizontal Blender: The potential for hazardous operations with a horizontal blender utilizing a molten thermoplastic polymer binder are considered more severe to operating a horizontal blender with grout binder, resulting in an average score of 2. A heated polymer tank, heated polymer lines, heated horizontal blender and clamp-on drum heater will all increase potential hazards to the operators.

2) Planetary Mixer: The potential hazards factors for operating an out-of-drum planetary mixer using molten polymer are essentially the same as those for operating out-of-drum thermoplastic processing with a horizontal blender. Operations will include a heated polymer tank, heated lines for polymer and polymer/waste mixtures, a heated planetary mixer and clamp-on drum heater. This yields an average score of 2 for the out-of-drum planetary mixer.

3. Extrusion Mixer: This mixer is unique in that is not used with any other binder. The operation is more complex (involving high temperature electric heaters and high pressure extrusion of molten polymer) than a horizontal blender or planetary mixer but clean-up between shifts is normally not required. Thus, no significant hazard differences are seen between the extrusion mixer and the horizontal blender or planetary mixer and the resultant average score for the extrusion mixer will be a 2.

TABLE 6-10
EVALUATION OF POTENTIAL HAZARDS FOR THERMOPLASTIC POLYMER BINDER

	POTENTIAL HAZARDS FACTORS					
	Operator Dose Exposure	Potential for Operator Injury	Potential for Leaks, Spills or Uncontrolled Releases	Potential for Dropping Objects	Potential for Flammable or Hazardous Gas Generation	Average Score
In-Drum Mixing Equipment						
Planetary Mixer	2	1	2	2	2	2
Out-Of-Drum Mixing Equipment						
Horizontal Blender	2	2	3	3	2	2
Planetary Mixer	2	2	3	3	2	2
Extrusion Mixer	2	2	3	3	2	2

6.4.1.2 Operability

A. Grout Binders

1. In-Drum Mixing

a. Single Shaft Agitator With Lost Paddle: It is assumed that this mixer is provided with variable frequency motor control or some other means to infinitely adjust mixer RPM. Paddle configuration and RPM adjustments can be accommodated remotely and this provides considerable flexibility to adjust mixing parameters prior to and during mixing (assuming paddle configuration is acceptable) there is limited clean up with the lost paddle method and start up and shut down operations are minimal. This was given a raw score of 4.

b. Single Shaft Agitator without Lost Paddle: Assuming controllable RPM features as noted above this system will require operator action to change out paddle and requires some action to clean impellers between batches. The start up and shut down operations are also affected by the requirement to clean or adjust paddles. However, paddle location in-drum can be adjusted. This was assigned a raw score of 3.

c. Planetary Mixer: This type of mixer can be adjusted to modify speed, agitator type, agitator diameter and mixing intensity. However, operator action is required to change out agitators and significant cleaning with water may be required between batches. Contact maintenance may be required to change out agitators. Therefore, a raw score of 3 was assigned.

2. Out-of-Drum Mixing

a. Horizontal Blender: This system is convertible for agitator type, diameter and speed. Agitator location is fixed within a heavily contaminated zone and extensive contact maintenance is required to change out agitators. Very significant clean up with water is required between batches. Therefore a raw score of 2 was assigned.

b. Planetary Mixer: Again the system is easy to operate as noted in the in-drum mixer write up. Out of drum use requires auxiliary vessel clean up besides mixer clean up, however this was not significant enough to affect the raw score of 3.

B. Thermoset Polymer

1. In-Drum Mixing

a. Single Shaft Agitator with Lost Paddle: Operability considerations are generally the same as with grout binder and therefore the raw score is assigned at 4.

b. Single Shaft Agitator without Lost Paddle: Operability consideration are generally the same as with grout binder however, clean up is significantly more difficult with thermoset polymers (solvents required) and therefore the raw score has been dropped one point to 2.

c. Planetary Mixer: Operability consideration are generally the same as with grout binder however, clean up is significantly more difficult with thermoset polymers (solvents required) and therefore the raw score has been dropped one point to 2.

2. Out-Of-Drum Mixing

a. Single Shaft Agitator without Lost Paddle: This is similar to the in-drum single shaft agitator except that significantly more clean up is involved with the auxiliary vessel and therefore a score of 1 is assigned.

b. Horizontal Blender: Operability consideration are generally the same as with grout binder however, clean up is significantly more difficult with thermoset polymers (solvents required) and therefore the raw score has been dropped one point to 1.

C. Thermoplastic Polymer

1. In-Drum Mixing

a. Planetary Mixer: Operability considerations are similar to thermoset binder use. Score assigned is 2.

2. Out-Of-Drum Mixing

a. Horizontal Blender: Operability considerations are identical to thermoset binder use. Score assigned is 1.

b. Planetary Mixer: The overwhelming impact to operability is clean up between batches. Score assigned is 1.

c. Extrusion Mixer: This equipment is designed specifically for use with polymers. Clean up merely requires shut down of waste flow with continued thermoplastic feed. Raw score is 5.

ent of binder selection. Additionally,
d water, has not been addressed in
an up, binder selection and waste
ler operability, process flexibility and
reviewed from a mechanical
placement standpoint.

dle: These single shaft mixers are
drive arrangements, direct, geared,
rol and the mounting methods may
e mixer should include consideration
nce out of the area if required. It is
aintenance will be contaminated,
sposable agitators. Therefore this
bility and ease of maintenance and

dle: This system is quite similar to
e except that the mixer/shaft and
ed to erosion as a result of mixing
is not assumed to be dropped each
e some contact maintenance of
s are protected from catastrophic
rigid object) by various torque/slip
ly this mixer was given a raw score

s fairly complex and subject to
higher than single shaft agitators.
of the equipment disassembly and
time consuming. The paddle
and it requires operator contact
ccordingly it was given an average

ixing

ft Agitator without Lost Paddle: This mixer is quite similar to the
ft agitator with lost paddle described above except that the
t and paddle may require maintenance related to erosion as a
ixing abrasive formulations. Since the paddle is not assumed to
d each cycle it has the potential to require some contact
ce of contaminated components. All mixers are protected from
ic failure (should a paddle jam or strike a rigid object) by various
compensating mechanisms. Accordingly this mixer was given
re of 4.

Mixer: The mixer drive is fairly complex and subject to
ce requirements which are higher than single shaft agitators.
lly, due to the configuration of the equipment disassembly and
place is more difficult and time consuming. The paddle
tion is also more complex and it requires operator contact
nce to remove and/or adjust. Accordingly it was given an average
of 2.

l Blender: The reliability of the horizontal blender is on a par with
tary mixer. The equipment drive and paddle components are
and contact maintenance of major contaminated components is
y required. It was given an average raw score of 2.

Mixer: Because of the necessity for much higher level of control
umentation, the extruder mixer appears to have a lower reliability
other mixer with respect to electrical controls of various
ms. However, vendors dispute this and indicate high levels of
us operation. Additionally, all major components except the drive
e likely to be contaminated and will, at some point, require contact
nce. This maintenance will include a significant in place
bly of the machine. Therefore, the extruder was given a raw
2.

pment

ng

shaft agitators operating without the lost paddle technique are
ly used in the commercial and DOE industry to mix grout and
. DOE facilities which have previously utilized this mixing
ue on a full scale basis include Rocky Flats Plant, West Valley,
ah River, and Hanford. Rocky Flats has developed an in-drum
system identified as OASIS (Organic and Sludge Immobilization

System). This system utilized a Lightnin 2 horsepower variable speed mixer with 2-11.3" diameter impellers[2]. The unit was used to mix approximately 30 gallons of liquid organic waste or sludge with Envirostone cement at a rate of up to seven drums per 8 hour shift. West Valley has also used a high shear lightnin mixer to mix LLWTF sludge with dry portland cement for a total production of approximately 1250 drums[3]. However, it was found that over 50% of these drums contained free liquid after the curing stage and have been slated for reprocessing using a double planetary mixer. Use of a single shaft agitator with lost paddle mixing is less widespread and the only known commercial use, for treating mixed wastes, is overseas with BNFL at WPEP and EP2. This process, developed after over 10 years of experimentation, has proven successful for dilute, water slurries; waste forms that may represent a portion of the WRAP 2A feedstreams. Planetary mixing, in-drum, has been demonstrated on a full scale limited basis only at West Valley with LETF sludges similar to WRAP basin sludges.

b. Therefore, on the above demonstrated experience basis, single shaft agitators without lost paddle are rated 5, followed by single shaft with lost paddle, and planetary mixing, both with a 4 rating.

2. Out-Of-Drum Mixing

a. The use of horizontal blending mixers such as pug mills or screws for mixing LETF metal sludges with grout have been demonstrated full scale on a limited basis at the Rocky Flats Plant in Bldg. 374. The RFP mixing system was used to mix dried LETF sludge with portland cement in a pug mill. The system was eventually discarded due to severe dusting problems which rendered the process offgas scrubber inoperative. There were also significant quality control problems related to assuring that all cement and waste was well mixed. However, since this mixing technique is no longer used in lieu of a redesign of the mixing system in favor of an in-drum agitated system, the technique is rated a 4. Planetary mixing of grout with waste out-of-drum is not practiced at any known DOE or commercial facility on a full or pilot scale basis. Therefore the technique is rated a 2 until this type of operation is verified in industry.

B. Thermoset Binders

1. In-Drum Mixing

a. The method of mixing waste with thermoset binders such as VES resin or water extendable polyesters has almost exclusively been done with single shaft agitators. Stock Equipment Company has demonstrated a disposable single shaft auger type mixer for mixing dry incinerator ash with VES resin. This mixing was on a commercial basis using preloaded polymer and in-drum mixing agitators at Aerojet. Since this method did not use preloaded

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waste in-drum the rating is downgraded from 5 to 4. Use of high speed agitators without lost paddle adaption has been used by Diversified Technologies via several mobile treating units at various DOE facilities. As such, this type of operation was considered to be a limited capacity type operation and rated a 3.

b. Planetary type mixers have not been demonstrated for mixing waste with thermoset polymers at a commercial, DOE, or laboratory facility. However, there is evidence of use of planetary type mixers for mixing of particulate ammonium perchlorate crystals with thermoset polymer. This operation is practiced by United Technologies to produce solid rocket propellant under extremely hazardous operating conditions. As such, the technique was upgraded from 1 to 2.

2. Out-Of-Drum Mixing

a. The use of high speed, single shaft agitators to mix ion exchange resins with VES resin has been demonstrated commercially in 200 ft^3 liners by Diversified Technologies. However, this technique assumes that the vessel is disposable and does not allow reuse of the vessel for subsequent batches, which would be the intent of this out-of-drum mixing technique. As such, the rating is downgraded from 5 to 4.

b. Horizontal blending of waste with thermoset polymers, out-of-drum, has no known demonstrated application commercially or in the laboratory. Therefore, this mixing technique is rated 1.

C. Thermoplastic Binder

1. In-Drum Mixing

a. Mixing of thermoplastic polymers with waste, in-drum, has not been attempted using any known mixing technique. This is due to the inherent problems of heating the drum to maintain a molten state long enough to mix the thermoplastic. As such, planetary mixers are rated 1 for demonstrated technology.

2. Out-Of-Drum Mixing

a. Thermoplastics such as sulfur cement and asphalt or bitumen have been successfully mixed with a wide variety of waste materials. Oxidized asphalt has been employed extensively overseas to encapsulate radioactive ion exchange resins and evaporator concentrates with high nitrate salts. Commercial processing facilities are located in Austria, Belgium, Finland, France, Germany, Japan, Sweden, and Switzerland. The most common mixing technique is a full scale extruder or thin film evaporator depending

on the waste water content. Brookhaven National Laboratory, in conjunction with other DOE facilities such as Rocky Flats Plant, has performed extensive laboratory and pilot scale testing using single screw extruders. Most of their testing has involved mixing of molten low density polyethylene with high nitrate salt wastes. Waste loadings of 70 wt% have been obtained in 1 1/4" diameter laboratory extruders and 60 wt% for 4 1/2" diameter production size extruders capable of steady state throughputs of 1000 lb/hr[1]. Therefore the extruder is rated 5 for demonstrated technology due to its full scale and wide spread use. Both horizontal and vertical thin film evaporators are used commercially overseas to dry and encapsulate salt slurries with bitumen. However, the use of horizontal mixer-evaporators appears to be significantly less common than vertical units. Therefore the horizontal blending mixing technique is downgraded from 5 to 4.

b. The use of low speed wiping type mixers for asphalt blending is commonly used in commercial applications in this country. Many agitator manufacturers (Meyer, Hockmeyer, etc.) supply single shaft or twin shaft concentric low speed mixers that have been commercially used in this application. However, specific use of planetary mixers for mixing thermoplastics has only been done at a laboratory scale (Brookhaven National Lab) using bench scale equipment. Modified sulfur cements have been used to encapsulate incinerator ash at 55 wt% loadings. Due to the extensive commercial experience with low speed wiping type mixers for thermoplastics the planetary mixing technique which employs the same principal as the wiping type mixer was upgraded from 1 to 2, which indicates bench scale experience.

6.4.1.5 Capital Cost

A. Capital cost is considered to be independent of binder selection, assuming a system has been identified as compatible with a particular waste/binder combination. Where appropriate, options such as mix vessels are quoted. The relative relation to CDR baselines are discussed, but scoring is based upon absolute costs.

1. <u>In-Drum Mixing</u>

a. <u>Single Shaft Agitator</u>: The CDR baseline mixer cost is in the $3000 range. This is for a 3 horsepower low speed mixer (0-350 RPM) suitable for use with grout or polymer (dry particulate only). However, polymer requires a high speed mixer with a disperser blade when used with wastes requiring emulsification of free water. The proposed configuration is a 15 horsepower high speed (650 - 3200 RPM) disperser. Its cost is approximately $6,300. For the purposes of the study the high speed mixer cost is utilized as a worst case and is scored a 5.

b. Planetary Mixer: The equipment complete with hydraulic lift and all related controls is $71,200. This system cannot be configured independent of the lifting mechanism. It is by far the most complex of the paddle type mechanical mixers and is scored a 2.

2. Out-of-Drum Mixing

a. Single Shaft Agitator: The basic mixer cost is in the $3,000 range. Out-of-drum jacketed mix vessel is estimated at approximately $8,000 for a 25 ft^3 vessel. Total equipment arrangement cost is $11,000. For polymer binders, the system configuration results in a one for three mixer replacement or a differential cost of $5,000. This is given a score of 5.

b. Planetary Mixer: The equipment complete with hydraulic lift and all related controls is $71,200. An auxiliary mix vessel is an additional $8,000. Therefore, the total equipment arrangement cost is $79,200. For polymer binders the system configuration results in a one for three mixer replacement or differential cost of $73,200. This is given a score of 2.

c. Horizontal Blender: Vendor quotes run from $ 19,000 to $ 42,000. Total equipment cost utilized for this estimate is $42,000. For polymer binders the system configuration results in a one for three mixer replacement or a differential cost of $36,000. This is given a score of 3.

d. Extrusion Mixer: This mixer is a drastic departure from the CDR. Estimated costs (including feed mechanisms) can range from $420,000 to $530,000 for a twin screw extruder capable of handling the throughput necessary to process all particulates and sludge waste feedstreams requiring polymer encapsulation. The extruder score is 1. The impact of mixer one for three or one for four replacement is negligible in this instance.

3. Lost Paddle Expenditures:

In order to estimate lost paddle expenditures we have utilized cost ranges based solely upon vendor preliminary estimates for paddle manufacturing costs.

Binder	Configuration	Cost Estimate Ranges	Average Cost
Grout	Bow tie/BNFL	$100-900	$500
Polymer	Disperser/Bowtie	$55-390	$222
Estimated per drum costs:			
Grout Paddles		$ 500.00	
Polymer Paddles		$ 222.00	

For the purposes of discussion lost paddle operational costs provided for information but have not been added to the capital cost scoring. It should be noted that mockup testing may provide design refinements which lower paddle costs.

6.4.1.6 Process Flexibility

A. To allow a more equitable comparison, mixing equipment used for in-drum mixing will be compared separately from mixing equipment used for out-of-drum mixing.

B. In-Drum Mixing Equipment

1. In **Table 6-11**, three types of in-drum mixing equipment are evaluated for process flexibility. They are:

   a. Single shaft agitator with lost paddle.

   b. Single shaft agitator without lost paddle.

   c. Planetary mixer.

2. The total calculated time (i.e. number of binders x volume %, summed for each waste form) that each type of in-drum mixing equipment can be used with the three binders and five waste forms is shown in **Table 6-11**. The three types of in-drum mixing equipment can be ranked as follows:

Type of In-Drum Mixing Equipment	Total Calculated Time Equipment can be Used	Score
Planetary mixer	238.5	5
Single shaft agitator with lost paddle	159.0	3
Single shaft agitator without lost paddle	159.0	3

3. The score for each type of in-drum mixing equipment is then entered on **Tables 6-5, 6-6 and 6-7** that compare the eight evaluation criteria for each type of binder.

C. Out-Of-Drum Mixing Equipment

1. In **Table 6-12**, four types of out-of-drum mixing equipment are evaluated for process flexibility. They are:

   a. Single shaft agitator without lost paddle.

   b. Planetary mixer.

   c. Horizontal blender.

   d. Extrusion mixer.

TABLE 6-11

PROCESS FLEXIBILITY EVALUATION FOR IN-DRUM MIXING

		WASTE FORMS AND PERCENT OF TOTAL WASTE						
Type of Mixing Equipment	Type of Binder	Dry Particulate 56.8 vol%	Wet Particulate 15.3 vol%	Dry Size Reduced 14.2 vol%	Wet Size Reduced 4.7 vol%	Ion Exchange Resin 7.4 vol%	Total Calculated Time Equipment Can Be Used	Score
Single Shaft Agitator with Lost Paddle	Grout	X	X			X		
	Thermoset Polymer	X	X			X		
	Thermoplastic Polymer							
	TOTAL	2 x 56.8 = 113.6	2 x 15.3 = 30.6	0	0	2 x 7.4 = 14.8	159.0	3
Single Shaft Agitator without Lost Paddle	Grout	X	X			X		
	Thermoset Polymer	X	X			X		
	Thermoplastic Polymer							
	TOTAL	2 x 56.8 = 113.6	2 x 15.3 = 30.6	0	0	2 x 7.4 = 14.8	159.0	3
Planetary Mixer	Grout	X	X			X		
	Thermoset Polymer	X	X			X		
	Thermoplastic Polymer	X	X			X		
	TOTAL	3 x 56.8 = 170.4	3 x 15.3 = 45.9	0	0	3 x 7.4 = 22.2	238.5	5

X Denotes that this type of equipment can be used with a particular binder and a particular waste form.

TABLE 6-12
PROCESS FLEXIBILITY EVALUATION FOR OUT-OF-DRUM MIXING

		WASTE FORMS AND PERCENT OF TOTAL WASTE						
Type of Mixing Equipment	Type of Binder	Dry Particulate 56.8 vol%	Wet Particulate 15.3 vol%	Dry Size Reduced 14.2 vol%	Wet Size Reduced 4.7 vol%	Ion Exchange Resin 7.4 vol%	Total Calculated Time Equipment Can Be Used	Score
Single Shaft Agitator without Lost Paddle	Grout Thermoset Polymer Thermoplastic Polymer TOTAL	X 1 x 56.8 = 56.8	X 1 x 15.3 = 15.3	0	0	X 1 x 7.4 = 7.4	79.5	2
Planetary Mixer	Grout Thermoset Polymer Thermoplastic Polymer TOTAL	X X 2 x 56.8 = 113.6	X X 2 x 15.3 = 30.6	0	0	X X 2 x 7.4 = 14.8	159.0	3
Horizontal Blender	Grout Thermoset Polymer Thermoplastic Polymer TOTAL	X X X 3 x 56.8 = 170.4	X X X 3 x 15.3 = 45.9	0	0	X X X 3 x 7.4 = 22.2	238.5	5
Extrusion Mixer	Grout Thermoset Polymer Thermoplastic Polymer TOTAL	X 1 x 56.8 = 56.8	X 1 x 15.3 = 15.3	0	0	X 1 x 7.4 = 7.4	79.5	2

X Denotes that this type of equipment can be used with a particular binder and a particular waste form.

2. The total calculated time that each type of out-of-drum mixing equipment can be used with the three binders and five waste forms is shown in **Table 6-12**, the four types of out-of-drum mixing equipment can be ranked as follows:

Type of Out-Of-Drum Mixing Equipment	Total Calculated Time Equipment can be Used	Score
Horizontal blender	238.5	5
Planetary mixer	159.0	3
Single shaft agitator without lost paddle	79.5	2
Extrusion mixer	79.5	2

3. The score for each type of out-of-drum mixing equipment is then entered on **Tables 6-5, 6-6 and 6-7** that compare the eight evaluation criteria for each type of binder.

6.4.1.7 Waste Mixing Effectiveness

A. Grout Binders

1. <u>In-Drum Mixing</u>

a. Waste mixing effectiveness is a measure of the capability of a given mixing technique to produce a homogeneous mixture in a reasonable amount of time. Assuming preloading of waste for in-drum mixing operations, product homogeneity will be related to that portion of the total drum volume that can be adequately covered by the mixer operating internals. This requirement is related to the mixing process objective of particle suspension where preloaded waste must be initially set in motion or suspended from the drum bottom. After the suspension is established, the process objectives of particle dispersion or blending can be accomplished. Particle dispersion will apply particularly to wet particulates that tend to agglomerate in the preloaded waste. Planetary mixers are capable of sweeping the entire drum volume with intersecting agitator blades. The agitator blades have close tolerances with the drum walls and bottom and will allow effective particle suspension and dispersion with preloaded waste. This type of mixing also provides a low shear rate kneading operation which is sufficient to blend waste with grout. As such, the planetary mixer is rated highest of all in-drum mixing techniques at a 4.

b. Single shaft agitators, with or without lost paddle, are generally less effective than planetary mixers in sweeping the entire drum cross section. Therefore unless the shear rate is quite high, the mixing time very long or viscosities very low, mixing of preloaded waste is less effective than planetary mixing. Therefore single shaft agitators are rated a 3.

2. Out-Of-Drum Mixing

a. Mixing of many waste types, especially particulates and ion exchange resins, are easily accomplished out-of-drum. This is because the sequence of addition of waste, binder, or other additives can be adjusted to allow optimum mixing efficiency. Also, out-of-drum mixing vessels can be designed to have smooth internal surfaces that can allow close tolerances between the vessel wall and mixer internals. Therefore the potential for dead spots or unswept portions is minimized. By controlling the sequence of addition, there is less chance of waste agglomeration and better control of particle suspension and dispersion than the in-drum mixing systems.

b. The two out-of-drum mixing devices considered, the horizontal blender and planetary mixer, are both capable of sweeping the entire mixing vessel and adjusting the sequence of material addition. As such, both mixing techniques are rated at 5, the best potential for mixing homogeneity.

B. Thermoset Binders

1. In-Drum Mixing

a. Thermoset binders such as VES resin or water extendable polyesters have lower inherent viscosities than grout and may yield better mixing results with single shaft agitators than viscous grouts or thermoplastics. Also, in the case of wet wastes with free water, it is necessary to produce high shear rates during mixing to emulsify the free water. Although single shaft agitators are capable of producing high shear rates in localized areas of the drum, optimum mixing will still be limited by potential dead spots when waste is preloaded in the drum. Planetary mixing will adequately cover the drum volume to allow solids suspension, dispersion, and low shear coating of particulates but may not produce sufficient high speed shear rate to emulsify water. Therefore single shaft and planetary mixing techniques are both rated 3 as average for mixing particulate waste with thermosets.

2. Out-of-Drum Mixing

a. Generally, as with grout, out-of-drum mixing of waste with thermoset polymers will be more efficient than in-drum mixing due to better control of mixing vessel geometry and sequence of material addition. The single shaft agitator can be designed to cover a majority of the drum volume by use of multiple agitator props or vessel internals. This also applies to the horizontal blender. However, the single agitator is rated better than the horizontal blender (5 vs. 4, respectively) for thermosets due to the higher potential shear rate capability of the single shaft agitator which will allow better emulsification of any free water.

C. Thermoplastic Binders

1. In-Drum Mixing

a. Mixing efficiency of thermoplastic binders with waste will be governed to a large extent by the degree of agitator coverage of the entire drum volume. Again. as with thermoset polymer, the primary mixing objectives will be to suspend and disperse the preloaded waste and to thoroughly coat all waste particulates. This is especially true due to the high inherent viscosity of thermoplastics. However, thermoplastic viscosity is, in turn, highly dependent upon polymer temperature which will be very difficult to control during in-drum mixing. Use of external heating jackets or internal drum bayonet heaters will be very difficult on a large scale basis.

b. Therefore, without proper temperature control, in-drum mixing of thermoplastics will be very difficult. The mixing efficiency of planetary mixers will be average, 3, at best.

2. Out-Of-Drum Mixing

a. Mixing of thermoplastic polymers with all waste forms is best accomplished in an out-of-drum mixing device where precise temperature control is possible. Temperature control is best accomplished when the heat transfer surface area is greatest per unit volume of binder. Of the mixing techniques suggested for out-of-drum thermoplastic mixing, the extruder has the highest heat transfer surface area per unit volume. It also has the potential for multiple, independently controlled, heating zones. A carefully controlled temperature profile throughout the barrel length is possible. Also due to the short residence time, polymer and waste are not degraded due to extended exposure to elevated temperatures. The dispersion, suspension and coating of particulates with thermoplastic polymer are easily controlled mixing objectives when processing sludges or other fine particulate waste. The excellent heat transfer capability of the extruder allows removal of any free water as vapor with proper barrel and screw design. Other process parameters which can be easily controlled, such as throughput (screw speed) and pressure drop (orifice plate opening size) allow a good homogeneous mixed product. These advantages allow the best rating for the extruder for product homogeneity, or a 5.

b. The other out-of-drum mixing techniques, horizontal blender and planetary mixer, score lower than the extruder. Their rating, 4, is still higher than the in-drum mixing techniques. This is because the mixing vessel can be fabricated with a heat transfer jacket and close tolerances can be achieved between the mixing internals and vessel wall. Therefore, particulate suspension and dispersion capabilities are higher for the out-of-drum mixers.

6.4.1.8 Waste Minimization Evaluation

A. In this evaluation, the use of a lost paddle is not considered an increase in the primary waste volume for two main reasons: 1) The paddle volume is not a significant portion of the drum volume. The BNFL lost paddle has been estimated to be less than one percent of the drum volume (based on BNFL drawings) 2) If a reusable BNFL type paddle was used, and the paddle was lifted out of the drum after mixing, the small amount of settling due to the paddle being removed (say 1-2 percent) would not make "topping off" the drum feasible. Thus, using the lost paddle technique would not increase the volume of primary waste being handled compared to mixing without a lost paddle.

B. Secondary waste considered is the dust generated by grout operations, fumes generated by thermoset or thermoplastic polymers, water produced from dewatering of ion exchange resin, and solid or liquid waste produced from clean-up of permanent mixing devices (i.e., mixers that do not use a "lost paddle"). The relative amounts of dust from grouting operations or chemical fumes from thermoset polymer or thermoplastic polymer operations can be ranked as follows:

High	• Fumes from thermoset polymer
	• Dust from grouting
Low	• Fumes from thermoplastic polymer

Some proposed methods for cleaning the paddles are:

- Wiping the paddles with disposable wipes wetted with a water/solvent (water for grout, chemical solvent for polymers).
- Using a high pressure water/solvent spray.
- Stirring the paddles in a drum (in-drum mixing) or tank (out-of-drum mixing) filled with water/solvent.

Since the method of cleaning is not precisely defined, the form of secondary waste is also not known. However, for the purposes of this report, the amount of secondary waste produced from cleaning either grout, thermoset polymer, or thermoplastic polymer from a particular type of agitator were ranked equally.

When considering cleaning a particular type of binder from various types of mixers, the size (surface area) and number of the mixing paddles must be considered. For out-of-drum mixing, all mixing vessels were assessed to be about 25 ft^3 in volume. The ranking of secondary waste from cleaning of the mixing devices can be shown as follows:

	Out-of-Drum	In-Drum
High	• Planetary Mixer, Horizontal Blender • Agitator without Lost Paddle	• Planetary Mixer • Agitator without Lost Paddle
Low	• Extrusion Mixer (normally no clean-up between batches)	• Agitator with Lost Paddle

C. For the purpose of this evaluation, both in-drum mixers (without lost paddles) and out-of-drum mixers were assumed to be cleaned at the end of each operating day.

D. Grout Binder

1. The waste minimization evaluation for grout binder is shown in **Table 6-13**. In this table, the relative amount of secondary waste for the three in-drum mixing types and the two out-of-drum mixing types are compared to each other for the waste forms considered.

2. Grout Binder with In-Drum Mixing

a. The three in-drum mixing types evaluated were:

1) Single shaft agitator with lost paddle.

2) Single shaft agitator without lost paddle.

3) Planetary mixer

b. Single Shaft Agitator with Lost Paddle

1) Dry or Wet Particulate Waste. These were both given a score of 5 since the only secondary waste generated is some dust from the grouting operation.

2) Ion Exchange Resin Waste (Slurried). This was also given a score of 5 since the only secondary waste generated is some dust from the grouting operation and no waste water was produced since the waste was slurried.

3) Average Score. The single shaft agitator with lost paddle had an average score of 5.

c. Single Shaft Agitator without Lost Paddle

1) Dry or Wet Particulate Waste. These were both given a score of 4 due to the increase in secondary waste volume caused by agitator clean up.

2) Ion Exchange Resin Waste (Slurried). This was given a score of 4 since there was an increase in agitator clean-up waste volume. No waste water was generated due to the use of slurried resin.

3) Average Score. The single shaft agitator without lost paddle had an average score of 4.

TABLE 6-13
WASTE MINIMIZATION EVALUATION FOR GROUT BINDER

	WASTE FORMS					
	Dry Particulate	Wet Particulate	Dry Size Reduced	Wet Size Reduced	Ion Exchange Resin[1]	Average Raw Score
In-Drum Mixing Equipment						
Agitator w/Lost Paddle Secondary Waste	5 Dust No paddle clean-up	5 Dust No mixer clean-up	(N/A)	(N/A)	(S) 5 Dust No mixer clean-up	5
Agitator w/o Lost Paddle Secondary Waste	4 Dust Paddle clean-up	4 Dust Paddle clean-up	(N/A)	(N/A)	(S) 4 Dust Paddle clean-up	4
Planetary Mixer Secondary Waste	3 Dust (2) Blades clean-up	3 Dust (2) Blades clean-up	(N/A)	(N/A)	(S) 3 Dust (2) Blades clean-up	3
Out-Of-Drum Mixing Equipment						
Horizontal Blender Secondary Waste	2 Dust Blender clean-up	2 Dust Blender clean-up	(N/A)	(N/A)	(S) 2 Dust Blender clean-up	2
Planetary Mixer Secondary Waste	2 Dust Mixer clean-up	2 Dust Mixer clean-up	(N/A)	(N/A)	(S) 2 Dust Mixer clean-up	2

1) All ion exchange resin feedstreams are assumed to be in a slurried condition and can be processed without dewatering since the water is compatible with grout binder.

(S) = Slurried

(N/A) = Not Applicable

d. Planetary Mixer

1) Dry or Wet Particulate Waste. These were both given a score of 3 due to the increase in secondary waste volume caused by clean-up of the two relatively large mixing paddles.

2) Ion Exchange Resin Waste (Slurried). This was given a score of 3 since the secondary waste was equivalent to the dry or wet particulate waste using the same mixer (due to mixer paddle clean-up).

3) Average Score. The planetary mixer was given an average score of 3.

3. Grout Binder with Out-Of-Drum Mixing

a. The Two Out-of-Drum Mixing Types Evaluated Were:

1) Horizontal blender

2) Planetary mixer

b. Horizontal Blender

1) Dry or Wet Particulate Waste. These were both given a score of 2 due to the increase in secondary waste volume (larger blender paddle and inside area and transfer piping than in-drum mixing creates more clean-up waste) compared to the planetary mixer (score of 3).

2) Ion Exchange Resin Waste (Slurried). This was given a score of 2 since the increase in the secondary waste volume was similar to using the horizontal blender to process dry or wet particulate waste.

3) Average Score. The horizontal blender had an average score of 2.

c. Planetary Mixer

1) Dry or Wet Particulate Waste. These were both given a score of 2 since the increase in secondary waste volume is similar to a horizontal blender mixing the same waste.

2) Ion Exchange Resin Waste (Slurried). This was given a score of 2 since the increase in secondary waste volume is almost identical to horizontal blender processing the same waste.

3) This was given an average score of 2.

E. Thermoset Polymer Binder

1. The waste minimization evaluation for thermoset polymer binder is shown in **Table 6-14**. In this table, the relative amount of secondary waste volume for the three in-drum mixing types and two out-of-drum mixing types are compared to each other for the waste forms considered.

2. Thermoset Binder with In-Drum Mixing

a. The three in-drum mixing types evaluated were:

1) Single shaft agitator with lost paddle.

2) Single shaft agitator without lost paddle.

3) Planetary mixer.

b. Single Shaft Agitator with Lost Paddle

1) Dry or Wet Particulate Waste. These were both given a score of 4 since the volume of fumes generated from this polymer process were considered greater than the dust generated by grouting using the same lost paddle mixing technique.

2) Ion Exchange Resin Waste (slurried). This was given a score of 4 since the volume of secondary waste generated was considered to be similar to dry or wet particulate. Because the resin was slurried no waste water volume was generated.

3) Average Score. This was given on average score of 4.

c. Single Shaft Agitator without Lost Paddle

1) Dry or Wet Particulate Waste. These were both given a score of 3 due to the increase in secondary waste caused by the clean-up of the permanent agitator compared to the same waste with lost paddle (score of 4).

2) Ion Exchange Resin Waste (Slurried). This was given a score of 3 since the secondary waste volume is equivalent to dry or wet particulate (score of 3) using an agitator without lost paddle.

3) Average Score. This was given an average score of 3.

TABLE 6-14
WASTE MINIMIZATION EVALUATION FOR THERMOSET POLYMER BINDER

	WASTE FORMS					
	Dry Particulate	Wet Particulate	Dry Size Reduced	Wet Size Reduced	Ion Exchange Resin[1]	Average Raw Score
In-Drum Mixing Equipment						
Agitator w/Lost Paddle Secondary Waste	4 Fumes No paddle clean-up	4 Fumes No paddle clean-up	(N/A)	(N/A)	(S) 4 Fumes No paddle clean-up	4
Agitator w/o Lost Paddle Secondary Waste	3 Fumes Paddle clean-up	3 Fumes Paddle clean-up	(N/A)	(N/A)	(S) 3 Fumes Paddle clean-up	3
Planetary Mixer Secondary Waste	2 Fumes (2) Blades clean-up	2 Fumes (2) Blades clean-up	(N/A)	(N/A)	(DW) 1 Fumes Water (2) Blades clean-up	2
Out-Of-Drum Mixing Equipment						
Agitator w/o Lost Paddle Secondary Waste	1 Fumes Agitator clean-up	1 Fumes Agitator clean-up	(N/A)	(N/A)	(S) 1 Fumes Agitator clean-up	1
Horizontal Blender Secondary Waste	1 Fumes Blender clean-up	1 Fumes Blender clean-up	(N/A)	(N/A)	(DW) 1 Fumes Water Blender clean-up	1

1) All ion exchange resin feedstreams are assumed to be in a slurried condition and the water is either emulsified by high speed agitators or removed (as a secondary waste) before mixing with thermoset polymer in low shear rate mixers such as the planetary mixer and horizontal blender.

(S) = Slurried
(DW) = Dewatered
(N/A) = Not Applicable

d. Planetary Mixer

1) Dry or Wet Particulate Waste. These were both given a score of 2 since the increase in secondary waste volume (due to clean-up of the double planetary mixer blades) is greater than the waste volume generated during clean up of the agitator without a lost paddle.

2) Ion Exchange Resin Waste (Dewatered). This was given a score of 1 since the increase in secondary waste due to clean-up of the permanent mixer blades and due to waste water generated from dewatering was greater than dry or wet particulate with no waste water.

3) Average Score. The planetary mixer had an average score of 2.

3. Thermoset Binder with Out-Of-Drum Mixing

a. The two out-of-drum mixing types evaluated were:

1) Single shaft agitator without lost paddle.

2) Horizontal blender.

b. Single Shaft Agitator without Lost Paddle.

1) Dry or Wet Particulate Waste. Both of these were given a score of 1 since the increase in secondary waste due to clean-up of a large mixer tank and paddle was greater than the waste increase for the planetary mixer using the same waste in drum.

2) Ion Exchange Resin Waste (Slurried). This was given a score of 1 since the increase in secondary waste volume was similar to dry or wet particulate using the same agitator.

3) Average Score. The single shaft agitator without lost paddle had an average score of 1.

c. Horizontal Blender

1) Dry or Wet Particulate Waste. These were both given a score of 1 based on a large increase in secondary waste (due to clean-up waste from the large blender volume and mixing internals) similar to the agitator without lost paddle.

2) Ion Exchange Resin Waste (Dewatered). This is given a score of 1 based on a large net increase in secondary waste due to the large amount of waste generated during clean-up of the large blender and mixing internals. Since this waste is dewatered, there is also an increase in waste water volume.

3) Average Score. The horizontal blender has an average score of 1.

F. Thermoplastic Polymer Binder

1. The waste minimization evaluation for thermoplastic polymer binder is shown in **Table 6-15**. In this table, the relative amount of secondary waste volume for the one in-drum mixing type and three out-of-drum mixing types are compared to each other for each of the waste forms considered.

2. Thermoplastic Binder with In-Drum Mixing

a. The in-drum mixing type evaluated was:

1) Planetary mixer

b. Planetary Mixer

1) Dry or Wet Particulate Waste. These were both given a score of 3 since the increase in secondary waste volume was considered similar to mixing the same waste with a planetary mixer and grout binder.

2) Ion Exchange Resin Waste (Dewatered). This is given a score of 2 since the secondary waste volume is increased compared to dry or wet particulate (using the same mixer) due to an increase in waste water volume.

3) Average Score. The planetary mixer is given an average score of 3.

3. Thermoplastic Binder with Out-Of-Drum Mixing

a. The three out-of-drum mixing types evaluated were:

1) Horizontal blender

2) Planetary mixer

3) Extrusion mixer

TABLE 6-15
WASTE MINIMIZATION EVALUATION FOR THERMOPLASTIC POLYMER BINDER

	WASTE FORMS					
	Dry Particulate	Wet Particulate	Dry Size Reduced	Wet Size Reduced	Ion Exchange Resin[1]	Average Raw Score
In-Drum Mixing Equipment						
Planetary Mixer Secondary Waste	3 Less fumes (2) Blades clean-up	3 Less fumes (2) Blades clean-up	(N/A)	(N/A)	(DW) 2 Less fumes Water (2) Blades clean-up	3
Out-Of-Drum Mixing Equipment						
Horizontal Blender Secondary Waste	2 Less fumes Blender clean-up	2 Less fumes Blender clean-up	(N/A)	(N/A)	(DW) 1 Less fumes Water Blender clean-up	2
Planetary Mixer Secondary Waste	2 Less fumes Mixer clean-up	2 Less fumes Mixer clean-up	(N/A)	(N/A)	(DW) 1 Less fumes Water Mixer clean-up	2
Extrusion Mixer Secondary Waste	5 Less fumes No mixer clean-up	5 Less fumes No mixer clean-up	(N/A)	(N/A)	(S) 5 Less fumes Water Boil-Off No mixer clean-up	5

1) All ion exchange resin feedstreams are assumed to be in a slurried condition and the water is either removed (as a secondary waste) before mixing with molten thermoplastic polymer in low shear rate mixers such as the planetary mixer and horizontal blender or boiled off in the extrusion mixer.

(S) = Slurried
(DW) = Dewatered
(N/A) = Not Applicable

b. Horizontal Blender

1) Dry or Wet Particulate Waste. These were both given a score of 2 since the secondary waste volume is increased, compared to in-drum planetary mixing of the same waste, due to the extensive clean-up required for the large blender and mixing internals.

2) Ion Exchange Resin Waste (Dewatered). This is given a score of 1 due to the increase in secondary waste volume compared to mixing dry or wet particulate waste. Major volume increase results from waste water generated during dewatering.

3) Average Score. The horizontal blender had an average score of 2.

c. Planetary Mixer

1) Dry or Wet Particulate Waste. These were both given a score of 2 since the increase in secondary waste volume was considered similar to the horizontal blender using the same waste.

2) Ion Exchange Resin Waste (Dewatered). This was given a score of 1 since the increase in secondary waste volume was considered similar to the horizontal blender processing ion exchange resin waste.

3) Average Score. The planetary mixer had an average score of 2.

d. Extrusion Mixer

1) Dry or Wet Particulate Waste. These were both given a score of 5 since the secondary waste volume consists of less fumes than thermoset polymer using in drum mixing with lost paddle (score of 4) and since the extrusion mixer does not normally need to be cleaned when it is shut down, thus generating no clean-up waste.

2) Ion Exchange Resin Waste (Slurried). This was given a score of 5 since secondary waste volume was similar to dry or wet particulate using an extrusion mixer. The extrusion mixer would normally not require cleaning before it is shutdown.

3) Average Score. The extrusion mixer had an average score of 5.

6.4.2 Selected Alternatives

The formal evaluation of mixing alternatives yielded the following relative total scores for the highest rated option for each binder:

Binder	Mixing Techniques	Total Score
Grout	1) Single Shaft Agitator with lost paddle - In-drum	4.10
Thermoset	1) Single Shaft Agitator with lost paddle - In-drum	3.80
Thermoplastic	1) Extrusion Mixer - Out-of-Drum	3.40

Single shaft agitators with lost paddles in-drum are recommended as the best mixing technology for grout or thermoset binders. This option normally scores higher in potential hazards, operability, maintainability, and waste minimization than the single shaft agitator without lost paddle technique.

However, extrusion mixing is the alternative of choice for thermoplastics due to very high scores in the operability, technology development, mixing effectiveness, and waste minimization categories. Waste minimization is a chief advantage of extruders because of volume reduction of the primary waste, if it contains water, due to vaporization of the water. However, it must be noted that extruders also score extremely low in categories such as maintainability, capital cost and process flexibility. Twin screw extruders are the most versatile type but still will not handle a great variety of waste particulate sizes. The initial capital cost of these extruders is very high and the potential maintenance costs are also potentially very high.

The above recommended mixing techniques do not apply to the small throughput waste types such as dry and wet size reduced solids. The mixing techniques which were applicable to these waste types (such as vibratory mixing) were screened out due to low throughput capability and will be considered in the final discussion of preferred alternatives to allow mixing of 100% of the WRAP 2A feedstreams.

7.0 DISCUSSION OF PREFERRED ALTERNATIVES

7.1 Selected Alternatives from Screening

A. Prior to initiating the evaluation of mixing techniques it was necessary to screen the potential alternatives assembled from the literature search. This was done in order to limit the evaluation process and avoid "high scoring" on extremely efficient but limited scope equipment. This screening required the elimination of techniques that could not be used with three or more waste types and with at least 50 volume % of the WRAP 2A waste feedstreams. Using this approach the final preferred alternatives were selected by evaluation. As a result of this selection logic two waste types, dry size reduced and wet size reduced, which account for approximately 19 volume % of WRAP 2A feeds cannot be accommodated by the preferred alternatives. It was therefore necessary to review the following screened (in-drum) options specific to these waste types for inclusion in the preferred alternatives selection (Section 7.3).

Grout Binder	Thermoset Polymer Binder	Thermoplastic Polymer Binder
• Vibratory Table	• Vibratory Table	• Vibratory Table
• Vibratory Pencil		
• Drum Rotation	• Drum Rotation	• Drum Rotation

Note that the single potential out-of-drum technique, rotating mixer, was not reconsidered because of the consistently low scoring of out-of-drum techniques when used with the majority of binders and mixer types. Of the remaining screened techniques only two, vibratory table and drum rotation, are suitable for use with all three binders. Of these two the vibratory table was selected for re-inclusion, based upon a simplified evaluation:

- It is considered to exhibit the least potential hazard to the operator.
- It has the highest level of operability with minimum operator intervention.
- It has a high level of reliability and is easy to maintain.
- It is a technology proven and utilized by BNFL.
- Capital costs are consistent with CDR estimates - configuration of installation does not require modification of existing proposed facility.
- Process flexibility is maximized.
- Waste mixing effectiveness has been demonstrated to be acceptable.
- Secondary waste generation is minimized.

B. Accordingly, vibratory mixing utilizing a vibratory table has been included in the final selected alternatives to assure treatment capability for all waste forms.

7.2 Selected Alternatives from Evaluation

A. The mixing options retained for evaluation after final screening are summarized in Table 6-4. They have been categorized by binder, in-drum vs. out of drum mixing and by waste form. Some techniques are identified for evaluation in several categories. The detailed evaluation has been described in Section 6.4.1. The summary of selected alternatives is provided in Section 6.4.2.

B. The alternatives remaining after evaluation and their suitability with selected binders is detailed below. Also, specific details of compatibility with previous CDR details is noted.

1. In-drum mixing utilizing a single shaft agitator with a (disposable) lost paddle was the consistent high scorer during the evaluation. It is acceptable for use with grout and thermoset polymer binders and is consistent with FDC requirements and all CDR details.

2. Out-of-drum mixing utilizing an extrusion mixer is suitable for use only with thermoplastic polymer binders. It does not reflect the details of the initial CDR findings and represents a dramatic cost impact. However, it was consistent with our direction to review an additional binder for use in WRAP 2A.

7.3 Final Selected Alternatives

A. The final selected alternatives include the mixing techniques developed as a result of the evaluation findings and a reintroduced screened technique required to accommodate all remaining waste types. This provides a series of techniques which are compatible/optimized for all waste and binder combinations identified in the CDR. The completed listing follows.

1. Selected Mixing Techniques

a. The single shaft agitator with lost paddle in-drum has been selected for use with grout and thermoset polymers. It is not compatible with large or oversized size reduced solids.

b. The extrusion mixer has been selected for use in out-of-drum mixing with thermoplastic polymers. It is not suitable for large or oversized size reduced solids.

c. The vibratory table has been selected for use with grout, thermoset and thermoplastic polymers for mixing in-drum of size reduced solids.

d. The recommended design details for the selected alternatives are discussed in Section 7.4.

7.4 Design Details for Selected Alternatives

A. The following recommendations have been developed as a result of the evaluation of mixing technique alternatives and from discussions with mixer apparatus vendors and users.

1. Container Configuration: The mixing container shall be 55 gallon drums as specified in the Functional Design Criteria. The containers (standard 17H steel drums with fully removable heads) should be lined with polyethylene. Lining thickness is to be determined by testing. The composite container shall be similar to containers developed by ENPAC Corporation. Drop in liners shall not be utilized as they require additional handling during mixing operations. The lining shall be provided on all portions of the drum which will remain in constant contact with the waste form. The lining shall be radiused as required to enhance particle suspension at reduced power and to avoid joints or pockets which may allow excess waste material to accumulate without mixing with solidification agents.

2. Container Free Board: In no case shall more than 10% by volume of the container remain unfilled. The limited permissible void space at the top of the container may require the use of a vortex suppression device during agitated mixing operations. This vortex suppression device is intended to limit spillage only, it is not required to improve mixing efficiency. There are two potential options:

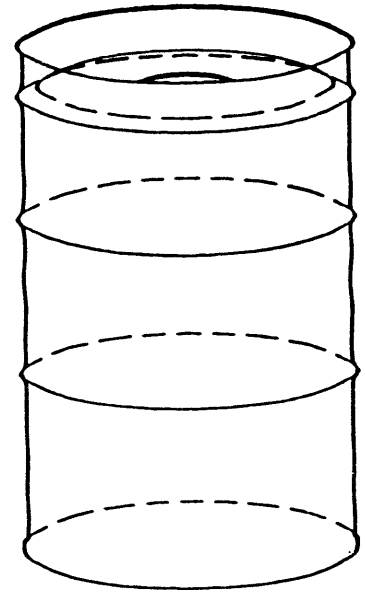
   - If the drum contents are mixed using a single shaft agitator with the closure lid off, a disposable annular ring can be fitted into the drum. See **Figure 7-1**. This flat ring snaps in place and literally deflects the vortex swell which may form near the outer perimeter of the drum as material near the mixer centerline is deflected outward and upward by the agitator.

   - If mixing with a single shaft agitator is performed with a closure lid or mixer alignment lid in place no other vortex suppression device is required.

   If vibratory mixing is being performed container free board is limited solely by maximum permissible void space limitations.

3. Mixer Impeller and Impeller Attachment Details

   a. The selected low speed mixing techniques include three proposed impeller configurations. Low speed (0-350 RPM) single shaft agitator mixing will be accomplished with grout and thermoset polymer binders utilizing either 1) a BNFL anchor style impeller, 2) an open bow tie anchor style impeller, or 3) a simple twin bladed impeller as detailed in **Figure 7-2**.



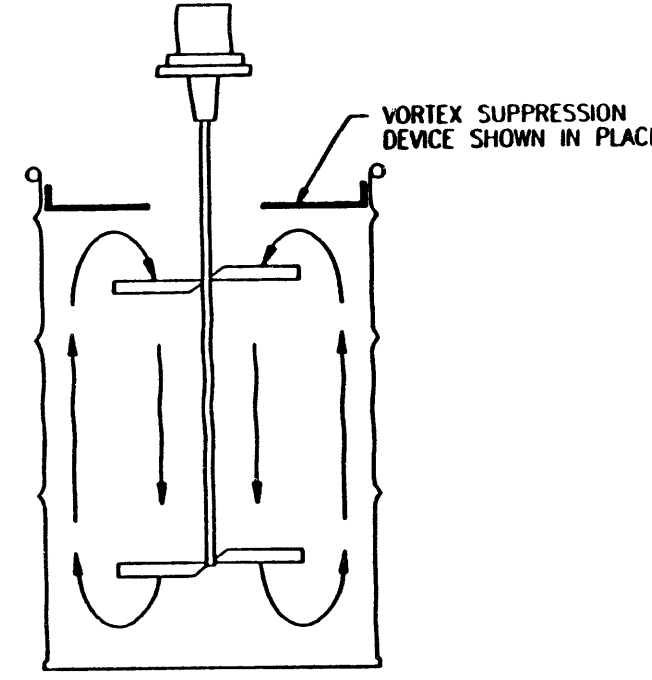
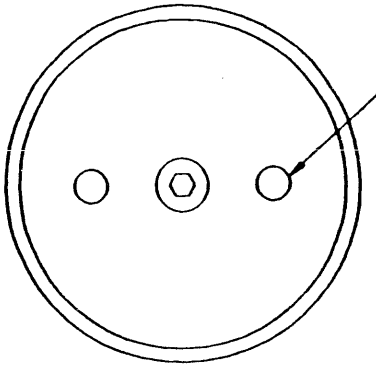


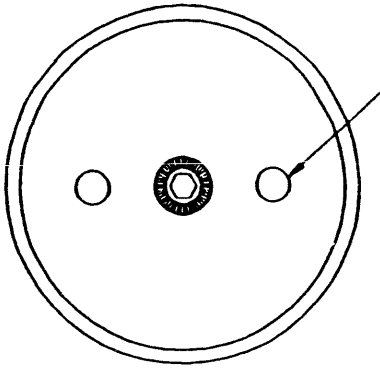
FIGURE 7-1

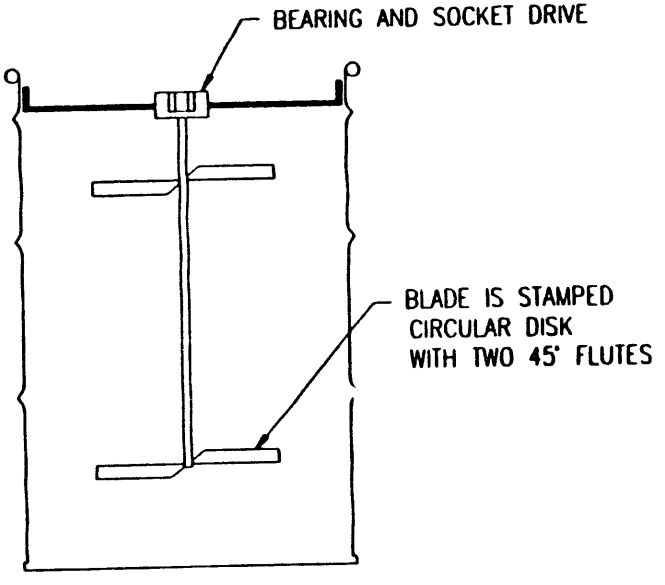
VORTEX SUPPRESSION DEVICE

NOTES :

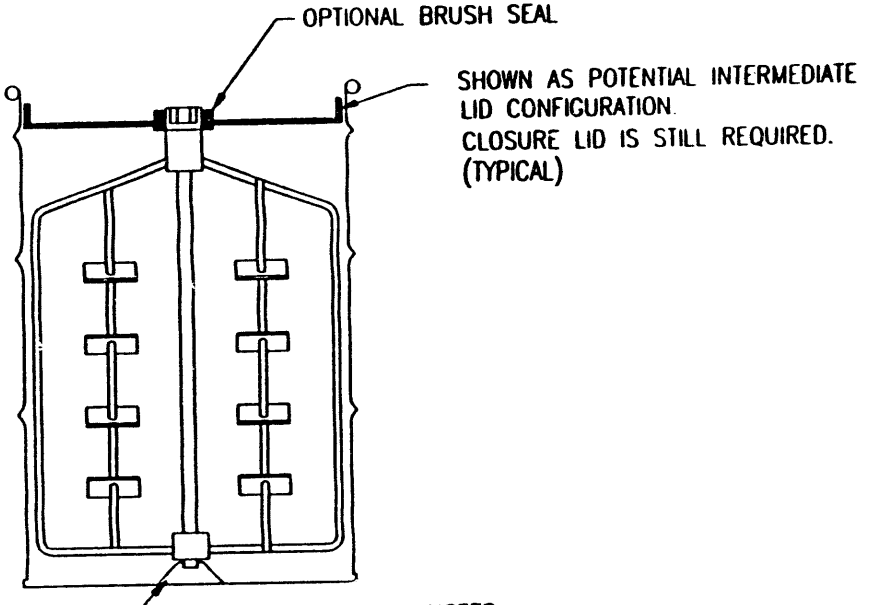
1. LOW SPEED (0-350RPM) TWIN IMPELLER SHOWN.
2. THIS DEVICE IS REQUIRED ONLY IF MIXING IS PERFORMED WITHOUT AN INTERMEDIATE OR CLOSURE LID ON THE DRUM.







(0-340 RPM)
TWIN BLADE IMPELLER



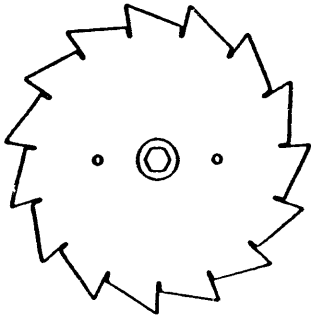
(0-80 RPM)
BNFL STYLE
IMPELLER

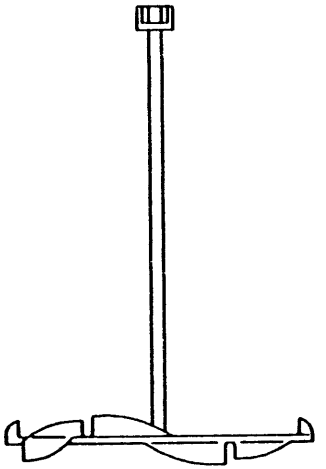
NOTES :

1. OPEN BOW TIE IMPELLER NOT SHOWN IS SIMILAR TO BNFL IMPELLER WITHOUT INTERMEDIATE BLADES.
2. BNFL AND OPEN BOW TIE ARE BOTH ANCHOR TYPE IMPELLERS.

FIGURE 7-2

IMPELLER CONFIGURATIONS





(600-3200 RPM)

FIGURE 7-3

HIGH SPEED AGITATOR DISPERSER TYPE BLADE

NOTES :

1. BLADE IS STAMPED FROM MILD STEEL.
2. DRIVE MOUNTING IS SIMILTAR TO TWIN BLADE IMPELLER CONFIGURATION.
3. BLADE DIAMETER IS 8" MAXIMUM.

b. High speed (600-3200 RPM) single shaft agitator mixing will be accomplished with an 8" diameter disposable disperser type blade see **Figure 7-3**.

c. Blade Attachments: The lost paddle attachments are intended to facilitate totally remote operation. A potential concept is the use of a socket type drive (see **Figure 7-2**) which is compatible with the CDR baseline lift table drum positioning design. This drive would be spring loaded and include a positioning pin.

4. Preload Sequence: The preload sequence for waste agitator and binder is currently conceived as follows:

a. Grout In-Drum Mixing/Thermoset Polymer In-Drum Mixing

1) In this situation the paddle will be preloaded into the waste drum prior to the drum being presented into the open/sort/repack enclosure. Waste will then be loaded in around the paddle. In the case of waste to be treated with grout binders the necessary fluids content may also be added at this point. Please refer to the sludge repack evaluation study.

2) The loaded drum will then be transferred to the applicable process enclosure. The paddle will be mated to the mixer drive and slowly accelerated to mixing speed. After a predetermined time delay the binders will be added and mixing will continue until setup or a predetermined torque load is achieved.

3) The loading sequence does not alter the CDR baseline which complies with all FDC requirements.

b. Thermoplastic Polymer Binder Out of Drum Mixing

1) The binder may be introduced to extruder mixer followed by the addition of waste. The addition ports would physically located separately along the extruder barrel and therefore the binder and waste addition would be controlled independently and concurrently. Optionally waste and binder addition could be concurrent through a single addition port.

2) The loading sequence requires the procurement of additional screw feeders to comply with FDC requirements.

5. Sinkers and Floaters

a. The encapsulation of size reduced materials will be performed utilizing vibratory techniques. All wastes will be placed in a mesh basket which stands inside the drum. This basket contains the waste during vibration and eliminates the potential for waste to travel to the extreme surfaces of the monolith.

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Part 6:	July 19, 1976	"How to Select Turbine Agitators for Dispensing Gas into Liquids"
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APPENDIX A

VENDOR CONTACTS

APPENDIX A

VENDOR CONTACTS

WRAP 2A ACDR STUDY 1604-3	MIXING EQUIPMENT CONTACTS	6237008 1/15/93
VENDOR/SUPPLIER	**EQUIPMENT TYPE**	**TELEPHONE CONTACT**
1 BERSTORFF CORP CHARLOTTE, NC	TWIN SCREW HEATED EXTRUDERS	GENE STROUPE 704-523-2614
2 B.E.S.T. INC. CLEVELAND, OH	VIBRATORY GRID DECK TABLES	RICHARD BREUDIGAM 216-362-1177
3 CLEVELAND VIBRATOR CLEVELAND, OH	PENCIL TYPE VIBRATORS	PATRICIA GEORGE 216-623-5944
4 D.W. DAIGLER DENVER, CO	LIGHTNIN SINGLE SHAFT HIGH SPEED MIXERS	DAVE DAIGLER 303-757-4981
5 HAYES & STOLZ INDUSTRIAL FT WORTH, TX	HORIZONTAL BLENDER - PADDLE TYPE	KEITH HOLT 800-725-7272
6 HOCKMEYER EQUIP CLAREMONT, CA	DISPERSERS, CONCENTRIC MULTIPLE SHAFT MIXERS	STEVE GUNTNER 714-626-2909
7 MUNSON MACHINERY UTICA, NY	HORIZONTAL BLENDER - PADDLE TYPE	TOM BASHANT 315-797-0090
8 MYERS ENGINEERING BELL, CA	LOW SEED SINGLE SHAFT AGIT & HIGH SPEED DISPENSERS	STEVE LODATO 213-560-4723
9 CHARLES ROSS & SON CO HAUPPAUGE, NY	TWIN SHAFT LOW SPEED PLANETARY MIXER	TOM O'SHAUGHNESSY 516-234-0500
10 SILVERSON MACHINES, INC. EAT LONGMEADOW, MA	HIGH SHEAR HIGH SPEED EMULSIFIERS	WILLIAM DIETSCHE 413-525-4825

WASTE RECEIVING AND PROCESSING FACILITY

TITLE: STUDY 1604-1 SINGLE IMMOBILIZATION

Revision: 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company
Western Operations

STUDY 1604-1
SINGLE IMMOBILIZATION

Prepared by: S A Sample for R Voke Date: 1/7/94

Reviewed by: JP Burkle Date: 1/7/94

Approved by: [illegible] Date: 1/7/94

Approved by: [illegible] Date: 1/7/94
Project Manager

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APPENDIX A ROM COST ESTIMATE

1.0 OBJECTIVE

This study will determine if a single immobilization process can be used to treat all WRAP 2A feed streams in compliance with FDC[1] requirements and if not, will evaluate the optimum immobilization process for each feedstream. Each process shall be compared using the same base feedstream data. Any significant changes in the base data during preparation of the report shall be investigated and their impact on the results of the study reported in a sensitivity analysis section.

1.1 Scope

A. Review previous literature surveys[2] and process evaluations[3] and identify all processes which could potentially treat all WRAP 2A feedstreams and comply with FDC requirements.

B. For each process selected for further evaluation assess whether it will be necessary to pretreat and/or use low waste loadings in order to achieve product quality requirements.

C. Compare each process selected for further evaluation using standardized criteria to determine the most appropriate technology for WRAP 2A. Section 6.2.1.4 identifies the process configuration boundary for option evaluated.

1.2 Background

A. The WRAP 2A CDR[10] has provided two process routes for immobilization of feed streams i.e. grouting and encapsulation with polymer. Two routes were adopted because, without significant pretreatment or low waste loadings for some feedstreams, it was not possible to identify one process to treat all wastes. Due to the diversity of physical properties of WRAP 2A feed streams, each process route has two mixing techniques provided for in the CDR to accommodate the different physical properties of the wastes.

B. The following CDR design review comments will be addressed in this study:

Comment #	Comment
15	Develop modifications required for 48 hour storage of grout drums.
16	Consider eliminating agitated grout process by using agitated polymer process instead.
201	Evaluate the stabilization methods to identify most suitable process, i.e., grout or polymers, for various types of waste material

C. Potential immobilization techniques considered for use in WRAP 2A included the use of cementitious materials, organic binders and inorganic binders. For the purposes of this study it was assumed that the equipment required for handling all cementitious binder materials would be similar and therefore it would not be necessary to identify only one material for evaluation.

D. The organic binders fall into two categories; thermosetting polymers and thermoplastic polymers. Vinyl Ester Styrene (VES) was selected as the thermosetting polymer to be evaluated for the reasons identified in the CDR and that is because there is vendor information which provides experience of encapsulation of similar waste forms to WRAP 2A. Polyethylene was selected as the thermoplastic polymer to be evaluated based on the fact that there is direct DOE site experience of immobilizing wastes in polyethylene at Rocky Flats Plant and at Brookhaven National Laboratory.

E. Inorganic binders were not considered worthy of further evaluation as there is limited experience of using these materials for immobilization of wastes with similar characteristics to those expected at WRAP 2A.

F. Details of VES, polyethylene and grout properties are given in Section 6.2.

1.3 Purpose and Need

A. In the CDR, WRAP 2A is designed as a two process plant using similar mixing technology in each process but employing different immobilization binders. If a single immobilization process can be defined there is the potential for large savings on both capital and operating costs.

B. This study will compare the three "single" immobilization process options selected from the literature survey and two "dual" immobilization process options (defined later in Section 5.1.2.1). Based on the results of this study a decision will be taken whether to proceed with the current CDR design or to a different process configuration.

2.0 SUMMARY

A. This study considers immobilization binders which may be suitable for treating WRAP 2A feedstreams. Three single binder options: grout, Vinyl Ester Styrene and polyethylene and two dual binder processes: VES/grout and polyethylene grout are selected for detailed evaluation to determine the best process option for WRAP 2A feedstreams. For the purpose of the study it is assumed that pretreatment options will be limited and that reduced waste loadings will be the primary method of ensuring that waste form performance specifications are complied with.

B. A detailed analysis of the five selected options is performed based on the following evaluation criteria:

Process Hazards
Operability
Maintainability and Reliability
Demonstrated Technology/Development Requirements
Capital Cost
Raw Materials/Operating Cost
Flexibility
Waste Minimization

C. As there are a number of assumptions made in the study related to waste throughputs, waste loadings and agitator costs, a sensitivity analysis is performed to confirm the process selected as the best option.

D. This study recommends a dual polyethylene/grout process as the best process for WRAP 2A. The rough order of magnitude (+/- 25%) total estimated cost of this option is $79,946,000. The ROM total estimated cost for the CDR option is $81,068,000 based upon the July 31, 1992 WRAP Module 2A TEC estimate.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Recommendations

A. Section 6.4, Evaluation of Alternatives, clearly shows that WRAP 2A should incorporate a grout process and a polymer process. This will ensure that the facility has the flexibility to treat the wide range of waste types which will be routed to WRAP 2A at waste loadings which will minimize the volume of product for disposal. Section 6.4 also shows that in terms of process hazards, cost and waste minimization, a process using polyethylene is significantly better for WRAP 2A than a process using Vinyl Ester Styrene. Hence, it is recommended that the WRAP 2A design is based on a polyethylene/grout process.

3.2 Conclusions

A. The Advanced Conceptual Design Report for WRAP 2A should be based on a three line process using polyethylene extrusion encapsulation, vibro-grout encapsulation and sludge/particulate grout solidification.

4.0 UNCERTAINTIES

A. Waste stream chemical and physical characteristics:

When this study was initiated the only source of information on the waste stream chemical and physical properties was the WRAP 2A CDR documentation[3, 10, 20]. Since then WHC have provided draft feedstream data sheets[32] which have been used in the sensitivity analysis section of this study. However, this information will be subject to change and therefore, until all the waste feedstreams are fully characterized there will be some uncertainty as to the precise treatment to be used in WRAP 2A for some feedstreams.

B. Binder selection:

Over the next few years there will abe a continuing development program to identify binder formulations most applicable for each feedstream. Until this work is completed, details of the treatment process for each feedstream cannot be finalized.

C. Waste loadings/product quality:

The waste loadings used in this study were based upon previous experience with use of each binder for solidification of similar wastes to that expected for WRAP 2A. As development of the binder formulation progresses, the individual waste loadings may change.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC [1] Requirements

A. The single immobilization option must meet the following FDC requirements:

1. The system must be capable of controlling and easily changing immobilization formulations.

2. The system must be capable of conditioning, de-activating and immobilizing low-level RMW.

3. Treated waste shall be packaged into new 55 gallon drums.

4. Handling of dry waste materials, if required, is to be accomplished by a conveyance system.

5. Capability shall be available for extracting samples for verification of successful treatment.

6. Capability to track waste entering the treatment areas to the exiting containers as required by the regulations.

7. Provisions for bulk storage with ventilation and controlled delivery systems for dry and liquid agents to support treatment shall be provided.

8. The capability to determine and control the weight of the containers of waste for disposal during treatment and addition of volume fillers as needed shall be provided.

9. The WRAP 2A process shall be designed to treat 29,000 cf of waste each year.

10. Treatment shall be non-thermal. (i.e. processes shall operate at less than 500°F).

11. Immobilization means shall comply with Land Disposal Restrictions[21] and provide a waste form compatible with DOE, local and national jurisdictional requirements as referenced by the FDC.

5.1.2 Study Criteria

5.1.2.1 Study Basis

A. An evaluation will be performed on the following immobilization processes considered suitable for WRAP 2A.

1. A cement based grouting process (undergoing waste form testing at Hanford).

2. Thermosetting polymer encapsulation (undergoing waste form testing at Hanford).

3. Thermoplastic polymer encapsulation (developed by Brookhaven National Laboratory and Rocky Flats Plant).

4. The grouting process defined in A.1 above and the thermosetting polymer encapsulation process defined in A.2 above.

5. The grouting process defined in A.1 above and the thermoplastic polymer encapsulation process defined in A.3 above.

B. This study will identify pretreatment and/or reduced waste loading requirements for each WRAP 2A feedstream if required to achieve an acceptable product in each of the above immobilization processes, and will evaluate the economics of such options.

C. Each immobilization process will consist of common unit operations which will be evaluated in this study. The unit operations include the following:

1. Binder/Additives Bulk Storage.

2. Binder/Additives/Waste Delivery System.

3. Waste Pretreatment

4. Binder/Additives/Conditioned Waste Mixing System.

5. Treated Waste Cure/Monitoring System.

6. Secondary Waste (Off-gas, Liquids etc.) Treatment System.

5.1.2.2 Potential Study Impacts

A. This study will not rely primarily on existing data from the CDR baseline. Test results from WFQ testing will be utilized as results become available from the WFQ study, 1604-2, and the mixing study, 1604-3. It is not anticipated that such results will significantly alter the results of this study. This test work will be used to confirm study assumptions. Findings which will be of interest to this study include:

1. Binder formulation.

2. Waste Loadings

3. Cure times, peak exotherm temperature and free water generation.

4. Product quality data such as TCLP, compressive strength, immersion/leachability, biodegradation, radiation stability, thermal cycling and hazardous characteristics.

5. Waste mixing technique.

6. Pre-treatment requirements.

B. If appropriate, recommendations will be made for additional development work for both the WFQ study and the mixing study.

5.1.3 Screening and Evaluation Criteria

A. All potential options for single immobilization of all feed streams to WRAP 2A that are identified in the literature search will be evaluated based on standardized criteria. This criteria will consist of screening and evaluation criteria.

5.1.3.1 Screening Criteria

A. This study will use the following preliminary screening criteria to allow a reduction of the total available immobilization options applicable to this study. This will give a reasonable number of options to evaluate per formal criteria. The screening criteria are:

1. Compliance with the FDC and other mandatory requirements.

2. Demonstrated commercial or industrial use in a similar application.

B. For all options meriting further evaluation, preliminary mass balances and block flow diagrams will be prepared.

5.1.3.2 Evaluation Criteria

A. All alternatives which are not eliminated by the first level evaluation will undergo further evaluation using a pre determined list of criteria. Each individual evaluation criteria is given :

1. A weighing factor.

2. A range of raw scores reflecting the potential relative merits of the alternative.

B. Scoring is calculated by multiplying the raw score selected and the weighing factor.

C. Evaluation criteria, weighing, and scoring factors.

1. Process Hazards

a. Weighing Factor: 15%

b. Scoring Factor: All processes obviously must be acceptably safe. Factors to consider include operator dose exposure; human factors; potential for operator injury; potential for leaks, spills or uncontrolled releases; potential for dropping objects; potential for flammable or hazardous gas generation; potential process hazards due to storage and/or use of reagent feed streams.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

2. Operability

   a. Weighing Factor: 15%

   b. Scoring Factor: Assessment of impact of immobilization binder type on plant clean out operations, including number of operations and plant design. Assessment of the ease of adjusting binder formulations. Assessment of the startup and shutdown operation requirements.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

3. Maintainability and Reliability

   a. Weighing Factor: 10%

   b. Scoring Factor: Assessment of equipment replacement/maintenance requirements. Assessment of routine maintenance requirements. Assessment of equipment reliability.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

4. Demonstrated Technology/Development Requirements

   a. Weighing Factor: 15%

   b. Scoring Factor: Evaluation of the current status of technology development for a process configuration. Rating is based upon past experience in a similar or identical application and potential for further development if significant uncertainties are identified. Identical and similar experience is related to waste form, binder, and equipment type.

Best	5
Above average	4
Average	3
Below Average	2
Worst	1

5. Capital Cost

   a. Weighing Factor: 10%

   b. Scoring Factor: Comparison of total estimated capital cost of proposed process system with the equivalent CDR base case system cost. Cost impacts to supporting process or utility areas will also be considered.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

6. Raw Materials/Operating Costs

   a. Weighing Factor: 15%

   b. Scoring Factor: Comparison of total estimated raw material/operating cost of each process system with the CDR base case system.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

7. Flexibility

   a. Weighing Factor: 10%

   b. Scoring Factor: The capability to meet or exceed current waste acceptance criteria (WAC) for multiple waste feedstreams using the minimum number of finder formulations/process variations (see **Table 5.1** for details of WAC criteria). The capability to accommodate future WAC disposal and regulatory criteria that is more restrictive.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

8. Waste Minimization

   a. Weighing Factor: 10%

   b. Scoring Factor: The overall minimization of primary and/or secondary waste. Factors such as primary waste loadings and generation of secondary waste treatable within or outside of WRAP 2A will be considered. The evaluation will be based on the minimum number of drums generated per unit volume of waste processed.

Best	5
Above average	4
Average	3
Below average	2
Worst	1

5.2 Assumptions

5.2.1 Study Prerequisites

A. There are no prerequisites to this study, however studies 1604-2 (Waste Form Qualification) and 1604-3 (Waste Mixing) may impact on the direction of this study as results emerge (see Section 5.1.2.2 for possible impacts).

B. Immobilized waste in any of the three binders will satisfy appropriate regulatory acceptance criteria for disposal. This includes compliance with the following regulations:

   1. Washington Administrative Code (173-303) which defines treatment and packaging of hazardous waste.

   2. Hanford Site Radioactive Solid Waste Acceptance Criteria (WHC-EP-0063) which defines site specific disposal criteria.

   3. Land Disposal Restrictions, 40 CFR 268.

   4. DOE Order 5820.2A Radioactive Waste Management.

C. In addition to the above, the immobilized waste should also comply with the following recommended criteria:

   1. Licensing Requirements for Land Disposal of Radioactive Wastes, 10 CFR 61.

5.2.2 Study Assumptions

A. Literature searches and contacts with industry will be used to assess any potential changes to the CDR approach. The study will evaluate the relative merits of each of the alternative processes (single or multiple) based on documented information from industry or the literature.

B. Waste feedstream characteristics for this study will be based on the latest draft feedstream specification data[32]. The feedstream throughputs will be based on the CDR throughputs.

C. All waste feedstreams for WRAP 2A can be immobilized via one or more of the selected study immobilization techniques and all waste feedstreams will be immobilized using one of the selected study processes prior to disposal.

D. For the purpose of this study it is assumed that pretreatment will be limited and that reduced waste loadings will be the primary method of ensuring that the waste form performance specifications, summarized in Table 5-1, are complied with by all products.

TABLE 5-1 WRAP 2A WASTE FORM PERFORMANCE SPECIFICATIONS

Waste Form Characteristic	Test Method	Acceptance Criteria
Compressive Strength	ASTM D695 or ASTM C39	Strength > 500 lbf/in^2
Leachability Index	ANS 16.1	Leach Index > 6
Biodegradation	ASTM G21 and G22, ASTM D695 or ASTM C39	No Growth, Strength > 500 lbf/in^2
Thermal Cycling	ASTM B553, ASTM D695 or ASTM C39	Strength > 500 lbf/in^2 after 30 cycles
Radiation Stability	ASTM D695 or ASTM C39	Strength > 500 lbf/in^2 after irradiation to 10^8 rad
Immersion	ASTM D695 or ASTM C39	Strength > 500 lbf/in^2 after 90 day water immersion
Free Liquids	ANS 55.1	Free Liquid < 0.5%
Hazardous Characteristics	40 CFR 261	Not Ignitible, not corrosive, not reactive
Toxicity Characteristics	EPA 1311 (TCLP), EPA 6010	TCLP leachable constituents below EPA limits*

* EPA limits as described in 40 CFR 268.41, Table CCWE

ANS = American Nuclear Society
ASTM = American Society for Testing and Materials
EPA = U.S. Environmental Protection Agency
TCLP = Toxicity Characteristic Leaching Procedure

6.0 DESCRIPTION OF ALTERNATIVES AND SOLUTIONS

6.1 Listing of Alternatives

A. The following alternatives have been selected for evaluation:

1. Grouting
2. Thermoplastic Polymer Encapsulation
3. Thermosetting Polymer Encapsulation
4. A combination of Grouting and Thermoplastic Polymer Encapsulation.
5. A combination of Grouting and Thermosetting Polymer Encapsulation.

B. With suitable pretreatment and/or reduced waste loadings it is possible that any of these processes could immobilize all WRAP 2A feed streams. This study will investigate immobilization of raw waste feed streams and practical pretreatment/reduced waste loadings options. Each process shall be evaluated based on demonstrated technology, practicality, safety and economic grounds.

6.2 Detailed Discussion

6.2.1 Grouting

6.2.1.1 Description

A. Introduction

1. Grout is a mixture of cementitious material(s) and water, proportioned to produce a pourable consistency without segregation of the constituents[4]. In the context of the WRAP 2A CDR the cementitious material is a blend of Ordinary Portland Cement (OPC) and either ground granulated Blast Furnace Slag (BFS) or Pulverized Fly Ash (PFA)[10]. An alternative cementitious material, not discussed in the CDR, is a modified gypsum cement intended for low level radioactive waste solidification, for example, U.S. Gypsum Company "Envirostone"[6].

2. Hydrating (i.e. curing) grout pastes are chemically very active systems[5]. Concentrated alkali hydroxide solutions present in pores of OPC create a very high internal pH in the range of 13.0 - 13.5. Conditioning of any acidic waste material is essential to avoid an exothermic (i.e. heat generating) acid-base reaction between the waste and cement which could disrupt proper setting of grout or crack the grout monolith. The high alkalinity of grouts is advantageous in that most embedded metallic wastes are then passivated against corrosion[13]. Sulfate solution wastes respond undesirably in an alkaline environment. Sulfates react with phases of the cured cement to create products, principally calcium sulfo aluminates, of greater volume than the original reactants, cracking the grout monolith[11]. However, sulfates can be grouted if the grout formulation is tailored to minimize the reaction of the sulfates with the cement materials.

3. Precise determination of the appropriate cementitious material formulation(s) can not be made in this study because the complete waste characterization data and developmental work, cited as necessary in the CDR, is not available. However, the general properties and effects of the potential grout constituents will be discussed in the following paragraphs in order to provide a background for their selection and relative value to the process.

B. Portland Cement

1. Portland cement is the artificial mixture of lime, silica, alumina, iron oxide, and gypsum developed in the early nineteenth century by the construction industry to address the considerable variations in the properties of natural cements produced from rock quarried in different localities[5,7]. The composition, sampling procedures and testing procedures of Portland cement are fully documented by, and specifiable under, nationally recognized standards such as those published by the American Society for Testing and Materials (ASTM). This documentation, and hence control in manufacture, of portland cement makes it an appropriate choice as a cementitious material in the WRAP 2A waste solidification process. Since approximately 99 percent of all concrete construction in the U.S. utilizes Portland cement under either ASTM C150 or ASTM C595, material complying with the desired specification would be widely (and thus, relatively inexpensively) available[5].

2. Portland cement is a hydraulic cement, in that, unlike non-hydraulic types (e.g. plaster), it will fully set and harden underwater (i.e. without air contact). Hydraulic character is then a requirement for proper homogenous in-drum curing of the waste form product. This is because as the cement paste cures, it essentially sinks somewhat in the water with which it is mixed, potentially bringing a standing layer of displaced water to the top of the casting, a condition known as bleeding[4]. By careful control of the water content of the waste/cement mix the amount of bleed water generated can be eliminated.

3. Other hydraulic cements, such as natural cement, pozzuolana cement and hydrated lime do not offer the wide availability, documented composition or prerequisite structural properties provided by Portland cement[7].

4. In recent years, the level of technical sophistication in the knowledge of Portland cement mineralogy has increased substantially owing to the use of scanning electron microscopy and other modern analytical methods. From microscopic observation, researchers are able to predict strength and curing properties of the various cement compositions produced when mix, fineness, and kiln parameters are changed. As a result, the manufacturing process is controlled to the extent that five specific types of Portland cements exist under ASTM C150 with differing characteristics[5]. The general purpose specification, ASTM C150 Type I, also known as Ordinary Portland Cement (OPC), was selected for the WRAP 2A CDR process since the particular characteristics of the other types are not necessary[10]. OPC represents 87 percent of the U.S. Portland cement production and is thus widely available[5].

5. In the construction industry, Portland cement is often blended with pozzuolanic materials or other cementitious materials, most notably pulverized fly ash or ground granulated blast furnace slag. The intent is to improve specific characteristics of the cement both during the fabrication process and in the cured product[5]. The improvements derived are essential to the usefulness of Portland cement in waste immobilization so each is discussed in detail in subsequent paragraphs. The blending practice is common enough at the point of manufacture that a separate specification ASTM C595 exists, defining six types of Portland cement blends[4]. However, in the WRAP 2A process it is desirable to have the flexibility to formulate a blend that is optimal for radioactive waste immobilization, so cement blended with pozzuolanic material or other cementitious materials to a construction industry standard may not be appropriate. Therefore, the Portland cement constituent in the WRAP 2A Process Flow Diagrams is the ASTM C150[47] Type I (OPC) form.

C. Blast Furnace Slag

1. Blast furnace slag is a nonmetallic product, consisting of silicates and aluminosilicates of calcium, developed in a molten condition simultaneously with iron in a blast furnace[4]. Blast furnace slag is utilized as a structural material in two forms. If slowly cooled in air upon removal from the blast furnace, the slag solidifies into a crystalline porous stone. While having no cementitious properties of its own, air-cooled slag is mixed as an aggregate with cement to form a type of concrete. If rapidly chilled upon removal from the furnace, usually by water spray, the slag solidifies into hard, glassy, noncrystalline particles. Ground into a granulated powder, the rapidly cooled slag particles are much more chemically active and if combined with lime the slag becomes very cementitious[9] (Note: some slags contain a high lime content and hence are sufficiently cementitious in nature not to require the addition of further lime). It is only this latter product, ground granulated blast furnace slag (GGBFS), that is applicable to the WRAP 2A immobilization process.

2. Slag cement, produced by mixing GGBFS with calcium hydroxide in the form of lime, has found applications as a hydraulic cement since 1774[9]. However, slag cement alone is significantly slower setting than Portland cement, so that the modern uses of GGBFS, including its utility in waste immobilization, involve blending GGBFS with Portland cement. In this case the calcium hydroxide necessary for the reaction of the GGBFS into a cement comes from the hydration of the Portland cement[9]. Additionally, the heat generated by the Portland cement hydration accelerates the setting of the slag cement[12].

3. The reaction is of major importance to the utility of portland cement grouts as a successful waste immobilization binder. As the Portland cement hydrates, calcium hydroxide is released and accumulates in the pores of the cement paste. The presence of GGBFS means that the pores, which would otherwise contain soluble calcium hydroxide deposits, instead become sites of slag cement formation. Essentially the pores of the Portland cement are filled, at least partly, with the slag cement, significantly decreasing the permeability of the binder[9]. The reduced permeability should improve the leachability index of the binder as determined by ANS 16.1 procedure compared to OPC alone.

4. Cement hydration is a heat generating reaction. The amount and rate of heat generation are functions of the composition and fineness of the cement[5]. In waste immobilization tests in the U.K. involving OPC filled 55-gallon drums, centerline temperatures in excess of 110°C (230°F) were recorded. Such temperatures may lead to boiling of the reactant water, resulting in waste particulate release, improper cure, and cracking of the binder[13]. Combining GGBFS with the OPC produces a blended cement with a reduced heat of hydration and lower peak temperature[13,9].

5. Other characteristics noted for GGBFS - OPC blended cements compared to unmodified OPC include improved flowability, increased setting time, both increased and reduced bleeding, reduced strength loss when cured at elevated temperature, virtual elimination of expansion during curing and improved resistance to sulfate attack. These characteristics function in direct proportion to the ratio of GGBFS to OPC constituents and also to the relative chemical activity of the GGBFS constituent. The GGBFS relative chemical activity is in direct proportion to the ratio of surface areas and hence the fineness, of the powders. As an example, for a given weight ratio of GGBFS to OPC, bleeding is reduced if the GGBFS is finer than the OPC and increased if the GGBFS is coarser[9].

6. The chemical composition, physical properties (e.g. fineness), sampling, testing, storage,and inspection requirements of GGBFS can be specified under a U.S. National industrial standard, ASTM C989[16].

D. Fly Ash

1. Contrary to common household usage, ash by its technical definition is not unburned hydrocarbon residue but rather white to gray color oxides of the inorganic minerals present as trace elements in a fuel. Fly ash is the finer grain product light enough to be carried off in the exhaust gas and is collected by cyclone separators and electrostatic precipitators in the stack systems of pollution abatement. Fly ash from the combustion of pulverized coal, called Pulverized Fuel Ash (PFA), consists principally of oxides of silicon, aluminum, calcium and iron, with traces (1% - 10%) of carbon[11]. PFA, is pozzuolanic meaning that, while not cementitious itself, it becomes so when combined with the calcium hydroxide[4]. While it has few uses as a cement itself (10) it has been extensively employed by the construction industry as a constituent in blended Portland - PFA cements since the 1930s[11]. Due to its wide use, substantial scientific research has been conducted on PFA in mixture with Portland cement (OPC), yielding well documented information on chemical behavior and mechanical property effects[11].

2. The properties of OPC - PFA grouts are similar to OPC - GGBFS grouts when compared to OPC alone. Despite a longer setting time, the OPC - PFA mixtures have lower heat generation and temperature rise, lower permeability, improved sulfate resistance and reduced tendency to expand upon curing. The spherical shape of the PFA particles makes the OPC - PFA paste more easily pumped for a given water content than OPC alone, so that less water in excess of the hydration requirement is needed to provide a flowable grout for proper filling and mixing during in-drum waste immobilization. Less excess water in the paste means not only less potential for bleeding, but also lower permeability in the waste form product because more volume of the drum is occupied by solids as the grout sets[11]. As in the case with GGBFS, the influence of PFA on the properties of OPC -PFA grout is a function of its proportion in the mixture. Ratios ranging from 1 PFA : 4 OPC to 15 PFA : 1 OPC are in common use by construction industry, depending on the properties desired[14].

3. The chemical composition, physical properties (e.g. fineness), sampling, testing, storage, and inspection requirements of PFA can be specified under a U.S. national industrial standard, ASTM C618[15].

E. Gypsum Based Cements

1. There are a number of cementing materials consisting of calcium sulfate that are produced by the partial or complete dehydration of gypsum, $CaSO_4$ $2H_2O$. Natural deposits of gypsum provide the raw material for manufacture. There are no examples of where purely gypsum based cements have been used for solidification of radioactive mixed wastes. However, the United States Gypsum Company has developed a polymer modified gypsum cement called 'Envirostone' which has been successfully demonstrated on a number of radioactive mixed wastes[6].

6.2.1.2 Waste Immobilization History

A. Introduction

1. This section summarizes current experience of cement solidification of mixed waste by other facilities. The experience is mainly at US DOE sites, but also refers to experience in the UK and France.

B. Pacific Northwest Laboratory (PNL)/Hanford Grout Technology Program, Pilot - Scale Test, 1986[45].

1. This test evaluated finished properties of a particular grout blend when combined with a non-radioactive simulated liquid waste and then pumped 150 ft. as slurry to cure in a 60 ft. x 29 ft. lined trench. Sampler tubes inserted to various depths in the monolith prior to hardening provided pilot-scale data of waste form product.

2. PNL used a grout formula of 41% Type I/II Portland Cement, 40% ASTM C618 Class F fly ash, 11% Attapulgite Clay and 8% Illitic Clay. The waste stream was a solution of sodium phosphate and sodium sulfate, produced to simulate the neutralized phosphoric acid and sulfuric acid used for primary piping decontamination and ion exchanger regeneration respectively. Waste pH was 12.2 with negligible amounts of LDR metals. The attempted waste loading in wt-% can not be determined directly from the report data because the waste stream density is unavailable. The waste form criteria applied included compressive strength (on standard), corrosivity per Washington DOE Method 83-13, leachability index per ANS 16.1, and TCLP.

3. Mean compressive strength data varied in the range 258-440 psi. The monolith was determined non-corrosive (pH < 12.5), however, bleed water was corrosive. Bleed water was reabsorbed within 30 days. Leachability index was satisfactory, ranging from 7.7 to 9.1 as curing progressed. TCLP was not conclusive due to the small amount of LDR metals present.

C. West Valley Nuclear Services Co. (WVNS)/Sludge Solidification Program Production-Scale, 1988-89[8,22].

1. WVNS unsuccessfully attempted immobilization of radionuclide contaminated aqueous sludge from their Low-Level Waste Treatment Facility (LLWTF). The reports reviewed do not characterize the LLWTF waste completely. The WVNS in-drum solidification process consisted of pouring dry portland cement into approximately 2000 55-gallon drums, each roughly half-full of the sludge. Mixing consisted of rolling each drum on a horizontal roller machine with iron mixing bars sealed inside.

2. Visual inspections of cured products appeared to be satisfactory. The program was halted when some stored drums were found leaking water. Subsequently it was found that over half of the drums processed contained an average of 10 gallons of free water in pockets where mixing of sludge with cement had never taken place. After drainage, these drums continued to release water[22, 23].

3. The WVNS process was clearly deficient as many drums greatly exceeded the < 0.05% volume free water criteria. Although the cause was attributed to poor mechanical mixing, there is no assurance from the data that the waste load would have allowed acceptable product even if the mixing had been thorough.

4. WVNS has successfully immobilized supernatant from a high-level liquid waste tank. The waste is a slurry with a total solids content in the range 37-41 wt-%. The slurry is mixed with Portland Cement in high shear mixers and then poured into square drums and allowed to cure. By 1990, approximately 10,000 drums of product had been produced and so far only 27 appear not to meet product quality requirements.

D. WVNS/NuPack Services Inc/Laboratory Scale Test and Full - Scale Demonstration, October 1989[18].

1. NuPack services was contracted by WVNS to develop a more carefully considered process for LLWTF sludge as a result of the previously discussed failure. Ten drums of waste were immobilized.

2. Despite improvements in viscosity control and agitation during mixing, half the NuPack product failed NRC and DOE disposal/burial criteria. The two best of the satisfactory drums had waste loadings of 24 and 26 wt-% as compared to the 8 failed drums which ranged 52-64 wt-%.

E. Rocky Flats Plant (RFP) 207A Solar Evaporator Pond Sludge, Full - Scale, 1986-88[8].

1. RFP unsuccessfully attempted to immobilize high nitrate waste by mixing with OPC in a pug mill and a concrete mixer truck then pouring the mixture into cardboard boxes to cure. Over half the 16,000 boxes processed this way failed waste form criteria for the intended disposal site. Inappropriate use of equipment intended for concrete (where mixing is enhanced by the aggregate stones) for a grout process may have contributed to the failures. Unfortunately, there apparently was also a loss of process control during the program, so it is not known what the actual waste loading of the acceptable products were.

F. Oak Ridge National Laboratory (ORNL) K-25 Plant Evaporation Pond Sludge, Full - Scale Production[8].

1. This unsuccessful process at Oak Ridge produced 46,000 89 and 96 - gallon drums containing evaporation pond sludge processed by mixing with blended grout. The grout consisted of 50 wt-% Portland cement 50 wt-% PFA with an air entrainment agent the waste loading was 50 wt-%.

2. After storage, corrosion of some drums indicated free liquid trapped inside, with about 6% of drums actually leaking liquid. Poor process control and improper grout formulation are the attributed causes, although the attempted waste load is roughly that which also proved excessive in the NuPack tests.

G. Los Alamos National Laboratory (LANL) TA-50 and TA-55 Processes[8].

1. Nitric acid based aqueous waste from plutonium production operation at LANL was distilled in an evaporator, generating two waste streams; distillate treated by the TA-50 process; and sludge treated by the TA-55 process. Waste form criteria in both cases was the WIPP criteria.

2. The TA-50 process precipitated radionuclides from the distillate by neutralization. The resulting sludge was poured in 23 gallon lots into a drum with 282 lbs Portland cement, 3 gallons vermiculite and 2.5 gallons sodium silicate. Mixing involved tumbling the drums at 25 rpm for 20 minutes. At the time of the source referenced (December 1990) there had been no evidence of unsatisfactory results attributed to this process, although some drum corrosion had occurred due to weathering.

3. In contrast to the TA-50 results, the TA-55 process failed when a large percentage of the product were found to be generating substantial amounts of free liquid. In this case the binder used was the "Envirostone" commercial gypsum - polymer product, chosen based on compatibility with the acidic (pH = 4) waste sludge. The on-going liquid generation may be due to radiolysis of the cement as the waste activity level was high. Quantitative data on the weight - % waste load was not proved. However, attempts to eliminate the problem by adjusting the waste load delayed but did not prevent liquid generation.

H. Westinghouse Hanford Company (WHC)/Hanford 183-H Solar Evaporator Basin Waste.

1. Solidification of this waste, which is now feedstream 1A to WRAP 2A[10], was attempted using a commercial special - purpose grout "Sorbond LPC-II". The LPC-II grout (which is 70% OPC/25% lime) was mixed in 2323 lb. batches with 320 gallons raw liquid waste. The mixed batches were loaded into 55 - gallon drums[23].

2. Failure of the waste form was noted two years later when drums began to swell and corrosion became evident. One cause of the swelling is attributed to be chemical attack by sulfates in the waste, which form expansive hydration products (aluminosulfates) discussed in Section 6.2.1.1.A.2. It would follow then, that a lower waste load is necessary to ensure the integrity of a grouted waste form with sulfate - containing waste. Due to the time that transpires before failures become evident, empirical data would be difficult to obtain.

I. Rocky Flat Plant (RFP)/Organic and Sludge Immobilization System (OASIS), Full-Scale Production, 1984[24].

1. Following the experience of the RFP Low-Level Organic Immobilization (Section 6.2.1.2E) the OASIS was developed to solidify both aqueous precipitation sludge and TRU organic liquids. While the waste characterization is not detailed in the report reviewed[24], the sludge is cake removed from filters through which hydroxide precipitated aqueous metallic sludge (from plutonium production) had passed. The TRU organic liquids are predominately hydraulic oil, solvents and lathe coolants. The waste form qualification in both cases is WIPP criteria.

2. For sludge, the OASIS mixes OPC, water and the waste in the waste drum by rotary agitator for five minutes. Water addition is controlled by the measured moisture content of the sludge. OPC addition is programmed to achieve an established wt-% in the product. Tests of six product samples ranged from 40-50 wt-%. All samples passed waste form criteria.

3. For organic liquid, the OASIS uses "Envirostone" cement as the binder. Addition of the waste liquid, the three "Envirostone" constituents, and water occur in programmed sequence in predetermined amounts. Tests of eight product samples ranged from 33-39 wt-% waste.

J. Rockwell Hanford Operations (RHO)/Solid Shredded CH-TRU Waste Immobilization, Laboratory - Scale Tests, 1986[25].

1. This program determined optimal OPC grout formulation and mixing technique for CH-TRU solid shredded waste expected to be immobilized at the then pre-conceptual WRAP 2A facility. The surrogate waste used contained miscellaneous metals, glass rubber, cloth and wood debris which appear representative of what is now CDR feedstreams 3 and 4[20]. Waste forms program were 3" x 6" cylinders and 6" x 6" cubes. Waste form criteria was the WIPP-WAC with additional compressive strength requirements on the product and rheological requirements on the grout.

2. The program determined that a grout formulation of OPC and water in a 0.7 water/cement ratio mixture with 3 wt-% bentonite clay produced acceptable results. Waste loading, which was not manipulated for this study, was approximately 20 wt-%.

3. Because waste forms produced in this program were not full-size product,the data is of limited value since there may be scale up problems due to the cure exotherm at 55-gallon drum scale.

K. U.S. Ecology/Pacific Nuclear/Ammonium Sulfate Liquid Waste Immobilization[26].

1. Discussion with Pacific Nuclear indicates they have successfully grouted ammonium sulfate salt solution (in this case 20-30 wt-% solids, pH = 10.5) using a "modified" (proprietary) Portland cement binder. Waste form criteria included Washington State Department of Ecology land disposal restrictions. A waste form was produced with 78-83 wt-% waste loading, but due to the ammonia off-gassing the product was honeycombed.

2. A significant hazard associated with grouting this feedstream is ammonia gas evolution which is triggered by the cement hydration. Pacific Nuclear stated maximum evolution in the first 2 hours of curing, requiring vent holes in the monolith.

L. British Nuclear Fuels plc (BNFL)/Cumulative experience in Grouting Radioactive Wastes, 1982 - Present[41][13][27][28][29].

1. Development of grouted waste immobilization technology by BNFL has to date involved a 10 year $50 + million effort leading to commissioning of (several) major grouting plants. The success of grout as an immobilization medium for non-heat generating wastes has resulted in its adoption for all currently identified wastes of this kind by BNFL. Experiences with wastes relevant to WRAP 2A are summarized in the following paragraphs. (Note: The regulatory requirements for product quality are different in the UK compared to the US. Hence TCLP testing is not required).

2. A notable feature of BNFL/AEA grout immobilization projects is the development of specific blends of OPC and GGBFS or PFA, each optimal for a particular waste feedstream. Use of the pozzuolanas began when pure OPC generated unacceptable exotherms during hydration when used in full-size waste forms (refer to Section 6.2.1.1c)[13]. Successful immobilization of particular waste feedstreams relevant to WRAP 2A is discussed in the following paragraphs.

3. <u>Ion Exchanger Resin</u>: The waste resin involved was a sludge of 81 wt-% damp polystyrene powder, 10 wt-% hydrated lime with the remainder mostly metal oxides. Sludge dry solids were 30 wt-% total weight. Satisfactory waste form was produced with a 90 wt-% GGBFS/10 wt-% OPC grout blend at a waste load of approximately 20 wt-%.

4. <u>Nitric Acid Liquids</u>: Allowing the waste liquid to "age" after neutralization, precipitated aluminum from solution. This solution was immobilized using a 90 wt-% GGBFS/10 wt-% OPC grout.

5. CH-TRU Solid Wastes: Wastes consisting of materials corresponding to CDR feedstreams 3 and 4 were immobilized by a 75% PFA/25 wt-% OPC grout.

6. Light Metals: Solids containing sodium, potassium, and aluminum require pre-treatment and/or careful formulation to prevent excessive reaction and gas generation[28].

7. Sludges: Water content of the grout must be balanced with that already present in the sludge to avoid excess bleeding, creating free water on the waste form product[28].

8. Absorbed Organics: Absorbants which are completely saturated will dewater the grout[28]. This could prevent adequate cement hydration, leaving parts of the waste form uncured.

9. Soluble Salt Solutions: Solutions bearing up to 40 wt-% sodium nitrate have been successfully immobilized at waste loadings of up to 20 wt% nitrate solution. Ammonia (3 wt-%) and calcium (1.4 wt-%) nitrate solutions have also been successfully immobilized.

M. (CEA) Nuclear Research Center, Cadarache, France/Immobilization of Incinerator Ashes C. 1990[30].

1. The CEA conducted research of incinerator ash immobilization with grout in an effort to maximize waste load. While the major result of the effort was development of a composite cement/polymer formulation, data was also obtained on purely grout matrices which are relevant to WRAP 2A. Waste form criteria was not quantitatively reported, but compressive strength, permeability and solidification exotherm were compared to a baseline grout formulation which was currently acceptable.

2. The baseline grout consisted of 51% OPC, 24% GGBFS and 25% PFA. This formulation was satisfactory with up to 20 wt-% incinerator ash waste load. It was found that waste ash could be substituted for the PFA in the baseline blend, which would be in addition to the ash normally embedded in the final matrix. Satisfactory product was obtained with a 34 wt-% ash waste load by this approach.

N. Westinghouse Hanford Company (WHC)/WRAP 2A Waste Form Qualification Program Laboratory - Scale Tests, 1992[46]

1. The primary intent of this on-going program is to verify the ability of various mixed waste immobilization binders to produce satisfactory waste form products given the waste feedstreams particular to WRAP 2A.

2. The waste form criteria for screening were to (a) obtain a hard set within a 6 to 48 hr time frame and (b) obtain a subjectively acceptable waste loading.

3. Screening tests concluded the following formulations as appropriate in the case of each surrogate[46]:

   a. Feedstream 1D (183H Miscellaneous (sandblast grit)) with high copper content - ASTM C150 Type III portland cement at a water to cement ratio of 0.4. Waste load was 42 wt-%. Type III was chosen to offset the set retardant properties of transition series metals such as copper.

   b. Feedstream 1D (183H Miscellaneous (sandblast grit)) with high nitrate content -9:1 weight ratio GGBFS to ASTM C150 Type III Portland cement at w/c = 0.4. Waste load was 42 wt-%. Observations indicated nitrates did not affect the set time of slag cement, however, some Portland cement was necessary to initiate set within a reasonable time.

   c. Feedstream 2C (L-045 Plant Metal Sludge) - Neat ASTM C150 type III portland cement at w/c = 0.83. Waste loading was 15 wt-%. Formulations with type I cement and GGBFS produced satisfactory, but not optimal, product.

   d. Feedstream 7 (Incinerator Ash) - Slag cement was regarded as chemically similar to the waste ash, so was chosen here. Formulation was 9:1 weight ratio GGBFS to ASTM C150 Type III Portland cement at w/c = 0.55. Waste loading was 30 wt-%.

   e. Feedstream 2A (C-018 Plant Ammonium Sulfate) - The waste in this case is very acidic. A proprietary gypsum-based cement was chosen to avoid the acid-base reactions discussed in Section 6.2.1.1, which in this situation would evolve ammonia gas. This waste accelerated the gypsum set. By adding 2 wt-% citric acid to the proprietary cement a satisfactory set was achieved. Waste loading was 20 wt-% at w/c = 0.5.

4. Performance testing was conducted using laboratory-size specimens of the formulations determined in the screening tests. Waste forms of the Feedstream 1D (high Cu), 1D (high N03), 2C, and 7 formulations passed all criteria. Gypsum-based waste simulants of the Feedstream 2A formulation failed compressive strength criteria in as-cast, irradiated, liquid-immersed, and thermally cycled conditions[46].

6.2.1.3 WRAP 2A Feedstream Waste Loading Assumptions

A. Feedstream 1A (183H Solar Basin Waste - Solidified Liquid)

1. The characterization data [20, 32] indicates this waste contains mostly sulfate and nitrate metal salts. The waste also carries LDR code D007 for chromium, however, the primary concern limiting waste loading is chemical compatibility between the waste and grout.

2. Original analysis of this liquid[42] was: Nitrate, 380,000 mg/l; Sodium, 140,000 mg/l; moisture, 57 wt-%. Hence, the total concentration of nitrates in the feedstream is estimated to be 18 wt-%.

3. Based on the failure experiences with waste loads exceeding 25 wt-% (WVNS, ORNL), and the uncertainty of waste performance under more rigorous criteria in the case of the RFP OASIS data (40-50 wt-%), 25 wt-% is estimated to be the maximum waste loading for feedstream 1A. Success by WVNS/NuPack at this level confirms the credibility of the estimate.

B. Feedstream 1B (183H Solar Basin Waste - Crystalline Solids)

1. The chemical characterization of this waste is similar to that of 1A. A waste loading of 25 wt-% is estimated, based on the experience at WVNS/NuPack.

C. Feedstream 1C (183H Solar Basin Waste - Sludge)

1. The chemical characterization of this waste is similar to that of 1A and 1B. A waste loading of 25 wt-% is estimated based on the WVNS/NuPack work.

D. Feedstream 1D (183H Solar Basin Waste - Miscellaneous Cleanup)

1. The sandblast grit that constitutes most of this waste is not quantitatively characterized[20,32]. It is assumed that because the grit was used to scour the solar basin waste residues (including nitrate salts) from the basin surface, the concentration of nitrates in this grit will be much lower than that in the solar basin waste itself. When WHC developed surrogates to represent Feedstream 1D (Section 6.2.1.2.0), the nitrate concentrations chosen were 1.1 wt-% and 4.7 wt-%[20].

2. Based on the WHC Waste Form Qualification work using surrogate 1D waste, the waste loading is estimated at 40 wt-%.

E. Feedstream 2A (LETF; C-018 Ammonia Sulfate)

1. Characterization data for this future waste stream predict a pH of 4 and up to 83 wt-% ammonia sulfate[32]. As discussed in Section 6.2.1, mixing the strongly acidic waste with the strongly basic grout will create a highly active reaction liberating toxic ammonia gas. An effort to pretreat (i.e. adjust) the waste pH prior to mixing would mean that the ammonia would be evolved at the pretreatment stage. Either case would require secondary effluent treatment equipment for the ammonia gas.

2. As discussed in Section 6.2.1.1.E, the modified gypsum cement systems have a neutral pH. No ammonia gas would be generated upon mixing with ammonium sulfate, eliminating the need for secondary waste treatment. The obstacle in applying modified gypsum cement grout to feedstream 2A is that the test specimens in the WHC Waste Form Qualification work failed compressive strength criteria in all conditions (dry, water immersed, irradiated and biodegraded), with strengths of 70 psi or less at 20 wt-% waste loading.

3. Based on the WHC experience a waste loading of 10 wt-% will be assumed.

F. Feedstream 2B (LETF; Ion Exchange Resin)

1. The characterization data [20, 32] indicates this waste will be resins of the styrene divinyl benzene type. The resin will be in the form of solid beads, 0.3 to 1.2 mm in size.

2. Based on the experiences of the AEA in the UK, it is estimated that ion exchange resins (Feedstream 2B) can be grouted at a waste loading of 20 wt-%.

G. Feedstream 2C (LETF; L045 Sludge)

1. The characterization data [20,32] indicates that this will be a clay like substance with a moisture content of 70-80%, composed mainly of ferric hydroxide.

2. WHC Waste Form Qualification testing has shown that this waste stream can be successfully immobilized in OPC at 15 wt-%. In the UK, BNFL use a mixture of PFA and OPC to encapsulate ferric hydroxide sludges with a solids loading of up to 10 wt-%. The solids loading in this case is limited due to the viscosity of the flocculent waste. If the flocs are de-natured to a particulate, waste loadings of 30 wt-% solids are expected to be achievable[41].

H. Feedstream 2D (LETF; RO Filter Elements)

1. RO filter elements will be shredded and then macroencapsulated. The components of the filter elements will not react with grout, hence the waste loading factor is determined by the maximum volume of waste which will fit in a drum. Assuming a treated bulk density of 40 lb/ft^3, this permits a waste loading of 58 wt-%.

I. Feedstream 3 (Dry Active Waste)

1. It is assumed that there will be no components in this waste which will react with grout, hence the waste loading factor is determined by the maximum volume of waste which will fit in a drum. Assuming a treated bulk density of 40 lb/ft^3, this permits a waste loading of 58 wt-%.

J. Feedstream 4 (Construction Debris)

1. It is assumed that there will be no components in this waste which will react with grout, hence the waste loading factor is determined by the maximum volume of waste which will fit in a drum. Assuming a treated bulk of 60 lb/ft^3, this permits a waste loading of 51 wt-%.

K. Feedstream 5A1 (Elemental Mercury)

1. This waste will be amalgamated prior to immobilization. It has been assumed the amalgamated product will be tipped into a drum for in-drum agitated mixing (not placed, in bottles, in the drum for vibro-mixing as was the design in the CDR). The amalgamated mercury will not react with the grout, however, the waste loading will be limited by the 1000 lb maximum drum weight allowed. Assuming a density of 408 lb/ft^3 for the amalgamated mercury. The maximum waste loading possible is 21 wt-%.

L. Feedstream 5A2 (Mercury Contaminated Waste)

1. This waste will be shredded and the mercury evaporated prior to immobilization. It is assumed that there will be no components in this waste which will react with grout, hence the waste loading factor is determined by the maximum volume of waste which will fit in a drum. Assuming a bulk density of the treated waste of 40 lb/ft^3. This permits a waste loading of 51 wt-%.

M. Feedstream 5B (Reactive Metals)

1. This waste stream will be deactivated prior to immobilization. The waste loading will be limited by the 1000 lb maximum drum weight allowed. Assuming a treated waste bulk density of 200 lb/ft^3, the maximum waste loading possible is 30 wt-%.

N. Feedstream 5C1 (Elemental Lead)

1. There is a technology based treatment standard for lead which states that macroencapsulation using an inert inorganic material shall be used. For this study it is assumed that grout does comply with this requirement.

2. The waste loading will be limited by the 1000 lb maximum drum weight allowed. The density of lead is 710 lb/ft^3, hence the maximum waste loading possible is 18 wt-%.

O. Feedstream 5C2 (Lead Contaminated Waste)

1. It is assumed that macroencapsulation of this waste in grout complies with the technology based treatment standard for lead.

2. It is also assumed there will be no components in this waste which will react with grout, hence the waste loading factor is determined by the maximum volume of waste which will fit a drum. Assuming a bulk density for the shredded waste of 80 lb/ft^3, this permits a waste loading of 55 wt-%.

P. Feedstream 5D (Miscellaneous Metals)

1. It is assumed that there will be no components in this waste which will react with grout, hence the waste loading factor is determined based on the maximum drum weight allowed of 1000 lb. Assuming a bulk density of 450 lb/ft^3, the maximum waste loading possible is 20 wt-%.

Q. Feedstream 6 (Absorbed Chemicals)

1. The characterization data [20, 32] indicates that this waste will be absorbed liquids, spent resin (excluding LETF facilities) and some asbestos.

2. Without better characterization data it is assumed that there will be chemicals in this waste which will affect the rate of grout curing and therefore the waste loading will be limited.

3. For the purpose of this study a waste loading of 20 wt-% will be assumed.

R. Feedstream 7 (Incinerator Ash)

1. WHC Waste Form Qualification testing has shown that this waste stream can be successfully immobilized in a 9:1 BFS: OPC binder at a waste loading of 30 wt-%. This figure has been used for this study.

S. Feedstream 8 (Soils)

1. The characterization data [20,32] indicates that this waste could be contaminated with toxic metals, acids, nitrates, alkalies and pesticides.

2. Without better characterization to specify the quantities of these contaminants in the waste, it is assumed that they will be in sufficient quantity to affect the rate of grout curing and therefore the waste loading will be limited.

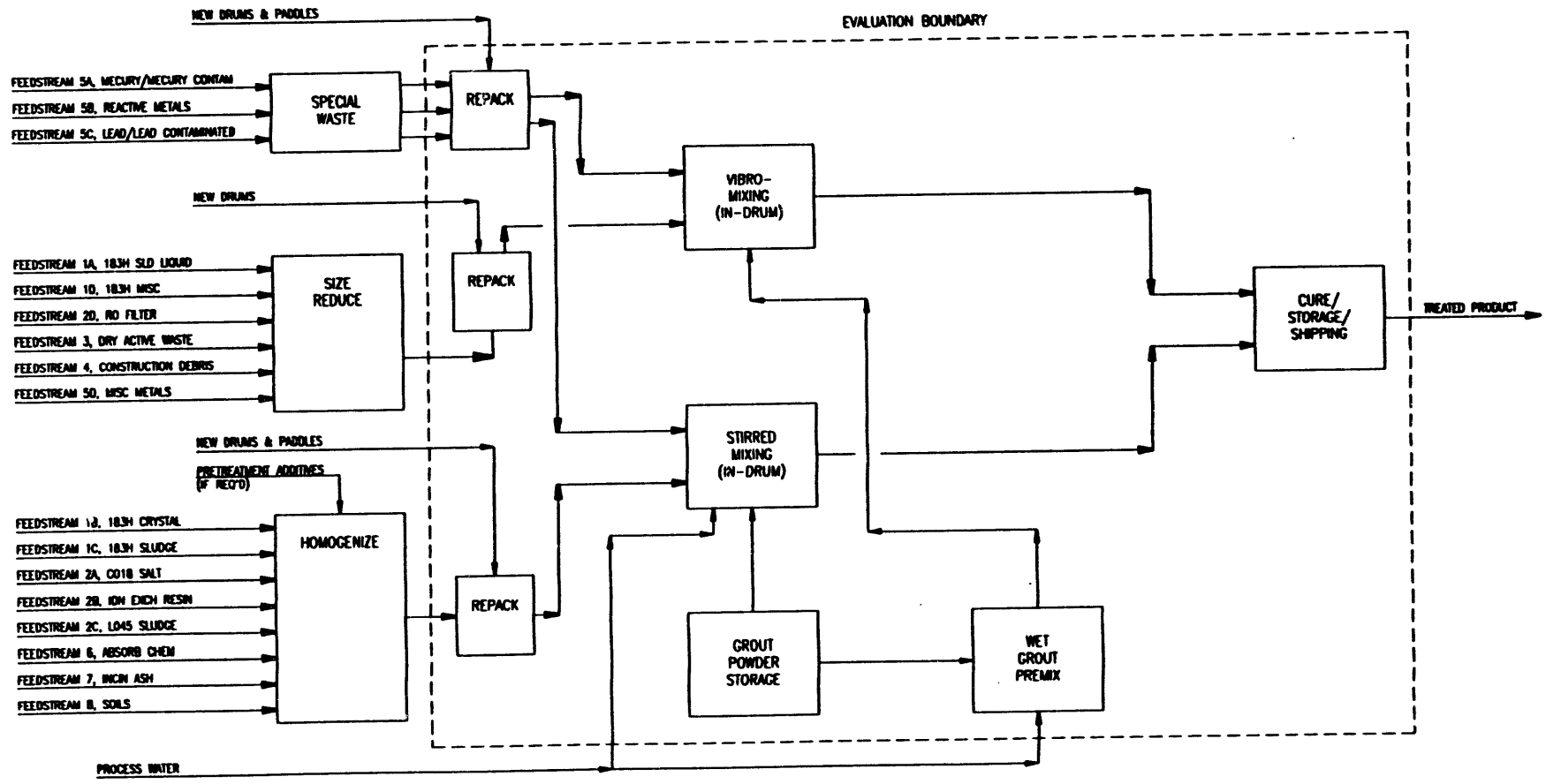
3. For the purpose of this study a waste loading of 20 wt-% will be assumed.

6.2.1.4 Process Operation

6.2.1.4.1 Process Description

A. The block flow diagram for the grout only solidification process is shown in **Figure 6-1**. The concept is identical to the baseline CDR design for the waste feedstreams that are pretreated by campaigning in the special waste area. These unit operations involve size reduction of mercury and lead bulk contaminated solids, evaporation of mercury from bulk solids, and amalgamation of elemental mercury. The size reduction pretreatment operation for feedstreams 1A, 1D, 2D, 3, 4, and 5D is also identical to the CDR baseline. Homogenization of all particulate feedstreams (1B, 1C, 2A, 2B, 2C, 6, 7, and 8) will occur in a pug mill operation similar to that employed in the CDR. The capability will exist to add pretreatment additives, as required, to the pug mill unit operation to absorb free moisture or chemically stabilize heavy metals.

FIGURE 6-1



WRAP 2A ADVANCED CONCEPTUAL DESIGN
SINGLE IMMOBILIZATION STUDY
BLOCK FLOW DIAGRAM

GROUT ONLY SOLIDIFICATION PROCESS

B. The in-drum repack areas will employ the same load-out techniques as the CDR baseline. The only change is that additional load out facilities will be required due to the greater drum throughput, resulting from reduced waste loadings from those used in the CDR. Facilities for binder storage will be limited to grout materials such as OPC, BFS, and PFA. The storage silos will be designed to maintain an atmosphere above the grout which is virtually moisture free. This will maximize the shelf life of the grout powders. There will be no requirements for polymer or solvent storage as well as waste hydrocarbon storage.

C. Solidification will be performed using in-drum vibro-mixing for size reduced material or stirred mixing for particulate material. There will not be any capability for vacuum dewatering. The number of vibro and stirred mixing stations will increase over the CDR configuration due to the lower waste loadings and increased throughput. Curing will occur in the solidification enclosure as described in the CDR. The overall cure/storage/shipping requirements will increase proportionally to drum throughput.

D. Should it be necessary to reprocess a drum because it has failed product quality requirements, the product would have to be size reduced to a size compatible with the WRAP 2A processes.

6.2.1.4.2 Material Balance

A. The associated material balance for the grout only system is given in **Table 6-1**. Based upon the assumed waste loadings discussed previously, the total treated waste drum throughput is estimated to be approximately 135 drums/day. The total treated waste volume is about 895 ft^3/day which corresponds to an overall average waste loading of 15.7%.

6.2.1.5 Process Reliability

A. Raw Material QC

1. Hydration of grout is a complex series of chemical reactions. Consistent mechanical properties and acceptability of waste form products depend on consistent chemical and physical properties in the constituents. For example, the cementitious activity of GGBFS is dependent to a large extent on its glass content and fineness[5]. The development of a satisfactory grout formulation for a particular waste feedstream will be of questionable value if the grout constituents vary widely in chemical and physical properties from those used in developing the formula. The vendor of the grout raw materials for WRAP 2A will be provided with a detailed specification for the powders to ensure that product quality is not put at risk due to uncontrolled changes in the binder properties.

B. Equipment Maintenance Requirements

1. Data regarding failure rates and maintainability of equipment is derived from production-scale operation. Data has not been readily available for production-scale mixed waste immobilization programs reviewed to date, probably because of the attention directed to obtaining successful immobilization. However, substantial experience exists in the cement products industry which would indicate that it should be possible to obtain low maintenance grout equipment for use in WRAP 2A.

TABLE 6-1 GROUT ONLY PROCESS – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	9:1 BFS:OPC	122	183333	124	2668	401
1B	183H CRYSTAL	60	1300	60	140	25	9:1 BFS:OPC	122	173333	126	2480	372
1C	183H SLUDGE	69	1400	69	100	25	9:1 BFS:OPC	122	214667	115	3347	503
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	10	ENVIROSTONE	80	6136533	82	111847	16794
2B	ION EX RESIN	55	2140	55	77	20	9:1 BFS:OPC	122	348741	109	5397	810
2C	L045 SLUDGE	75	3050	75	140	30	3:1 PFA:OPC	116	395370	122	6255	939
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	21	9:1 BFS:OPC	122	26809	142	320	48
5A2	MERCURY CONT	22	4256	40	58	51	9:1 BFS:OPC	122	66637	78	2354	353
5B	REACT METAL #	200	147	200	240	30	9:1 BFS:OPC	122	52045	142	700	105
5C1	ELEM LEAD #	83	846	83	710	18	9:1 BFS:OPC	122	245206	142	2819	423
5C2	LEAD CONT	58	44	80	105	55	9:1 BFS:OPC	122	1547	112	41	6
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	20	3:1 BFS:OPC	143	453333	128	5971	897
7	INCIN ASH	35	2300	35	90	30	9:1 BFS:OPC	122	139136	110	2434	365
8	SOILS	90	680	90	90	20	9:1 BFS:OPC	122	181333	114	2692	404
	TOTAL		+ 34058						9077960		156554	23507

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

6.2.1.6 Process Hazards

A. Binder Material Exposure

1. Eye and skin protection from cement and cement admixtures (GGBFS, PFA) is necessary as these powders can cause serious dermatitis and eye injuries. Wash facilities are necessary should inadvertent exposure occur.

B. Storage/Handling Safety

1. OPC and GGBFS are siliceous non-organic materials, however, there is a potential dust explosion hazard related to storage of these materials.

2. PFA, while predominantly inorganic, can contain up to approximately 6% carbon and still comply with ASTM C618. NFPA 8503 pertains to systems handling pulverized fuel, but is mandatory only for material at or exceeding 8% volatile content. There exists a potential dust explosion hazard related to the storage of PFA.

C. Process Equipment Safety

1. No unusual hazards are associated with a grouting process equipment operation.

6.2.1.7 Process Cost

A. Raw Materials

1. Raw materials are considered as being those materials (other than the waste) that comprise the final wasteform products. Included are drums, paddles, and binder materials. Raw material costs are developed on **Table 6-2**.

2. Cost bases for **Table 6-2** are as follows:

Drums:	$125/ea (polymer lined)[48]
Paddles:	$500/ea (grout design)[37]
OPS:	$80/ton[49]
GGBFS:	$100/ton[50]
PFA:	$36/ton[51]
Envirostone (Modified Gypsum):	$1330/ton[52]

3. Raw material costs are carried forward from **Table 6-2** to the total cost development on **Table 6-4**.

B. Operating Costs

1. Operating costs are considered as being those costs necessary to complete the process under evaluation, but not related to anything physically comprising the final wasteform products. These costs are identified as being waste pretreatment costs, secondary treatment costs and land burial disposal costs. Operating costs are developed on **Table 6-3**.

2. Cost basis for land burial disposal is assumed as $90/CF (estimate).

3. Operating costs are carried forward from **Table 6-3** to the total cost development on **Table 6-4**.

C. Plant/Capital Equipment

1. Plant and capital equipment includes each device or system identified by a block on the applicable block flow diagram. Cost bases were data from the WRAP 2A CDR[10] capacity factored to match the throughputs and residence times of the process option under evaluation. Plant and capital equipment costs are presented on **Table 6-4**.

TABLE 6-2 GROUT PROCESS RAW MATERIAL COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	GROUT FORMULATION	DRY MIX REQUIREMENT (K-LBS/YR)	OPC COST ($/YR)	BFS COST ($/YR)	PFA COST ($/YR)	MODIFIED GYPSUM COST ($/YR)	TOTAL RAW MATERIAL COST (K-$/YR)
1A	183H SLD LIQ	401	50	VIBRO		9:1 BFS:OPC	183	732	8235			59
1B	183H CRYSTAL	372	47	AGITATED	188	9:1 BFS:OPC	173	692	7785			241
1C	183H SLUDGE	503	63	AGITATED	252	9:1 BFS:OPC	215	860	9675			325
1D	183H MISC	76	10	VIBRO		9:1 BFS:OPC	26	104	1170			11
2A	C018 SALT	16794	2099	AGITATED	8397	MOD.GYPSUM	8137				4081105	14577
2B	ION EX RESIN	810	101	AGITATED	405	9:1 BFS:OPC	349	1398	15706			523
2C	L045 SLUDGE	939	117	AGITATED	470	3:1 PFA:OPC	508	5080		6858		599
2D	R O FILTER	39	5	VIBRO		3:1 BFS:OPC	6	60	225			5
3	D A W	211	26	VIBRO		3:1 BFS:OPC	34	340	1275			28
4	CONST DEBRIS	116	15	VIBRO		3:1 BFS:OPC	33	330	1238			16
5A-1	ELEMT MERCURY	48	6	AGITATED	24	9:1 BFS:OPC	365	1460	16425			46
5A-2	MERCURY CONT	353	44	VIBRO		9:1 BFS:OPC	67	268	3015			47
5B	REACT METALS	105	13	AGITATED	53	9:1 BFS:OPC	52	208	2340			66
5C-1	ELEMENT LEAD	423	53	VIBRO		9:1 BFS:OPC	2098	8392	94410			156
5C-2	LEAD CONT	6	1	VIBRO		9:1 BFS:OPC	2	8	90			1
5D	MISC METALS	643	80	VIBRO		9:1 BFS:OPC	814	3256	36630			120
6	ABSORB CHEM	897	112	AGITATED	449	9:1 BFS:OPC	453	4530	16988			582
7	INCIN ASH	365	46	AGITATED	183	3:1 BFS:OPC	139	556	6255			235
8	SOILS	404	51	AGITATED	202	9:1 BFS:OPC	181	724	8145			261
	TOTAL	23505	2938		10819		11835	28998	229805	6858	4081105	17903

TABLE 6-3 GROUT PROCESS OPERATING COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DISPOSAL COST (K-$/YR)	SECONDARY TREATMENT COST ($/YR)	TOTAL OPERATING COST (K-$/YR)
1A	183H SLD LIQ	401	267	0	267
1B	183H CRYSTAL	372	248	0	248
1C	183H SLUDGE	503	335	0	335
1D	183H MISC	76	51	0	51
2A	C018 SALT	16794	11185	0	11185
2B	ION EX RESIN	810	539	0	539
2C	L045 SLUDGE	939	625	0	625
2D	R O FILTER	39	26	0	26
3	D A W	211	141	0	141
4	CONST DEBRIS	116	77	0	77
5A-1	ELEMT MERCURY	48	32	0	32
5A-2	MERCURY CONT	353	235	0	235
5B	REACT METALS	105	70	0	70
5C-1	ELEMENT LEAD	423	282	0	282
5C-2	LEAD CONT	6	4	0	4
5D	MISC METALS	643	428	0	428
6	ABSORB CHEM	897	597	0	597
7	INCIN ASH	365	243	0	243
8	SOILS	404	269	0	269
TOTAL		23505	15654	0	15654

TABLE 6-4 GROUT PROCESS TOTAL COST

	INITIAL EXPENSES (K-$)	ANNUAL EXPENSES (K-$/YR)
PLANT AND CAPITAL EQUIPMENT:		
SPECIAL WASTE PRETREAT	1180	N/A
SPECIAL WASTE REPACK	440	N/A
SIZE REDUCE/HOMOGENIZE PRETREAT	2741	N/A
SIZE REDUCE/HOMOGENIZE REPACK	918	N/A
VIBRO-MIXING STATION	468	N/A
STIR-MIXING STATION	741	N/A
BULK GROUT STORAGE	1633	N/A
CURE/STORAGE/SHIPPING (NOTE 1)	4071	N/A
RAW MATERIAL COST	N/A	17903
OPERATING COST	N/A	15654
TOTAL EXPENSES	12192	33557

NOTES : (1) INCLUDES $ 985K BUILDING FLOOR SPACE COSTS FOR CURE/STORAGE

6.2.2 Thermoplastic Polymer Encapsulation

6.2.2.1 Description

A. Introduction

1. The physical character of organic molecules changes with increasing molecular weight. Organic polymers improve in their structural integrity with continued increase of molecular weight. However, to be useful as polymer immobilization binder, a minimum molecular weight of the order of 1400 is necessary. It is partly insufficient molecular weight that makes the natural examples of organic solids such as paraffin waxes (molecular weight 254) unsuitable. Properties such as toughness, stress-crack resistance, higher melt temperature, and higher melt viscosity, are properties enhanced by increased molecular weight (also called degree of polymerization) of a given polymer[17].

2. To be useful as an in-drum waste immobilization binder a polymer material must be able to be poured as a liquid, filling the waste drum, and then solidify with the waste encapsulated. Certain polymer materials, categorized as thermoplastics, do not develop chemical bonds between adjacent chain molecules. The separate but intertwined polymer chains are held together only by relatively weak electrostatic (i.e. Van Der Waals) forces, binding the material into a solid state. The electrostatic force is heat sensitive, becoming weaker as temperature increases, allowing chains to slide past each other (material softens) and at melt temperature chains freely flow as liquid. Cooling re-establishes the electrostatic force between separate chains, creating a solid in a new shape. During this process the individual chain molecules do not break down. The degree of polymerization is unchanged whether the material is in the form of pellet grains in a shipment bag, a liquid, or cast into a large drum. Only the influence of electrostatic forces and the macroscopic shape have varied. This character is termed thermoplastic and is in marked contrast to the thermosetting character discussed in Section 6.2.3. The differences between these two characters of polymers significantly impact processing concerns when applied to WRAP 2A.

3. Thermoplastic polymers which have been used to solidify low to intermediate level radioactive or mixed waste on a commercial or pilot basis include polyethylene (PE), bitumen, and sulfur cement. Bitumen or oxidized asphalt has been extensively used overseas to encapsulate radioactive ion exchange resins and evaporator concentrates with high nitrate salts. The most common method of mixing waste with thermoplastic binders is a full scale extruder or thin film evaporator depending upon the waste water content. Commercial processing facilities (using bitumen) are located in Austria, Belgium, Finland, France, Germany, Japan, Sweden, and Switzerland. The use of sulfur cement and polyethylene for waste encapsulation has also been demonstrated, although on a significantly smaller scale than bitumen.

B. Polyethylene

1. PE is a thermoplastic developed in the late 1930s and now the most widely used polymer[17]. When employed as a waste immobilization binder, molten PE is thoroughly mixed with waste, so that upon solidification, the waste is coated and embedded in a plastic monolith. This isolates the waste from the environment by macroencapsulation as defined under 40 CFR 268.42.

2. PE is one thermoplastic employed in waste immobilization to date[18, 19]. Control of the PE polymerization process allows manufacturers to produce many variations of the PE structure, presenting differences in processing requirements for the user, and in properties of the product. Polymerization in a low pressure reactor creates polymer chains with few side branches, the high-density PE (HDPE) form. HDPE has a sharp melting point changing suddenly between solid and low-viscosity liquid at a relatively high temperature. Shrinkage in the mold can occur upon solidification and the product is a hard material more susceptible to chipping. Manufacture in a high pressure reactor creates many branches in polymer chains, the low-density PE (LDPE) form. LDPE demonstrates gradual softening (or hardening) through its melt range, which occurs at a lower temperature. The product is relatively resilient and flexible, mold shrinkage (e.g. within a waste drum) is reduced[17]. Based on the effects of these character variations applied to waste immobilization processes, LDPE has been selected for all such programs to date[18, 19].

6.2.2.2 Waste Immobilization History

A. Introduction

1. Laboratory-scale, pilot-scale and limited production scale feasibility tests with waste immobilization have been performed using PE. The depth of experience is not as extensive as in grouting.

2. In most cases, PE was attempted on waste in which grouting had proven unsuccessful without unacceptably low waste loadings.

B. Brookhaven National Laboratory (BNL), Laboratory-Scale and Pilot-Scale Tests, 1991[18].

1. The BNL waste was sodium nitrate salt such as would result from neutralization of nitric acid used in fuel reprocessing. Binder used was LDPE with melt index of 55 g/10 min[18]. The production-scale process involved feeding dry granulated LDPE along with the salt through a vented, 380 psi, 300°F, 4.5 inch off-the-shelf extruder at net flows exceeding 1,000 lbs/hr. Filling each 30 gallon drum required approximately 25 minutes.

2. The waste form criteria complied with "NRC Technical Position on Waste Form" (which supports 10 CFR 61), EPA hazardous waste criteria per 40 CFR 261 and DOT solid oxidizer transport criteria per 49 CFR 173[18]. Tests of product with 60 wt-% waste loading correlated with data from earlier laboratory scale product which satisfied all waste form criteria. Extensive bench and laboratory scale tests have been performed with extruders ranging from 0.75" to 1.25" diameter at rates ranging from 20 to 30 lb/hr.

C. Rocky Flats Plant (RFP) Polymer Solidification Program, Laboratory - Scale, 1992 - Present.

1. Only interim reports[36] are available from this extensive on-going program,which is complementary to the earlier BNL work. With the processability and stability of LDPE binder already demonstrated by BNL, the focus of the RFP work to date has been in achieving satisfactory TCLP of EPA regulated LDR metals which are found in salt wastes. For this program, LDR concentrations from 50 ppm to 5000 ppm have been spiked into sodium nitrate salt surrogate waste[19].

2. The TCLP test involves crushing the subject waste form to a specified size, then immersing in liquid to determine if LDR metals leach out. Because the crushing step breaks down the encapsulation around the waste particles, the procedure has generated unsatisfactory results for PE binders when high concentrations of LDR metals are spiked into the waste salt. RFP has obtained satisfactory TCLP results on five LDR metals by pretreating the waste salt with calcium oxide (CaO). The CaO reacts with the metals, creating a less soluble metal hydroxide which resists leaching into water even when unencapsulated[19]. This form of pretreament is applicable to any pure encapsulation technique; for example, Vinyl Ester Styrene encapsulation.

3. The RPF report[36] states that the high force needed to crush the PE monolith in producing a TCLP sample represents an implausible situation in repository environments. Therefore, the TCLP procedure penalizes an encapsulating immobilization medium such as PE, resulting in unwarranted failures of leaching criteria.

6.2.2.3 WRAP 2A Waste Feedstream Waste Loading Assumptions

A. General

1. Unlike grout, polyethylene encapsulation waste loading is not limited by the chemical compatibility of the waste and binder as no chemical reaction takes place between them. The waste is immobilized by being coated by the binder.

B. Feedstream 1A-1D (183H Solar Basin Waste)

1. Immobilization history indicates PE performs satisfactorily with dried particulates such as stream 1B, though pretreatment may be necessary to stabilize TCLP metals.

2. No history exists for streams such as 1A, 1C and 1D, however developments in sludge experience indicate PE should apply satisfactorily to 1A and 1C, if 1C is dried first and 1A is crushed to a particulate. Stream 1D would require shedding of boxes shovels and buckets[20, 32] into approximately 2" x 2" pieces that can be in-filled in-drum with liquid polyethylene.

3. In the absence of actual waste stream test data it will be assumed waste loadings for stream 1A, 1B, 1C will approximate the 60 wt-% of the BNL data minus 20 wt-% CaO to pretreat TCLP metals, resulting in 40 wt-% waste loading. Stream 1D (misc. cleanup) will be assumed as 60 wt-% waste load.

C. Feedstreams 2A-2D (LETF Secondary Solids)

1. Although characterization data is minimal, immobilization of metal sludge stream 2C might correspond to positive BNL/RFP experience with salt waste spiked with TCLP metals.

2. No history exists for streams similar to 2A, 2B and 2D. Although test data is unavailable, it appears PE should be inert and therefore compatible with streams 2A, 2B, and 2D.

3. Waste loading in the case of metal sludges (stream 2C) will be assumed as similar to the BNL salt waste data (60 wt-%) minus 20 wt-% for TCLP metal pretreatment resulting in 40 wt-%. Waste loading for streams 2A, 2B and 2D will be assumed as 60 wt-% based on the BNL data. (Note: Where necessary, streams will need to be dried prior to extrusion).

D. Feedstream 3 (Compactible Solids)

1. Based on characterization data [20, 32] Feedstream 3 will be compatible with PE but will require cross-cut shredding of all waste material (plastic bottles, gloves, clothing etc.) to allow in-drum filling with liquid polyethylene from the extruder.

2. Waste loading will be assumed as 70 wt-%.

E. Feedstream 4 (Construction Debris)

1. Based on characterization data [20, 32] feedstream 4 will be compatible with PE. Scaffolding and concrete chunks will require volume reduction by shredder/rock crusher to allow in-drum in-filling with liquid polyethylene.

2. Waste loading will be assumed as 70 wt-%.

F. Feedstream 5A-5D (Campaigned Metals)

1. Feedstream 5A-1, amalgamated mercury, will be stabilized prior to polyethylene encapsulation and will not off-gas. Feedstream 5A-2, bulk mercury contaminated waste, will be pretreated using BDAT mercury removal technology prior to polyethylene encapsulation and will not cause significant mercury vaporization. Mercury, if present in the zone of a vented extruder, will vaporize along with any moisture at the extruder temperature of 300°F. This results in an off-gas which must be processed by condensing out water containing mercury. The mercury laden water stream must be handled by BDAT according to mercury concentration.

2. Based on the characterization data[20] feedstreams 5B, 5C, and 5D should be compatible with PE. Feedstream 5B contains no TCLP metals, so no pretreatment is required. Feedstream 5C (lead) and 5D (miscellaneous metals contain TCLP metals. However, 5C does not require pretreatment if PE is the binder since 40 CFR 268.42 permits waste code D008 lead to be exempt from TCLP if a macroencapsulation binder (such as PE) is used. Feedstream 5D is assumed to be size reduced into relatively large 2" x 2" particle sizes. This should not pose a leachability problem when in-filled with a liquid polyethylene.

3. Waste loadings are assumed as 60 wt-% for 5A, 60 wt-% for 5B and 65% to 70% for Feedstreams 5C and 5D depending on weight limitations for the solidified product in-drum.

G. Feedstream 6 (Absorbed Chemicals/Solidified Liquid)

1. No immobilization history has been found for PE used with waste of this characterization[20]; it is assumed the PE and waste are compatible. Waste does not contain TCLP metals[20]. Pretreatment is not necessary.

2. Waste loading is assumed as 40 wt-% due to possible presence of chemicals which may be incompatible with polyethylene.

H. Feedstream 7 (Incinerator Ash)

1. Meaningful characterization of this feedstream is not yet determined[20]. It is assumed PE and the waste are compatible. It is likely that incinerator ash will contain TCLP metals under 40 CFR 268.41 or 268.43, so pretreatment is necessary.

2. Waste loadings could be as high as 60 wt-% based on data available from tests performed by Stock Equipment Company on Aerojet incinerator ash encapsulated in VES resin which should give similar results for polyethylene[31].

I. Feedstream 8 (Contaminated Soil)

1. Meaningful characterization of this feedstream is not yet determined[20]. It is assumed PE and the waste are compatible. It is possible that contaminated soil will contain TCLP metals under 40 CFR 268.41 or 268.43, so pretreatment is necessary.

2. Waste loading is assumed as 40 wt-% based on the BNL/RFP data.

6.2.2.4 Process Operation

6.2.2.4.1 Process Description

A. Refer to **Figure 6-2** for the block flow diagram illustrating the polyethylene polymer only solidification process. The waste feed pretreatment involving special waste, size reduction, and homogenization/drying is identical to the grout only case with the exception of the need to dry the waste. The pretreated waste repack and interim storage area will vary from the grout only case based upon lower drum throughput requiring fewer loadout stations for special waste and size reduced waste. All particulate waste from homogenization will be stored in interim storage feed hoppers prior to solidification with polyethylene in the extrusion unit operation. Binder storage is limited to polyethylene pellets which can be stored and transferred by methods similar to dry grout materials. The binder pellets have an unlimited shelf life and hence the size of storage facilities will be optimized.

B. Waste and polyethylene mixing will occur in the extruder for dried particulate materials. The mixed waste and polymer will be extruded into new drums at approximately 300 °F and will be transferred to a curing area for cooling to ambient temperatures. Cooling to a temperature low enough to allow the drum to be moved will take about 2 days. While cooling, the polyethylene product may shrink away from the drum wall. However, shrinkage will not be significant and will not affect product quality.

C. Size reduced waste, repacked into new drums, will be preheated in a forced air drying chamber. The drums and waste will be heated to approximately 200°F to drive off any waste moisture present as this could interfere with in-drum vibro-mixing of melted polyethylene with waste. Also, preheated waste will prevent premature solidification of the melted polyethylene before adequate void space in-filling can occur. Melted polyethylene will be supplied at maximum recommended temperatures from the extruder (~450°F) for a majority of the waste.

D. The high operating temperature of the extruder will vaporize water and volatile materials in the waste. A number of the WRAP 2A feedstreams contain water and/or mercury and therefore an extruder with 3 to 4 heated and vented sections will be used to allow the vapor to be released. If off-gases are not vented in the extruder, the polyethylene melt will tend to foam as it is extruded producing an unacceptable product. Off-gas produced from the vented extruder and waste preheater/dryer will be routed to off-gas treatment where condensibles will be removed and pretreated. Pretreatment will consist of processing in a Duolite ion exchange bed to remove mercury which might carry over with the condensate. The pretreated effluent will be combined with other active waste water and transferred to the Hanford Liquid Effluent Treatment Facility for final treatment. The small volume of spent resin will be pretreated for mercury in the special waste evaporator and solidified in polyethylene.

E. Should it be necessary to reprocess an immobilized waste drum because it has failed product quality requirements the product would need to be shredded to pellet size to allow it to be refed to the extruder. The failed product could then be remelted and additional polyethylene could be added as necessary to improve the product quality.

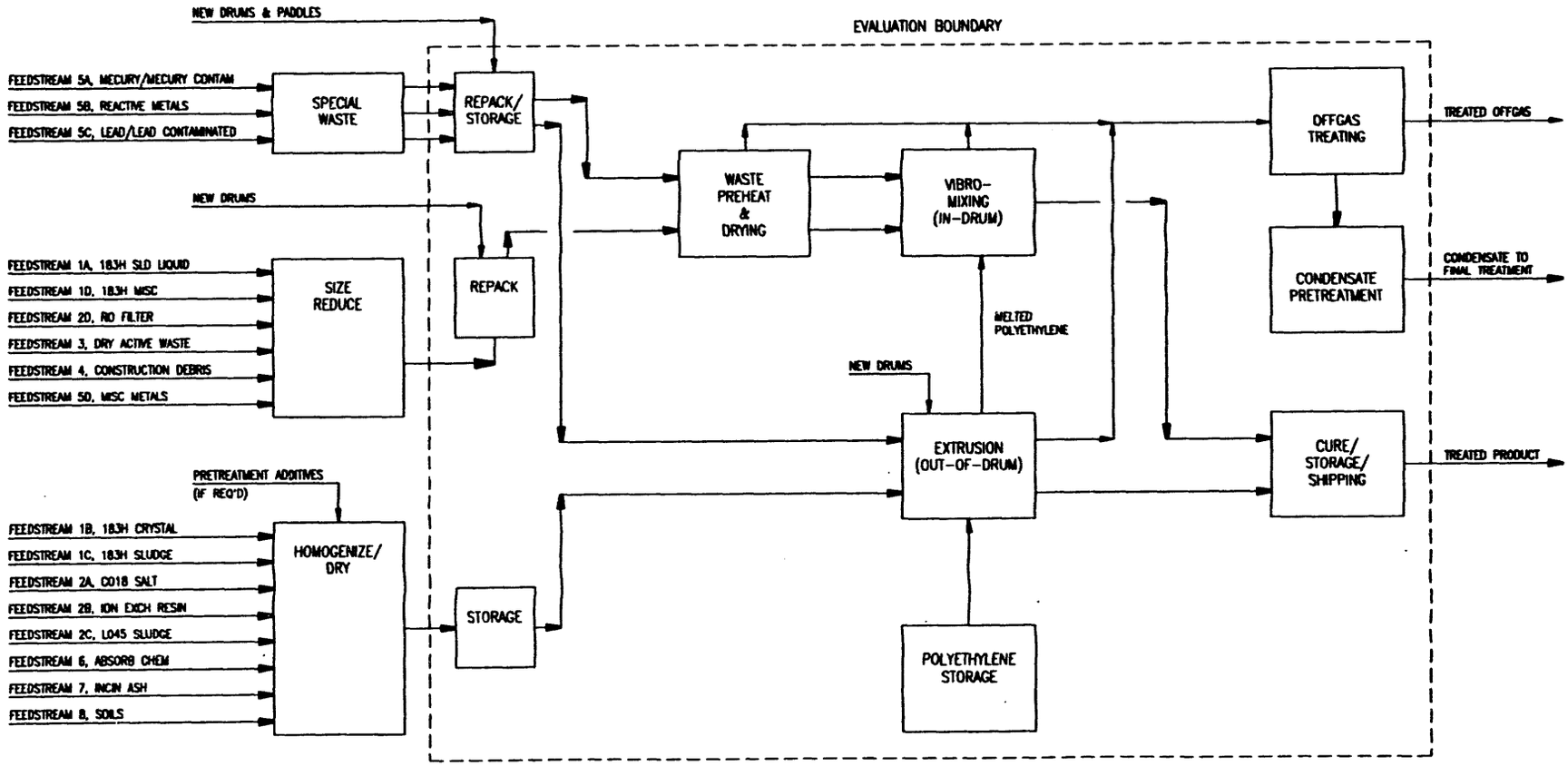
6.2.2.4.2 Binder Availability

A. The binder recommended for WRAP 2A is Low Density Polyethylene. This material is widely available from a number of suppliers and hence there will be no supply problems.

6.2.2.4.3 Material Balance

A. The polyethylene only solidification material balance is given in **Tables 6-5**. The total treated waste volume is estimated at 328 ft^3/day corresponding to a drum throughput of about 50 drums/day. This provides an overall average waste loading of 52.5%. Approximately 280 gal/day of condensate is produced from the off-gas.

FIGURE 6-2



WRAP 2A ADVANCED CONCEPTUAL DESIGN
SINGLE IMMOBILIZATION STUDY
BLOCK FLOW DIAGRAM

POLYETHYLENE POLYMER ONLY SOLIDIFICATION PROCESS

TABLE 6-5 POLYETHYLENE ONLY PROCESS – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	40	POLYETHYLENE	57	123750	74	2806	421
1B	183H CRYSTAL	60	1300	60	140	40	POLYETHYLENE	57	117000	75	2610	392
1C	183H SLUDGE	69	1400	69	100	40	POLYETHYLENE	57	144900	69	3508	527
1D	183H MISC	60	385	75	105	60	POLYETHYLENE	57	15400	79	490	74
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	2862
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	436
2C	L045 SLUDGE	75	3050	75	140	40	POLYETHYLENE	57	343125	75	7654	1149
2D	R O FILTER	30	350	40	50	60	POLYETHYLENE	57	7000	53	333	50
3	D A W	30	2100	45	58	70	POLYETHYLENE	57	27000	58	1560	234
4	CONST DEBRIS	40	1155	60	100	70	POLYETHYLENE	57	19800	82	809	122
5A1	MERCURY	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	20
5A2	MERCURY CONT	22	4256	40	58	60	POLYETHYLENE	57	62421	58	2709	407
5B	REACT METALS	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	70
5C1	ELEM LEAD #	83	846	83	710	65	POLYETHYLENE	57	37478	142	756	114
5C2	LEAD CONT	58	44	80	105	70	POLYETHYLENE	57	1094	84	43	7
5D	MISC METALS #	200	607	200	450	69	POLYETHYLENE	57	55310	142	1240	186
6	ABSORB CHEM	90	1700	90	90	40	POLYETHYLENE	57	229500	67	5726	860
7	INCIN ASH	35	2300	35	90	50	POLYETHYLENE	57	80500	70	2307	346
8	SOILS	90	680	90	90	40	POLYETHYLENE	57	91800	67	2291	344
	TOTAL		+ 34058						2074059		57405	8619

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

6.2.2.5 Process Reliability

A. Raw Material QC

1. Quality Control (QC) of raw material in a PE immobilization process will be less demanding than in the case of grouting. There is only one binder agent to address, the PE itself. Since PE is an inert macroencapsulating binder, the quality of the immobilization is not sensitive to chemical interactions between waste and binder, making detailed QC of binder chemical composition unnecessary.

2. Sufficient specifications for the raw PE would include density, physical form (granule size),and melt index.

B. Equipment Maintainability

1. The binder stream equipment necessary for PE extrusion has a well documented history in the commercial plastics industry. No conditions particular to the PE waste immobilization process exist which would be unusually detrimental to the equipment.

2. The relatively larger degree of volume reduction needed for PE immobilization using an extruder necessitates additional shedding/crushing capability in the waste stream, when compared to grouting or thermosetting processes. This additional equipment increases maintenance demands and lowers overall system reliability.

6.2.2.6 Process Safety

A. Binder Material Exposure

1. Exposure to PE powder results in relatively little hazard to personnel. There are no established TLV or PEL values. Ventilation is recommended to meet the standard of "Good General Ventilation" (Typically 10 air changes/hour) with local exhaust or dust respirators required only if the recommendation can not be met. Eye and skin protection and wash facilities are recommended as good practice, however, burns from contact with molten material is the only explicit hazard identified[38, 43].

B. Storage/Handling Safety of Raw Materials

1. PE powder can form an explosive dust-air mixture. Even though the PE will be stored as pellets, the precautions established by NFPA 654, typical for most process industries, should be applied[38,43].

2. PE is combustible. Water or Dry chemical are the recommended extinguishing agents[38, 43].

C. Storage/Handling Safety of Waste Binder Product[38, 43]

1. The polyethylene waste form is a non-explosive, safe material to produce, transport and store. It will not cause explosion or detonation by itself even if stored at temperatures up to well over 100°C. The waste form is thermally stable to temperatures well above 300°C. A hazards analysis study by Hughes Associates for Rocky Flats Plant concluded that low level radioactive salt waste encapsulated in polyethylene appeared to have minimal fire hazards associated with storage of the product[43].

D. Process Safety

1. Since personnel will normally be excluded from the process space during operation, the hazard of burns from molten PE should be avoidable.

2. The temperature of the PE process will be sufficient (about 300°F) to release mercury vapor from mercury contaminated waste. This is unavoidable if the extruder is vented to prevent foaming of the PE melt. Handling of a toxic off-gas is required.

3. The extruder operates well above ambient pressure and temperature hence there is the potential for release of material if there is a failure of the equipment.

6.2.2.7 Process Cost

A. Raw Materials

1. Raw materials are considered as being those materials (other than the waste) that comprise the final wasteform products. Included are drums, and binder materials. Raw material costs are developed on **Table 6-6**.

2. Cost basis for **Table 6-6** are as follows:

Drums:	$125/ea (polymer lined)[48]
Polyethylene:	$680/ton (estimate)

3. Raw material costs are carried forward from **Table 6-6** to the total cost development on **Table 6-8**.

B. Operating Costs

1. Operating costs are considered as being those costs necessary to complete the process under evaluation, but not related to anything physically comprising the final wasteform products. These costs are identified as being waste pretreatment costs, secondary treatment costs and land burial disposal costs. Operating costs are developed on **Table 6-7**.

2. Cost basis for land burial disposal is assumed as $90/CF (estimate).

3. Operating costs are carried forward from **Table 6-7** to the total cost development on **Table 6-8**.

C. Plant/Capital Equipment

1. Plant and capital equipment includes each device or system identified by a block on the applicable block flow diagram. Cost bases were data from the WRAP 2A CDR[28] proportioned to match the throughputs and residence times of the process option under evaluation. Plant and capital equipment costs are presented on **Table 6-8**.

TABLE 6-6 THERMOPLASTIC POLYMER PROCESS RAW MATERIAL COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	421	53	VIBRO	124	42	95
1B	183H CRYSTAL	392	49	EXTRUDER	117	40	89
1C	183H SLUDGE	527	66	EXTRUDER	145	49	115
1D	183H MISC	74	9	VIBRO	15	5	14
2A	C018 SALT	2862	358	EXTRUDER	614	209	567
2B	ION EX RESIN	436	55	EXTRUDER	78	27	81
2C	L045 SLUDGE	1149	144	EXTRUDER	343	117	260
2D	R O FILTER	50	6	VIBRO	7	2	9
3	D A W	234	29	VIBRO	27	9	38
4	CONST DEBRIS	122	15	VIBRO	20	7	22
5A-1	ELEMT MERCURY	20	3	EXTRUDER	85	29	31
5A-2	MERCURY CONT	407	51	VIBRO	62	21	72
5B	REACT METALS	70	9	EXTRUDER	20	7	16
5C-1	ELEMENT LEAD	114	14	VIBRO	321	109	123
5C-2	LEAD CONT	7	1	VIBRO	1	0	1
5D	MISC METALS	186	23	VIBRO	124	42	65
6	ABSORB CHEM	860	108	EXTRUDED	230	78	186
7	INCIN ASH	346	43	EXTRUDED	81	28	71
8	SOILS	344	43	EXTRUDED	92	31	74
	TOTAL	8621	1078		2506	852	1930

TABLE 6-7 THERMOPLASTICPOLYMER PROCESS OPERATING COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DISPOSAL COST (K-$/YR)	SECONDARY TREATMENT COST ($/YR)	TOTAL OPERATING COST (K-$/YR)
1A	183H SLD LIQ	421	280	136	281
1B	183H CRYSTAL	392	261	136	261
1C	183H SLUDGE	527	351	136	351
1D	183H MISC	74	49	136	49
2A	C018 SALT	2862	1906	6120	1912
2B	ION EX RESIN	436	290	0	290
2C	L045 SLUDGE	1149	765	0	765
2D	R O FILTER	50	33	0	33
3	D A W	234	156	0	156
4	CONST DEBRIS	122	81	0	81
5A-1	ELEMT MERCURY	20	13	0	13
5A-2	MERCURY CONT	407	271	0	271
5B	REACT METALS	70	47	0	47
5C-1	ELEMENT LEAD	114	76	0	76
5C-2	LEAD CONT	7	5	0	5
5D	MISC METALS	186	124	0	124
6	ABSORB CHEM	860	573	0	573
7	INCIN ASH	346	230	0	230
8	SOILS	344	229	0	229
	TOTAL	8621	5742	6664	5748

1f 1ds 1ts

TABLE 6-8 THERMOPLASTICPOLYMERPROCESS TOTAL COST

	INITIAL EXPENSES (K-$)	ANNUAL EXPENSES (K-$/YR)
PLANT AND CAPITAL EQUIPMENT:		
SPECIAL WASTE PRETREAT	1180	N/A
SPECIAL WASTE REPACK	241	N/A
SIZE REDUCE/HOMOGENIZE PRETREAT	2741	N/A
SIZE REDUCE REPACK	82	N/A
HOMOGENIZED WASTE STORAGE	5	N/A
WASTE PREHEATER/DRYER	100	N/A
VIBRO-MIXING STATION	162	N/A
EXTRUDER STATION	721	N/A
PE STORAGE	22	N/A
CURE/STORAGE/SHIPPING (NOTE 1)	1565	N/A
OFFGAS TREATMENT	15	N/A
RAW MATERIAL COST	N/A	1930
OPERATING COST	N/A	5742
TOTAL EXPENSES	6834	7672

NOTES : (1) INCLUDES $ 380K BUILDING FLOOR SPACE COSTS FOR CURE/STORAGE

6.2.3 Thermoset Polymer Encapsulation

6.2.3.1 Description

A. Introduction

1. When a polymer material has its chain molecules cross-linked by chemical bonds (as opposed to the relatively weak electrostatic attraction in thermoplastics) the material is classified as a thermoset polymer. Unlike thermoplastic materials, which can be delivered from the manufacturer as a completely polymerized products, thermoset materials require a two-stage polymerization; part is done by the manufacturer and part by the user. This allows the user to form the material (by casting, molding, or etc.) into the final product before initiating cross-linking, which bonds the chains into a permanent shape. Thermoset polymers cannot be melted and reformed since the energy required to break down the cross-linking bonds is also sufficient to break down the linear chains, destroying the entire polymer.

2. Generally, the polymerization process is interrupted by the manufacturer at the point where mostly linear chains have developed. The material is delivered as a liquid organic resin, which flows allowing the user to form the product. For some resins, the user initiates cross-linking by applying substantial heat and pressure to the resin in the mold. With other resins, the manufacturer delivers a catalyst and, possibly, a promoter, which when combined with the resin at room temperature, start the cross-linking growth of chains.

3. Applied to waste immobilization, cross-linking at room temperature by using chemical catalysts is desirable since it avoids complex thermal and pressurized processes. Early in-drum immobilization work with thermoset materials employed urea-formaldehyde resin, which is cross-linked by an acidic catalyst. The acidic conditions created a very reactive and exothermic situation where susceptible waste material and process equipment corroded readily. Moisture in the waste became highly acidic and laden with pollutants, weeping out of the waste form, attacking the drum. Additionally, urea-formaldehyde is biodegradable, hardly a desirable feature for land disposal of radionuclides.

4. Most recently, commonly used thermoset polymers for radioactive waste solidification have been water extendable polyesters and vinyl ester styrene (VES) resin. Although water extendable polyester can be used to encapsulate waste with high water contents the resulting monolith does not have reliable structural integrity due to shrinkage during gradual water evaporation. Also, the tensile and compressive strength properties of polyester are not as high as VES resin.

B. Vinyl Ester Styrene

1. Vinyl Ester Styrene (VES) is a material with a particularly complex chemistry involving two different monomers. A vinyl ester is polymerized into polyester chains and mixed into solution with a second monomer, styrene, which also serves as a solvent. When the user adds a promoter and a peroxide catalyst the styrene reacts to cross-link the polyester chains together, forming a thermoset polymer. Details of VES chemistry are presented in a reference document[23].

2. The polymerization reaction proceeds in two phases. The first, is the formation of a gel where styrene has sufficiently reacted so that the resin is no longer highly volatile or free flowing. Gel time (which normally ranges from 5 to 30 minutes) is adjustable based upon ambient temperature and formulation. The second phase, is an exothermic reaction where cross linking of the styrene and polyester occurs and the resulting monolith is cured. This curing step results in a temperature rise and fall with time which is dependent upon many variables such as VES resin reactivity, catalyst promoter formulation, waste specific heat and loading, and size of monolith. Detailed calculations that address cure time and peak exotherm temperature as a function of the above variables are presented in the Waste Form Qualification Treatability Study 1604-2.

6.2.3.2 Waste Immobilization History

A. Introduction

1. Test data on various thermoset polymers as hazardous or mixed waste immobilization binders exist at least as far back as 1979. Data specifically for the investigation of VES to solidify Hanford surrogate wastes was obtained recently under contract with Stock Equipment Company[35,44].

B. Dow Chemical Radioactive Waste Solidification Experience with VES Resin

1. Dow chemical developed the VES resin technology for potential solidification of low to intermediate level radioactive waste. The initial VES resin (Dow 101) was developed by the styrene polymer R&D group to solidify BWR & PWR reactor concentrates, ion exchange bead and powdered resins, filter aid sludge, decontamination waste and dry salts. A topical report produced in 1988[33] gave favorable waste loading and NRC 10 CFR 61 waste form testing results. Maximum volumetric loadings for the above wastes ranged from 60% to 67%.

2. However, Dow did not pursue commercial application of the VES resin technology for nuclear resin solidification. Although Dow still markets a wide range of VES resins (Derakane 411, 470, and 510) they do not recommend, and in fact, expressly prohibit the use of their resin for this purpose due to potential liability issues. Dow transferred the VES resin solidification technology to Diversified Technologies[33] and placed the process and the topical report in the public domain.

C. Diversified Technologies VES Resin Solidification Experience

1. Diversified Technologies currently utilizes the technical knowledge developed by Dow Chemical for radioactive waste solidification. Diversified Technologies has direct experience with solidification of ion exchange resins, decontamination solutions, and reactive metals. A revision to the Dow Topical Report[34] was issued to present data obtained by Diversified Technologies loading decontamination solutions high in heavy metals dissolved solids in VES resin. These metals included iron, nickel, copper, and chromium.

2. Diversified Technologies has also developed vacuum dewatering technology for bead ion exchange resins. This technique has been demonstrated commercially using solidification containers as large as 200 ft^3. This technology has the advantage of solidifying slurried bead resins in place with virtually no volume increase. The solidified waste volume loadings are near 100%. However, the resulting waste water must be treated as an organic mixed waste since it may potentially contain residual quantities of VES resin.

3. Direct encapsulation of reactive metals such as zirconium shavings has been demonstrated by Diversified Technologies at INEL[34]. Trial tests were performed where zirconium chips that normally would spontaneously combust with air could be encapsulated in VES resin in 1 gallon containers under water. The resulting monolith was tested for flame resistance and would not sustain combustion after removal of the flame source. Very high loadings in the range of 60 wt-% to 70 wt-% have been easily obtained.

D. Stock Equipment Company, Commercial Solidification of Radioactive Salts and Incinerator Ash[31].

1. Stock Equipment Company developed a commercial the process in 1981 to solidify dry sodium sulfate salt with 5% incinerator ash for Aerojet Corporation. The process utilized a mixing technique where preloaded VES polymer, in-drum, was combined with hot dry salt in an explosion resistant enclosure using a proprietary mixing agitator. The solidification technique was developed specifically for dry particulate waste and would not be applicable to dense solids or slurries containing water that must be emulsified. The waste loadings of dry salt in DOW 101 binder exceeded 70 wt-% for a majority of the runs.

E. Stock Equipment Company/Polymer Immobilization Technology Testing - Waste Form Verification, Laboratory - Scale, 1992[35,44].

1. This test program utilized VES to immobilize four forms of surrogate waste representing WRAP 2A feedstreams. The Type I surrogate approximated the actual Feedstream 2A LETF ammonium sulfate salt. Type 2 surrogate approximated the Feedstream 1C 183H solar basins 1 and 2 metal nitrate salt sludge. Type 3 surrogate approximated the Feedstream 1C 183H solar basins 3 and 4 metal nitrate salt sludge. Type 4 surrogate approximated the Feedstream 1B metal sulfate/nitrate crystallized solids. All surrogates contained at least one LDR metal in excess of the 40 CFR 268 limit for land disposal. Waste form qualification criteria included the requirements of 10 CFR 61, and the NRC technical position on waste form.

2. Test specimens were in the shape of cylinders, with dimensions normally 1 1/2" x 2" tall. The specimens were tested for compressive strength, radiation stability, resistance to biodegradation, resistance to thermal degradation, presence of free liquids, leachability, degradation due to immersion, TCLP and hazardous characteristics of the final waste form.

3. The test specimens passed all test criteria except for Type 1, 2 and 4 surrogates which failed TCLP testing for mercury (type 3 surrogate did not contain mercury).

F. Stock Equipment Company/Polymer Immobilization Technology Testing - TCLP Verification, Laboratory Scale, 1993[35].

1. This test program was to repeat TCLP testing of Type 1, 2 and 4 surrogates to determine if waste form could be produced with VES which would pass TCLP for these surrogates.

2. Test specimens were cast both as 1 1/2" x 2" tall cylinders and 9 mm x > 9 mm tall cylinders. The variation was necessary as Stock's TCLP testing incorporated three different procedures for collecting the necessary data. The intention was to compare the test outcomes when the test specimens are (a) cast originally in the small (<9.5 mm) size required by the TCLP, (b) size reduced by crushing a larger specimen (the accepted EPA practice) and (c) size reduced as in (b) with the very small remnants (< 1.0 mm) removed.

3. Exotherms were recorded to indicate complete specimen curing.

4. All waste form products satisfied the acceptance criteria with the exception of the Type 1 and 2 surrogates which failed TCLP requirements when tests were performed using the two techniques that involved size reduction. This would suggest that in order to use VES for these wastes and pan TCLP testing, the accepted EPA practice of crusting the product to reduce it to less than 9.5 mm would not work and it would be necessary to prepare a cast sample for testing.

6.2.3.3 WRAP 2A Feedstream Waste Loading Assumptions

A. Feedstream 1A-1D (183H Solar Basin Waste)

1. Due to the same origin as 1B and 1C, Feedstream 1A (solidified liquid) is assumed to have an equivalent waste loading of 25 wt-%.

2. The Stock Type 4 surrogate waste was characterized as similar to feedstream 1B. Based on the Type 4 data, estimated waste loading for Feedstream 1B is 25 wt-% due to chromium and mercury TCLP results.

3. The Stock Type 2 surrogate waste was characterized as similar to Feedstream 1C. Based on the Type 2 data, estimated waste loading for feedstream 1C is 25 wt-%, also due to chromium and mercury TCLP results.

4. Feedstream 1D (miscellaneous 183H Basin waste) is characterized as organic and inorganic solid scraps (poly bags, liner strips, etc.)[20]. While no VES immobilization data is available, it is assumed that VES performance with this waste should be no less than that of PE. Based on the PE estimate, waste loading of Feedstream 1D in VES is estimated at 60 wt-%.

B. Feedstreams 2A-2D (LETF Secondary Solids)

1. The Stock Type 1 surrogate waste test provides data for Feedstream 2A (ammonium sulfate). Based on that data, waste loading for Feedstream 2A is estimated at 25 wt-% due to mercury TCLP results.

2. Feedstream 2B (ion exchanger resin), although not fully characterized[20] most likely consists of plastic resin beads, contaminated by radionuclides but without EPA toxicity characteristics. In this case, VES immobilization performance should be similar to PE, so a waste load of 60 wt-% is estimated.

3. Feedstream 2C (metal sludges) is not fully characterized[20] but most likely has an EPA toxicity characteristic based on LDR metals. The heavy metals will be present in the sludge as stable hydroxides with limited solubility. Therefore a waste loading of 40 wt-% is assumed which will allow adequate safety margin for TCLP.

4. Feedstream 2D (Filter Elements) is characterized as all organic materials[16] and should be compatible with VES as it is with PE. Waste loading is estimated as 60 wt-%.

C. Feedstream 3 (Compactible Solids)

1. Based on characterization data[20] the plastic bottles, gloves, and clothes which predominately constitute Feedstream 3 should be compatible with VES.

2. Waste loading is estimated as 70 wt-%.

D. Feedstream 4 (Construction Debris)

1. Based on the characterization data[20] the concrete, metal and wood scrap of Feedstream 4 should be compatible with VES.

2. Waste loading is estimated at 70 wt-%.

E. Feedstream 5A-5D (Campaigned Metals)

1. Feedstreams 5A-1, amalgamated mercury, and Feedstream 5A-2, pretreated bulk mercury contaminated waste, will have the mercury stabilized or removed prior to solidification in VES resin. It is not anticipated that enough free mercury will be present to cause TCLP problems. A waste loading of 40 wt-% is predicted for both feedstreams which lies midway between the 25 wt-% recommended for 183H and LETF waste containing mercury and the CDR baseline design.

2. Feedstream 5B, reactive metals, do not pose a TCLP problem since zirconium and beryllium are not LDR metals. Estimated waste loading are 60 wt-%, the same as the CDR baseline design.

3. Feedstream 5C-1, elemental lead, and 5D, miscellaneous metals, will be loaded at the maximum drum weight limit which corresponds to 60.3 wt-% and 64.0 wt-%, respectively. This is because the listed metals will be present in relatively large bricks or 2" x 2" size reduced pieces which can easily be macroencapsulated. TCLP will either not be applicable to the waste form (as for macroencapsulated lead) or should not be a significant problem due to limited surface area exposure. However, further characterization of the miscellaneous metals feedstream must quantify the listed metals such as chromium or cadmium to determine the physical and chemical form of the metals and any potential pretreatment requirements. Feedstream 5C-2, shredded bulk contaminated lead will be loaded at 70 wt-% which is considered to be the maximum using vibro-mixing technology.

F. Feedstream 6 (Absorbed Chemicals/Solidified Liquids)

As with the PE thermoplastic, this waste feedstream is assumed to be loaded at 40 wt-% in VES resin due to the potential for the presence of organic or inorganic absorbed chemicals. Such chemicals may potentially interfere with the polymerization reaction. Further testing or characterization may modify this assumption.

G. Feedstream 7 (Incinerator Ash)

1. Characterization of this feedstream is virtually non-existent[20]. Incinerator ash generally consists of siliceous material with high concentrations of LDR metals. Such a material should not interfere with VES polymerization so it is assumed that the VES will perform similar to PE as a binder. Stock Equipment Company successfully loaded sodium sulfate with incinerator ash in a polymer matrix at waste loadings exceeding 60 wt-%[31].

2. Waste loading for Feedstream 7 in VES is estimated to be 47 wt-% based upon volume limitations of incinerator ash preloaded in-drum.

H. Feedstream 8 (Contaminated Soil)

1. Meaningful characterization of this feedstream is not yet determined[20]. It is assumed VES and the waste are compatible. It is possible that pretreatment of LDR metals in the soil will be necessary to achieve satisfactory TCLP. This situation is similar to that discussed for PE.

2. Based on the same assumption used for this feedstream with PE, the waste loading in VES is estimated at 40 wt-%.

6.2.3.4 Process Operation

6.2.3.4.1 Process Description

A. **Figure 6-3** shows the block flow diagram which describes the configuration for the VES polymer only solidification process. As with the grout and polyethylene only process, all pretreatment unit operations are identical. All waste is repacked into new drums for mixing with VES resin using stirred unit operations for particulate waste and vibro for size reduced waste. Per the recommendation of the waste mixing study, vacuum dewatering of ion exchange resins is not utilized as a solidification step.

B. Polymer resin, catalyst, promoter, extender, and cleanup solvent will be stored, transferred, and mixed similar to methods used in the CDR. VES resin and catalyst have limited shelf lives (up to 3 months) and must be kept in a temperature controlled environment. If the temperature of the store rises above 50°C the raw materials will begin to degrade quickly. Hence storage facilities will be temperature controlled and sized on plant throughput requirements. Tanks containing solvent or waste solvent will be stored underground in ventilated vaults. The polymer resin and additives will be stored outdoors in cooled tanks and premixed in a dry tank. Catalyst will be added directly to stirred mixing or via static mixers to vibro mixing solidification.

C. Treated waste curing will be carried out in a separate cure/store area with dedicated ventilation system as done in the CDR. Cure time is assumed to be 48 hours during which time the product may shrink. The shrinkage may be up to 9%[35] but will not affect product quality.

D. High exotherm temperatures will occur in the VES product when curing (see WRAP 2A ACDR Study 1604-2, WFQ Treatability Study). These temperatures will be high enough to drive off moisture and volatile materials from the waste. Hence the cure area will be well ventilated. Off-gas treatment will be the same as for the polyethylene extrusion process described in section 6.2.2.4.1.D.

E. Should it be necessary to reprocess an immobilized waste drum because it has failed product quality requirements, the product would have to be cut into pieces suitable for vibro-infilling (approx 2 x 2 x 2 in).

6.2.3.4.2 Binder Availability

A. Suppliers of Vinyl Ester Styrene include DOW Chemicals, Ashland Chemicals and Reichold Chemicals. These manufacturers could each meet the WRAP 2A requirements in terms of the quantities of material required, however, DOW Chemicals have stated that they would not supply VES for use as a waste encapsulation binder. This is of concern as other suppliers may, at some later date, choose to follow DOWs example.

6.2.3.4.3 Material Balance

A. The detailed material balance for the VES polymer only system is given in **Table 6-9**. The total treated waste volume is estimated to be 540 ft^3/day requiring a drum throughput of about 81 drums/day. This corresponds to an overall waste loading of about 32.6 wt-%.

6.2.3.5 Process Reliability

A. Raw Material QC

1. The VES solidification process is a complex chemical reaction which is very sensitive to the quality of the resin, promoter, and catalyst. The inventory of these materials must be monitored to assure that it is consumed within the manufacturer's recommended shelf life, or there is a risk of lowered reactivity or degradation.

B. Equipment Maintainability

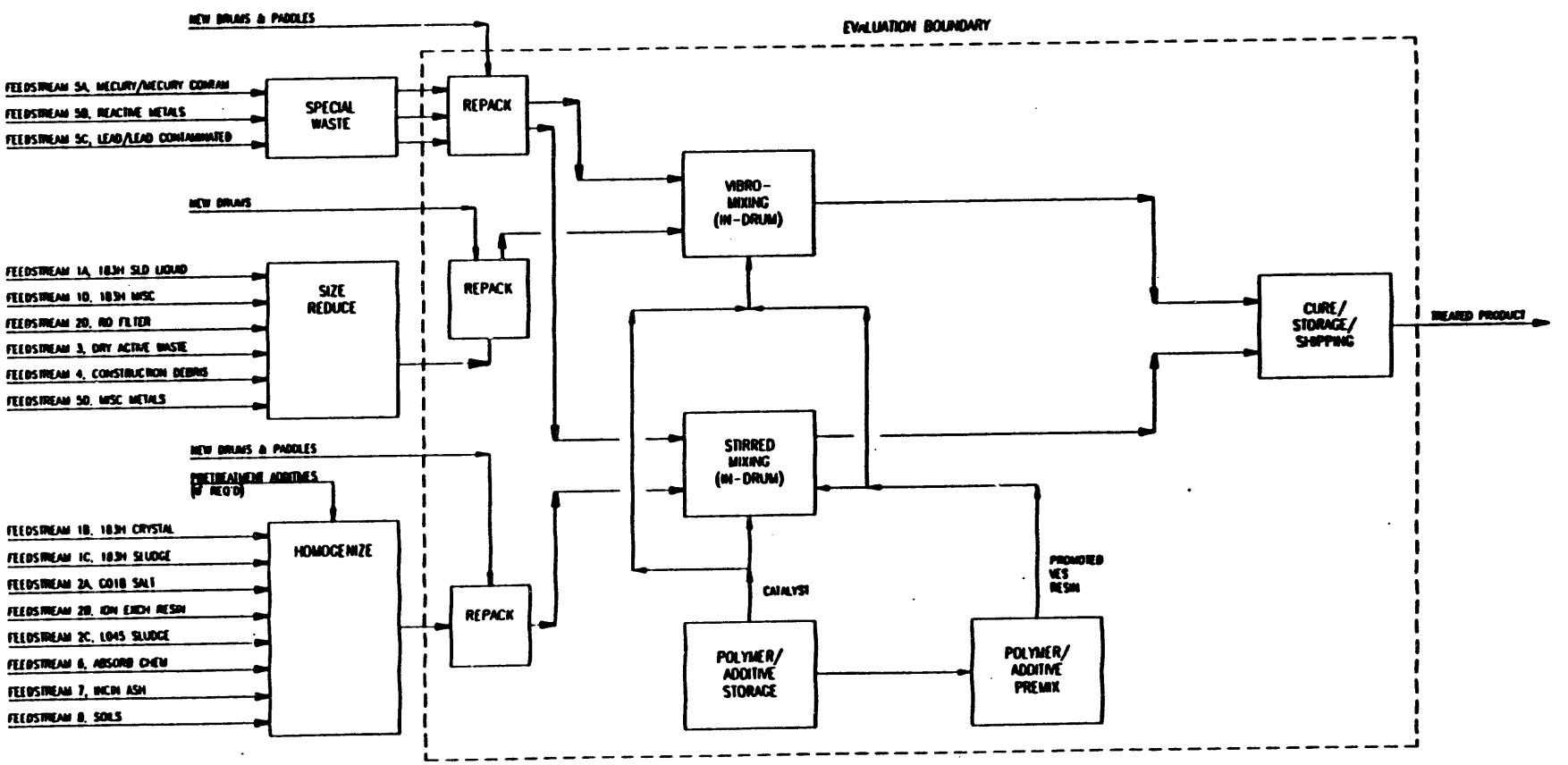
1. The VES solidification equipment will be designed to prepare a batch of promoted VES resin on a daily basis. The catalyst will be metered into the premixed resin at the final stage of solidification. However, there is still a significant potential for premature polymerization if the timing of batch preparation, quantities of catalyst or promoter additives, or other process variables are not carefully controlled.

2. Despite the use of careful process control, there will be a routine need to clean polymerized resin from piping and mixing equipment. The most serious consequence of the cleaning will be the use of volatile and toxic and solvents which could pose a significant hazard to operators. In-line static mixers, used to mix catalyst with promoted VES resin will require daily, if not more frequent, cleaning or replacement. In-drum mixing equipment such as agitators are assumed to be expended with the waste and will not require solvent cleanout. However, any spills due to overfilling in the mixing area will require action based upon the severity of the spill and the likelihood of jeopardizing operations.

C. Process Control

1. Preparation of VES is very precise operation if a quality product is to be produced. Hence, highly accurate metering of all components will be required.

FIGURE 6-3



WRAP 2A ADVANCED CONCEPTUAL DESIGN
SINGLE IMMOBILIZATION STUDY
BLOCK FLOW DIAGRAM

VES POLYMER ONLY SOLIDIFICATION PROCESS

TABLE 6-9 VES ONLY PROCESS – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	VES POLYMER	64	247500	74	4477	672
1B	183H CRYSTAL	60	1300	60	140	25	VES POLYMER	64	234000	74	4190	629
1C	183H SLUDGE	69	1400	69	100	25	VES POLYMER	64	289800	71	5465	821
1D	183H MISC	60	385	75	105	60	VES POLYMER	64	15400	84	459	69
2A	C018 SALT	88	10460	88	111	25	VES POLYMER	64	2761440	72	51159	7682
2B	ION EX RESIN	55	2140	55	77	60	VES POLYMER	64	78467	71	2747	412
2C	L045 SLUDGE	75	3050	75	140	40	VES POLYMER	64	343125	82	6960	1045
2D	R O FILTER	30	350	40	50	60	VES POLYMER	64	7000	55	319	48
3	D A W	30	2100	45	58	70	VES POLYMER	64	27000	60	1505	226
4	CONST DEBRIS	40	1155	60	100	70	VES POLYMER	64	19800	86	769	116
5A1	MERCURY	30	313	30	408	40	VES POLYMER	64	14085	97	242	36
5A2	MERCURY CONT	22	4256	40	58	40	VES POLYMER	64	140448	62	3795	570
5B	REACT METALS	200	147	200	240	60	VES POLYMER	64	19600	115	427	64
5C1	ELEM LEAD #	83	846	83	710	60	VES POLYMER	64	47597	141	838	126
5C2	LEAD CONT	58	44	80	105	70	VES POLYMER	64	1094	88	41	6
5D	MISC METALS #	200	607	200	450	64	VES POLYMER	64	69781	141	1353	203
6	ABSORB CHEM	90	1700	90	90	40	VES POLYMER	64	229500	73	5263	790
7	INCIN ASH	35	2300	35	90	47	VES POLYMER	64	90777	74	2304	346
8	SOILS	90	680	90	90	40	VES POLYMER	64	91800	73	2105	316
	TOTAL		+ 34058						4728214		94415	14176

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

6.2.3.6 Process Hazards

A. Binder Material Exposure

1. Vinyl ester styrene is essentially polyester resin dissolved in a styrene monomer. As such, the hazards of the binder are similar to styrene. Repeated exposure at concentrations above the TLE & PEL (50 ppm TWA, 100 PPM STEL) may cause damage to the human central nervous system, liver, kidneys, or respiratory tract. Styrene is a benzene derivative, and as such may be a suspect carcinogen although animal mutagenicity tests are inconclusive.

2. The promoter (dimethyl toluidine) and catalyst (benzoyl peroxide) anticipated to be used in the solidification process are also hazardous to personnel in terms of exposure and reactivity. Dimethyl toluidine in contact with strong oxidizing agents (such as benzoyl peroxide) will produce nitrogen oxide gas(NOx).

3. Methylene chloride, the polymer solvent, is extremely volatile, a suspected carcinogen and a listed substance. The TLV is 200 ppm and the OSHA standard is 500 ppm.

B. Storage/Handling Safety of Raw Materials

1. Styrene is a Class 1C liquid with a flashpoint in the range of 74-84°F. The explosive limits of styrene in air are 1.1% and 6.1% for the lower and upper limits, respectively.

2. Dimethyl toluidine and benzoyl peroxide are not volatile or explosive but each is capable of reacting violently with incompatible materials to produce noxious vapors. Methylene chloride is a practically non-flammable material with lower and upper flammable limits in air of 12% and 19%, respectively. However, methylene chloride is extremely volatile with a vapor pressure of 380 mm Hg @ 22°C.

3. The CDR baseline design assumes that the binder and styrene are contained in temperature controlled tankage outdoors to prevent premature polymerization and limit fire hazards within the building. Both fresh and spent methylene chloride are stored in an underground ventilated vault to minimize the exposure to operators in the event of a spill or leakage.

C. Storage/Handling Safety of Waste Binder Product[38]

1. VES resins show a high degree of resistance to thermal aging, corrosive environments. It also has a high ignition temperature in the range 400 to 500°F.

D. Process Safety

1. The VES solidification process does not require elevated temperatures for the initial gelling reaction just after mixing. However, the treated waste will experience an exotherm which may present a hazard with respect to off-gassing from the drums or external drum temperatures in excess of 200°F. It is anticipated that the curing drums will be held in a ventilated cure/store area to minimize contact with operators. However, it may be necessary to inspect a certain percentage of drums after curing to assure no free liquids are present.

6.2.3.7 Process Cost

A. Raw Materials

1. Raw materials are considered as being those materials (other than the waste) that comprise the final wasteform products. Included are drums, paddles, and binder materials. Raw material costs are developed on **Table 6-10**.

2. Cost bases for **Table 6-10** are as follows:

Drums:	$125/ea (polymer lined)[48]
Paddles:	$500/ea (grout design)[37]
	$222/ea (polymer design)[3.7]
VES:	$3200/ton[53]

3. Raw material costs are carried forward from **Table 6-10** to the total cost development on **Table 6-12**.

B. Operating Costs

1. Operating costs are considered as being those costs necessary to complete the process under evaluation, but not related to anything physically comprising the final wasteform products. These costs are identified as being waste pretreatment costs, secondary treatment costs and land burial disposal costs. Operating costs are developed on **Table 6-11**.

2. Cost basis for land burial disposal is assumed as $90/CF (estimate).

3. Operating costs are carried forward from **Table 6-11** to the total cost development on **Table 6-12**.

C. Plant/Capital Equipment

1. Plant and capital equipment includes each device or system identified by a block on the applicable block flow diagram. Cost bases were data from the WRAP 2A CDR[28] proportioned to match the throughputs and residence times of the process option under evaluation. Plant and capital equipment costs are presented on **Table 6-12**.

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Inches

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TABLE 6-10 THERMOSET POLYMER PROCESS RAW MATERIAL COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	672	84	VIBRO		248	397	481
1B	183H CRYSTAL	623	79	AGITATED	140	234	374	593
1C	183H SLUDGE	821	103	AGITATED	182	290	464	749
1D	183H MISC	69	9	VIBRO		15	24	33
2A	C018 SALT	7682	960	AGITATED	1705	2761	4418	7083
2B	ION EX RESIN	412	52	AGITATED	91	78	125	268
2C	L045 SLUDGE	1045	131	AGITATED	232	343	549	911
2D	R O FILTER	48	6	VIBRO		7	11	17
3	D A W	226	28	VIBRO		27	43	71
4	CONST DEBRIS	116	15	VIBRO		20	32	47
5A-1	ELEMT MERCURY	36	5	AGITATED	8	192	307	320
5A-2	MERCURY CONT	570	71	VIBRO		140	224	295
5B	REACT METALS	64	8	AGITATED	14	20	32	54
5C-1	ELEMENT LEAD	126	16	VIBRO		407	651	667
5C-2	LEAD CONT	6	1	VIBRO		1	2	2
5D	MISC METALS	203	25	VIBRO		157	251	277
6	ABSORB CHEM	790	99	AGITATED	175	230	368	642
7	INCIN ASH	346	43	AGITATED	77	91	146	266
8	SOILS	316	40	AGITATED	70	92	147	257
	TOTAL	14177	1772		2695	5353	8565	13032

TABLE 6-11 THERMOSET POLYMER PROCESS OPERATING COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DISPOSAL COST (K-$/YR)	SECONDARY TREATMENT COST ($/YR)	TOTAL OPERATING COST (K-$/YR)
1A	183H SLD LIQ	672	448	0	448
1B	183H CRYSTAL	629	419	0	419
1C	183H SLUDGE	821	547	0	547
1D	183H MISC	69	46	0	46
2A	C018 SALT	7682	5116	0	5116
2B	ION EX RESIN	412	274	0	274
2C	L045 SLUDGE	1045	696	0	696
2D	R O FILTER	48	32	0	32
3	D A W	226	151	0	151
4	CONST DEBRIS	116	77	0	77
5A-1	ELEMT MERCURY	36	24	0	24
5A-2	MERCURY CONT	570	380	0	380
5B	REACT METALS	64	43	0	43
5C-1	ELEMENT LEAD	126	84	0	84
5C-2	LEAD CONT	6	4	0	4
5D	MISC METALS	203	135	0	135
6	ABSORB CHEM	790	526	0	526
7	INCIN ASH	346	230	0	230
8	SOILS	316	210	0	210
	TOTAL	14177	9442	0	9442

TABLE 6-12 THERMOSET POLYMER PROCESS TOTAL COST

	INITIAL EXPENSES (K-$)	ANNUAL EXPENSES (K-$/YR)
PLANT AND CAPITAL EQUIPMENT:		
SPECIAL WASTE PRETREAT	1180	N/A
SPECIAL WASTE REPACK	276	N/A
SIZE REDUCE/HOMOGENIZE PRETREAT	2741	N/A
SIZE REDUCE/HOMOGENIZE REPACK	660	N/A
VIBRO-MIXING STATION	180	N/A
STIR-MIXING STATION	186	N/A
POLYMER/ADDITIVE STORAGE	490	N/A
POLYMER/ADDITIVE PREMIX (NOTE 1)	24	N/A
CURE/STORAGE/SHIPPING	2918	N/A
RAW MATERIAL COST	N/A	13032
OPERATING COST	N/A	9442
TOTAL EXPENSES	8655	22474

NOTES : (1) INCLUDES $ 888K BUILDING FLOOR SPACE COSTS FOR CURE/STORAGE

6.2.4 Grout and Thermoplastic Polymer Encapsulation

6.2.4.1 Process Operation

6.2.4.1.1 Process Description

A. The grout and polyethylene polymer solidification process is illustrated as two potential process configurations. **Figure 6-4** shows the BFD for Case 1 while **Figure 6-5** illustrates Case 2. The basic difference is that Case 1 shows the same type of binder treatment using grout or polymer for each feedstream as was used in the CDR. Polyethylene was simply substituted for VES resin for feedstreams treated via polymer and waste loadings were adjusted based upon previously stated estimates. Case 2 assumes that all particulate waste can be treated via polyethylene using the extrusion mixing unit operation. There is no requirement for stirred mixing for solidification of particulate waste with grout in Case 2, therefore the stirred mixing unit operation is totally deleted. All size reduced feed requiring vibro in-filling is assumed to be accomplished using premixed grout and water as binder. The only exception is lead bricks or size reduced elemental lead, which is macroencapsulated in-drum with molten polyethylene to achieve the maximum waste loading per drum. (Note: waste loading is limited by the weight of the product drum, hence, the lighter the binder material density is, the more lead can be put in a drum). Preheating of the elemental lead is not required due to the high density and resulting small volume of lead which is easily surrounded by molten polyethylene.

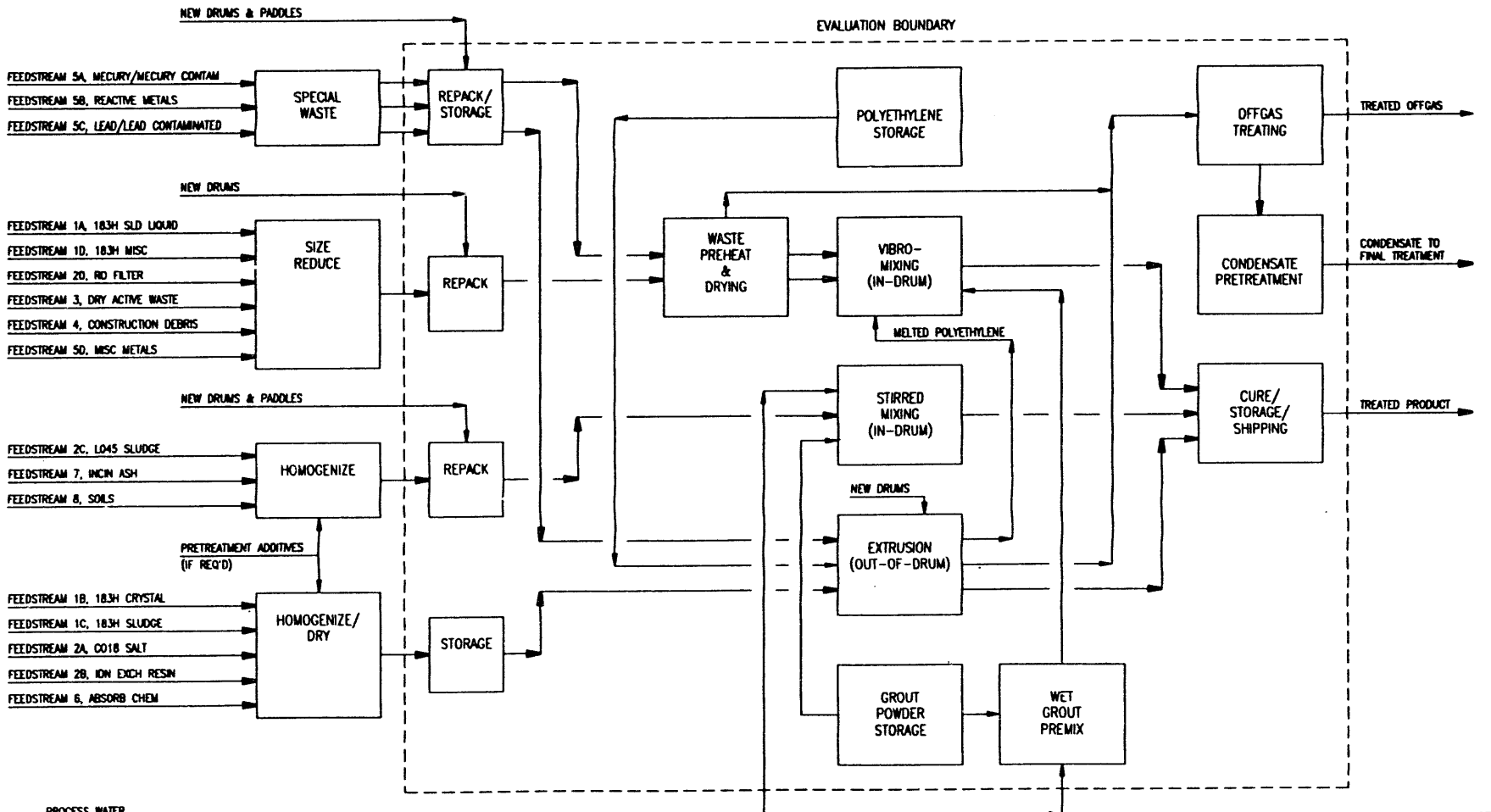
B. As shown on **Figure 6-4**, Case 1 is a complex process requiring 3 solidification unit operations; polyethylene extrusion, grout stirred mixing, and grout and polyethylene vibro mixing. Also, to allow in-drum vibro mixing of polyethylene with size reduced waste, a waste preheat and drying pretreatment step is required similar to that used in the polyethylene only process. Binder storage is provided for polyethylene, dry grout, and premixed wet grout for vibro-mixing. Off-gas from the extruder and waste preheater is treated in an off-gas and condensate pretreatment system similar to the polyethylene only process. A cure/storage area is provided and sized to accommodate cure time for grouted waste and sufficient time for polyethylene cooling.

C. Case 2, as shown on **Figure 6-5**, is a greatly simplified process in that solidification processes involving stirred mixing of grout and waste and vibro-mixing of waste and polyethylene have been eliminated. The preheating and drying of waste for polyethylene vibro-mixing is also eliminated. Also, the off-gas treatment and condensate pretreatment systems deal with a smaller volume of secondary waste since the moisture in the size reduced waste is used within the grout solidification process. Only vapor from the polyethylene extrusion process is collected for treatment.

6.2.4.1.2 Material Balance

A. Detailed material balances for both Case 1 and Case 2 for the polyethylene and grout solidification process are given in **Tables 6-13 and 6-17**, respectively. Case 1 shows a total treated waste volume of 339 ft^3/day or a drum throughput of 51 drums/day. Case 2 estimates a treated waste volume of 341 ft^3/day or about 51 drums/day. Although the total throughput is about the same for both cases, Case 1 treats about 69 vol-% of total waste with polyethylene while Case 2 treats about 71% via polyethylene.

FIGURE 6-4



22 11/06/03 11:21 CAD NO: WBFIGOOOL.DWG COLOR 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
LAK 6237.008 PLT SCALE: 1" = 1 FOR WEIGHT 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1

TABLE 6-13 POLYETHYLENE AND GROUT PROCESS – WASTE LOADINGS CASE 1

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	40	POLYETHYLENE	57	123750	74	2806	421
1B	183H CRYSTAL	60	1300	60	140	40	POLYETHYLENE	57	117000	75	2610	392
1C	183H SLUDGE	69	1400	69	100	40	POLYETHYLENE	57	144900	69	3508	527
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	2862
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	436
2C	L045 SLUDGE	75	3050	75	140	30	3:1 PFA:OPC	116	395370	122	6255	939
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	20
5A2	MERCURY CONT	22	4256	40	58	60	POLYETHYLENE	57	62421	58	2709	407
5B	REACT METAL #	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	70
5C1	ELEM LEAD #	83	846	83	710	65	POLYETHYLENE	57	37478	142	756	114
5C2	LEAD CONT	58	44	80	105	70	POLYETHYLENE	57	1094	84	43	7
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	40	POLYETHYLENE	57	229500	67	5726	860
7	INCIN ASH	35	2300	35	90	30	9:1 BFS:OPC	122	139136	110	2434	365
8	SOILS	90	680	90	90	20	9:1 BFS:OPC	122	181333	114	2692	404
	TOTAL		+ 34058						2609898		59332	8909

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

6.2.4.2 Process Cost

A. Raw Materials

1. Raw materials are considered as being those materials (other than the waste) that comprise the final wasteform products. Included are drums, paddles, and binder materials. Raw material costs are developed on **Tables 6-14 and 6-18**.

2. Cost bases for **Tables 6-14 and 6-18** are as follows:

Drums:	$125/ea (polymer lined)[48]
Paddles:	$500/ea (grout design)[37]
OPC:	$80/ton[49]
GGBFS:	$100/ton[50]
PFA:	$36/ton[51]
Envirostone (Modified Gypsum):	$1330/ton[52]
Polyethylene:	$680/ton (estimate)

3. Raw material costs are carried forward from **Tables 6-14 and 6-18** to the total cost development on **Tables 6-16 and 6-20**.

B. Operating Costs

1. Operating costs are considered as being those costs necessary to complete the process under evaluation, but not related to anything physically comprising the final wasteform products. These costs are identified as being waste pretreatment costs, secondary treatment costs and land burial disposal costs. Operating costs are developed on **Tables 6-15 and 6-19**.

2. Cost basis for land burial disposal is assumed as $90/CF (estimate).

3. Operating costs are carried forward from **Tables 6-15 and 6-19** to the total cost development on **Tables 6-16 and 6-20**.

C. Plant/Capital Equipment

1. Plant and capital equipment includes each device or system identified by a block on the applicable block flow diagram. Cost bases were data from the WRAP 2A CDR (28) proportioned to match the throughputs and residence times of the process option under evaluation. Plant and capital equipment costs are presented on **Tables 6-16 and 6-20**.

TABLE 6-14 COMBINED GROUT AND THERMOPLASTIC POLYMER PROCESS RAW MATERIAL COST (CASE 1)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	PE	421	53	VIBRO		124	42	95
1B	183H CRYSTAL	PE	392	49	EXTRUSION		117	40	89
1C	183H SLUDGE	PE	527	66	EXTRUSION		145	49	115
1D	183H MISC	9:1 BFS:OPC	76	10	VIBRO		26	1	11
2A	C018 SALT	PE	2862	358	EXTRUSION		614	209	567
2B	ION EX RESIN	PE	436	55	EXTRUSION		78	27	81
2C	L045 SLUDGE	3:1 PFA:OPC	939	117	AGITATED	470	508	12	599
2D	R O FILTER	3:1 BFS:OPC	39	5	VIBRO		6	0	5
3	D A W	3:1 BFS:OPC	211	26	VIBRO		34	2	28
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO		33	2	16
5A-1	ELEMT MERCURY	PE	20	3	EXTRUSION		85	29	31
5A-2	MERCURY CONT	PE	407	51	VIBRO		62	21	72
5B	REACT METALS	PE	70	9	EXTRUSION		20	7	16
5C-1	ELEMENT LEAD	PE	114	14	VIBRO		321	109	123
5C-2	LEAD CONT	PE	7	1	VIBRO		1	0	1
5D	MISC METALS	9:1 BFS:OPC	643	80	VIBRO		814	40	120
6	ABSORB CHEM	PE	860	108	EXTRUSION		230	78	186
7	INCIN ASH	9:1 BFS:OPC	365	46	AGITATED	183	139	7	235
8	SOILS	9:1 BFS:OPC	404	51	AGITATED	202	181	9	261
	TOTAL		8909	1114		854	3538	683	2651

TABLE 6-15 COMBINED GROUT AND THERMOPLASTIC POLYMER PROCESS OPERATING COST (CASE 1)

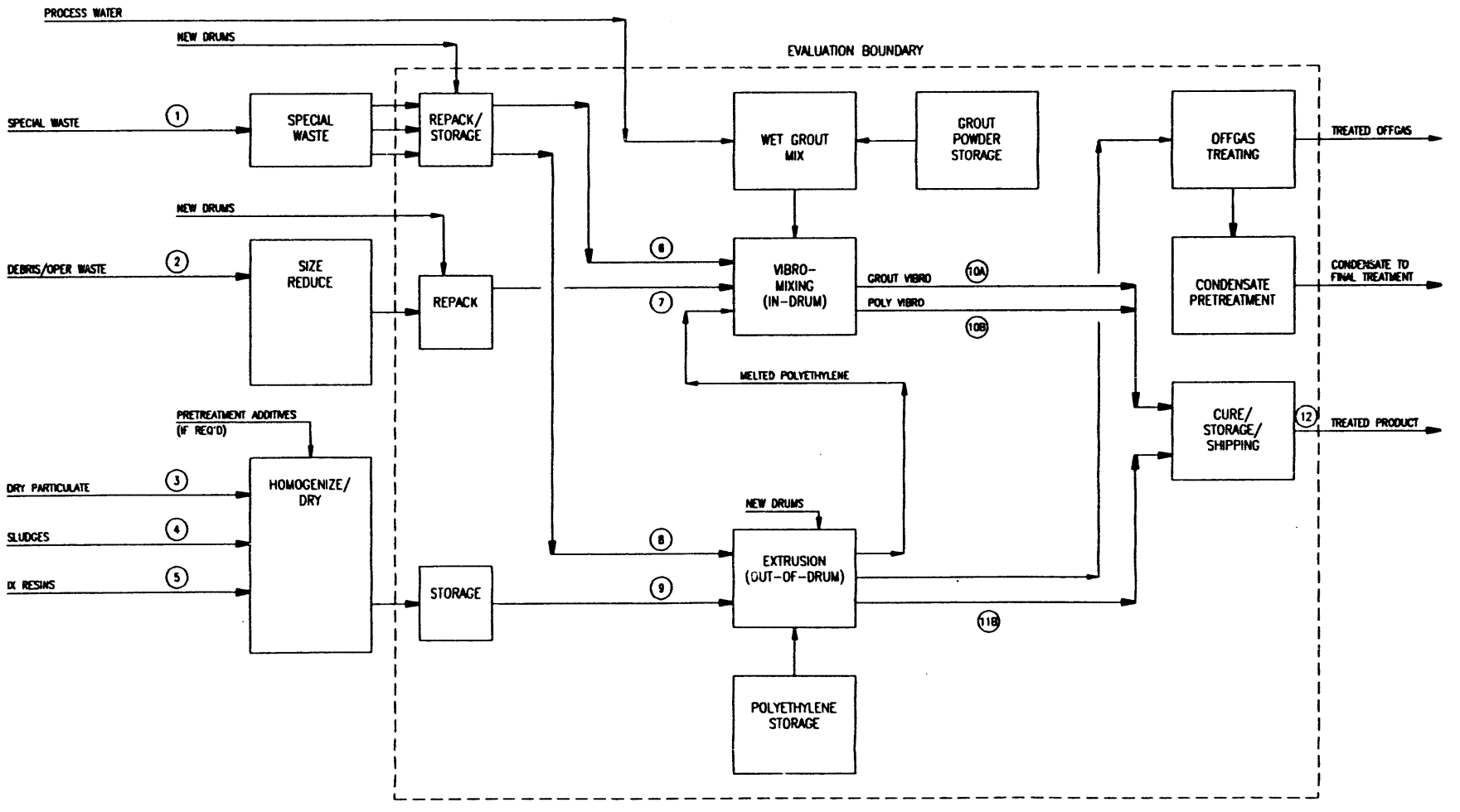
FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DISPOSAL COST (K-$/YR)	SECONDARY TREATMENT COST ($/YR)	TOTAL OPERATING COST (K-$/YR)
1A	183H SLD LIQ	421	280	136	281
1B	183H CRYSTAL	392	261	136	261
1C	183H SLUDGE	527	351	136	351
1D	183H MISC	76	51	0	51
2A	C018 SALT	2862	1906	6120	1912
2B	ION EX RESIN	436	290	0	290
2C	L045 SLUDGE	939	625	0	625
2D	R O FILTER	39	26	0	26
3	D A W	211	141	0	141
4	CONST DEBRIS	116	77	0	77
5A-1	ELEMT MERCURY	20	13	0	13
5A-2	MERCURY CONT	407	271	0	271
5B	REACT METALS	70	47	0	47
5C-1	ELEMENT LEAD	114	76	0	76
5C-2	LEAD CONT	7	5	0	5
5D	MISC METALS	643	428	0	428
6	ABSORB CHEM	860	573	0	573
7	INCIN ASH	365	243	0	243
8	SOILS	404	269	0	269
	TOTAL	8909	5933	6528	5940

TABLE 6-16 COMBINED GROUT AND THERMOPLASTICPOLYMER PROCESS TOTAL COST (CASE 1)

	INITIAL EXPENSES (K-$)	ANNUAL EXPENSES (K-$/YR)
PLANT AND CAPITAL EQUIPMENT:		
SPECIAL WASTE PRETREAT	1180	N/A
SPECIAL WASTE REPACK	246	N/A
SIZE REDUCE/HOMOGENIZE PRETREAT	2741	N/A
SIZE REDUCE/HOMOGENIZE REPACK	262	N/A
HOMOGENIZED WASTE STORAGE	5	N/A
WASTE PREHEATER/DRYER	66	N/A
VIBRO-MIXING STATION	600	N/A
STIR-MIXING STATION	414	N/A
EXTRUDER STATION	636	N/A
PE STORAGE	21	N/A
BULK GROUT STORAGE	782	N/A
CURE/STORAGE/SHIPPING (NOTE 1)	1933	N/A
OFFGAS TREATMENT	15	N/A
RAW MATERIAL COST	N/A	2651
OPERATING COST	N/A	5940
TOTAL EXPENSES	8901	8591

NOTES : (1) INCLUDES $ 559K BUILDING FLOOR SPACE COSTS FOR CURE/STORAGE

FIGURE 6-5



WRAP 2A ADVANCED CONCEPTUAL DESIGN
SINGLE IMMOBILIZATION STUDY
BLOCK FLOW DIAGRAM

GROUT & POLYETHYLENE POLYMER SOLIDIFICATION PROCESS
CASE 2

11/06/93 11:24 CAD NO: W2P1000B.DWG COLOR 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
LAK 03.37.008 PLT SCALE: 1 = 1 PEN WEIGHT 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1
7

TABLE 6-17 POLYETHYLENE AND GROUT PROCESS – WASTE LOADINGS CASE 2

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	9:1 BFS:OPC	122	183333	124	2663	400
1B	183H CRYSTAL	60	1300	60	140	40	POLYETHYLENE	57	117000	75	2610	392
1C	183H SLUDGE	69	1400	69	100	40	POLYETHYLENE	57	144900	69	3508	527
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	2862
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	436
2C	L045 SLUDGE	75	3050	75	140	40	POLYETHYLENE	57	343125	75	7654	1149
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	20
5A2	MERCURY CONT	22	4256	40	58	51	9:1 BFS:OPC	122	66637	78	2352	353
5B	REACT METAL #	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	70
5C1	ELEM LEAD #	83	846	83	710	65	POLYETHYLENE	57	37313	143	754	113
5C2	LEAD CONT	58	44	80	105	55	9:1 BFS:OPC	122	1547	112	41	6
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	40	POLYETHYLENE	57	229500	67	5726	860
7	INCIN ASH	35	2300	35	90	50	POLYETHYLENE	57	80115	70	2300	345
8	SOILS	90	680	90	90	40	POLYETHYLENE	57	91800	67	2291	344
	TOTAL		+ 34058						2473185		59691	8963

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 6-18 COMBINED GROUT AND THERMOPLASTIC POLYMER PROCESS RAW MATERIAL COST (CASE 2)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	9:1 BFS:OPC	400	50	VIBRO	0	183	9	59
1B	183H CRYSTAL	PE	392	49	EXTRUDED	0	117	40	89
1C	183H SLUDGE	PE	527	63	EXTRUDED	0	145	49	115
1D	183H MISC	9:1 BFS:OPC	76	10	VIBRO	0	26	1	11
2A	C018 SALT	PE	2862	358	EXTRUDED	0	614	209	567
2B	ION EX RESIN	PE	436	55	EXTRUDED	0	78	27	81
2C	L045 SLUDGE	PE	1149	144	EXTRUDED	0	343	117	260
2D	R O FILTER	3:1 BFS:OPC	39	5	VIBRO	0	6	0	5
3	D A W	3:1 BFS:OPC	211	26	VIBRO	0	34	2	28
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO	0	33	2	16
5A-1	ELEMT MERCURY	PE	20	3	EXTRUDED	0	85	29	31
5A-2	MERCURY CONT	9:1 BFS:OPC	353	44	VIBRO	0	67	3	47
5B	REACT METALS	PE	70	9	EXTRUDED	0	20	7	16
5C-1	ELEMENT LEAD	PE	113	14	EXTRUDED	0	319	108	123
5C-2	LEAD CONT	9:1 BFS:OPC	6	1	VIBRO	0	2	0	1
5D	MISC METALS	9:1 BFS:OPC	643	80	VIBRO	0	814	40	120
6	ABSORB CHEM	PE	860	108	EXTRUDED	0	230	78	186
7	INCIN ASH	PE	345	43	EXTRUDED	0	80	27	70
8	SOILS	PE	344	43	EXTRUDED	0	92	31	74
	TOTAL		8962	1120		0	3288	779	1899

TABLE 6-19 COMBINED GROUT AND THERMOPLASTIC POLYMER PROCESS OPERATING COST (CASE 2)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DISPOSAL COST (K-$/YR)	SECONDARY TREATMENT COST ($/YR)	TOTAL OPERATING COST (K-$/YR)
1A	183H SLD LIQ	400	266	0	266
1B	183H CRYSTAL	392	261	136	261
1C	183H SLUDGE	527	351	136	351
1D	183H MISC	76	51	0	51
2A	C018 SALT	2862	1906	6120	1912
2B	ION EX RESIN	436	290	0	290
2C	L045 SLUDGE	1149	765	0	765
2D	R O FILTER	39	26	0	26
3	D A W	211	141	0	141
4	CONST DEBRIS	116	77	0	77
5A-1	ELEMT MERCURY	20	13	0	13
5A-2	MERCURY CONT	353	235	0	235
5B	REACT METALS	70	47	0	47
5C-1	ELEMENT LEAD	113	75	0	75
5C-2	LEAD CONT	6	4	0	4
5D	MISC METALS	643	428	0	428
6	ABSORB CHEM	860	573	0	573
7	INCIN ASH	345	230	0	230
8	SOILS	344	229	0	229
	TOTAL	8962	5969	6392	5975

TABLE 6-20 COMBINED GROUT AND THERMOPLASTICPOLYMER PROCESS TOTAL COST (CASE 2)

	INITIAL EXPENSES (K-$)	ANNUAL EXPENSES (K-$/YR)
PLANT AND CAPITAL EQUIPMENT:		
SPECIAL WASTE PRETREAT	1180	N/A
SPECIAL WASTE REPACK	236	N/A
SIZE REDUCE/HOMOGENIZE PRETREAT	2741	N/A
SIZE REDUCE/HOMOGENIZE REPACK	143	N/A
HOMOGENIZED WASTE STORAGE	5	N/A
VIBRO-MIXING STATION	273	N/A
EXTRUDER STATION	687	N/A
PE STORAGE	19	N/A
BULK GROUT STORAGE	406	N/A
CURE/STORAGE/SHIPPING (NOTE 1)	2012	N/A
OFFGAS TREATMENT	15	N/A
RAW MATERIAL COST	N/A	1899
OPERATING COST	N/A	5975
TOTAL EXPENSES	7717	7874

NOTES : (1) INCLUDES $ 554K BUILDING FLOOR SPACE COSTS FOR CURE/STORAGE

6.2.5 Grout and Thermoset Polymer Encapsulation

6.2.5.1 Process Operation

6.2.5.1.1 Process Description

A. **Figure 6-6**, shows the grout and VES polymer solidification process. The configuration is identical to the CDR basecase with exception of removing vacuum dewatering as a VES resin solidification process for Feedstream 2B. Either binder can be mixed with waste using either stirred or vibro in-drum mixing techniques. Each feedstream is treated using the same solidification method as recommended in the CDR (with the exception of Feedstream 2B). Waste loadings have been adjusted based upon recommendations given under feedstream applicability.

6.2.5.1.2 Material Balance

A. The grout and VES resin material balance, as shown in **Tables 6-21**, yields a total treated waste volume of 553 ft^3/day or about 83 drums/day. Approximately 69 vol-% of the waste is treated with VES resin polymer.

6.2.5.2 Process Cost

A. Raw Materials

1. Raw materials are considered as being those materials (other than the waste) that comprise the final wasteform products. Included are drums, paddles, and binder materials. Raw material costs are developed on **Table 6-22**.

2. Cost bases for **Table 6-22** are as follows:

Drums:	$125/ea (polymer lined)[48]
Paddles:	$500/ea (grout design)[37]
	$222/ea (polymer design)[37]
OPC:	$80/ton[49]
GGBFS:	$100/ton[50]
PFA:	$36/ton[51]
Envirostone (Modified Gypsum):	$1330/ton[52]
VES:	$3200/ton[52]

3. Raw material costs are carried forward from **Table 6-22** to the total cost development on **Table 6-24**.

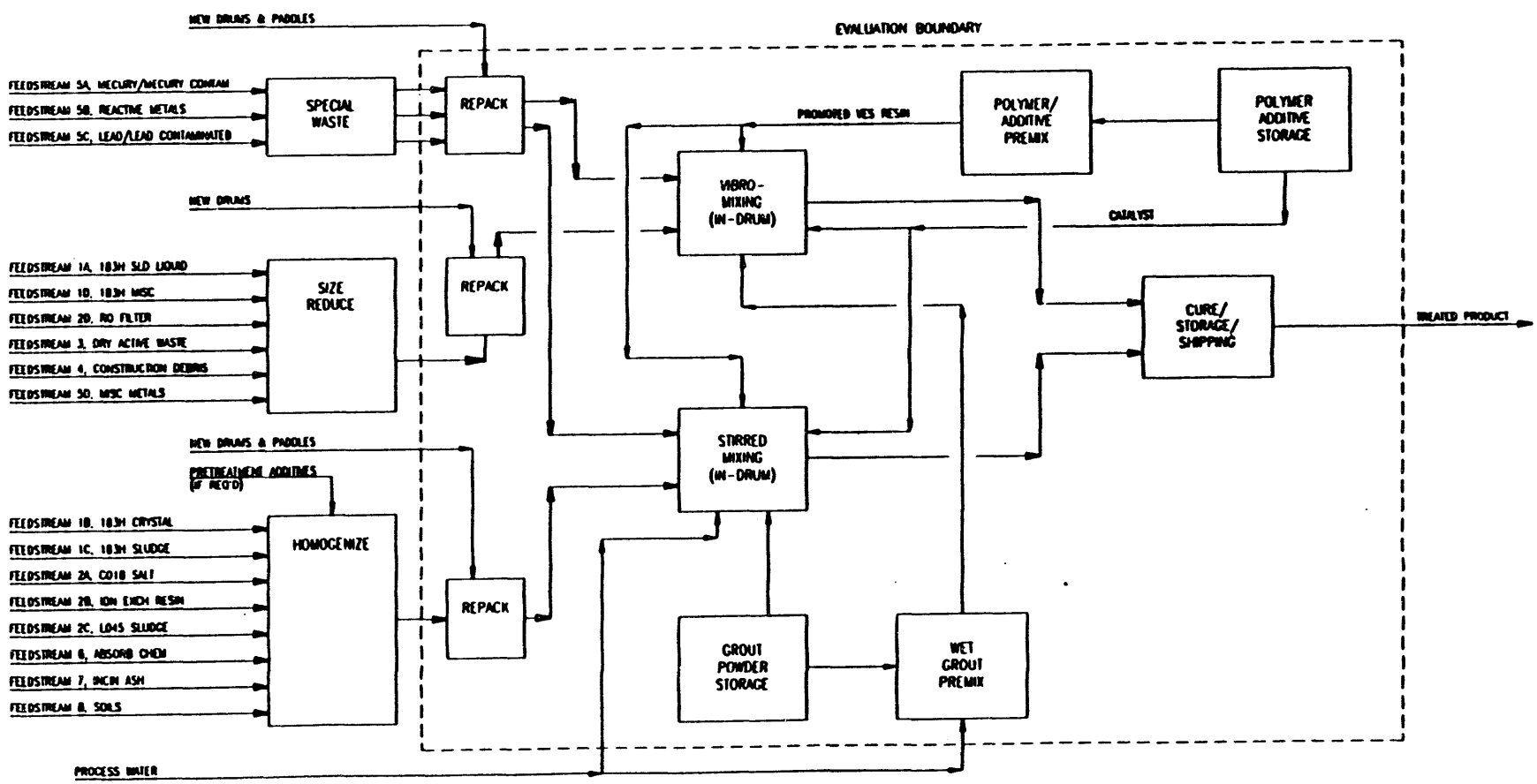
B. Operating Costs

1. Operating costs are considered as being those costs necessary to complete the process under evaluation, but not related to anything physically comprising the final wasteform products. These costs are identified as being waste pretreatment costs, secondary treatment costs and land burial disposal costs. Operating costs are developed on **Table 6-23**.

2. Cost basis for land burial disposal is assumed as $90/CF (estimate).

3. Operating costs are carried forward from **Table 6-23** to the total cost development on **Table 6-24**.

FIGURE 6-6



WRAP 2A ADVANCED CONCEPTUAL DESIGN
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GROUT & VES POLYMER SOLIDIFICATION PROCESS

TABLE 6–21 VES AND GROUT PROCESS – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	VES POLYMER	65	247500	74	4442	667
1B	183H CRYSTAL	60	1300	60	140	25	VES POLYMER	65	234000	75	4157	624
1C	183H SLUDGE	69	1400	69	100	25	VES POLYMER	65	289800	71	5424	814
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	25	VES POLYMER	65	2761440	73	50776	7624
2B	ION EX RESIN	55	2140	55	77	60	VES POLYMER	65	78467	72	2736	411
2C	L045 SLUDGE	75	3050	75	140	30	3:1 PFA:OPC	116	395370	122	6255	939
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	40	VES POLYMER	65	14085	98	240	36
5A2	MERCURY CONT	22	4256	40	58	40	VES POLYMER	65	140448	62	3775	567
5B	REACT METAL #	200	147	200	240	60	VES POLYMER	65	19600	116	424	64
5C1	ELEM LEAD #	83	846	83	710	60	VES POLYMER	65	47597	142	831	125
5C2	LEAD CONT	58	44	80	105	70	VES POLYMER	65	1094	89	41	6
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	40	VES POLYMER	65	229500	73	5231	785
7	INCIN ASH	35	2300	35	90	30	9:1 BFS:OPC	122	139136	110	2434	365
8	SOILS	90	680	90	90	20	9:1 BFS:OPC	122	181333	114	2692	404
	TOTAL		+ 34058						5239306		96688	14518

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 6-22 COMBINED GROUT AND THERMOSET POLYMER PROCESS RAW MATERIAL COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	AL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	VES	667	83	VIBRO		248	397	480
1B	183H CRYSTAL	VES	624	78	AGITATED	139	234	374	591
1C	183H SLUDGE	VES	814	102	AGITATED	181	290	464	746
1D	183H MISC	9:1 BFS:OPC	76	10	VIBRO		26	1	11
2A	C018 SALT	VES	7624	953	AGITATED	1693	2761	4418	7063
2B	ION EX RESIN	VES	411	51	AGITATED	91	78	125	267
2C	L045 SLUDGE	3:1 PFA:OPC	939	117	AGITATED	470	508	12	599
2D	R O FILTER	3:1 BFS:OPC	39	5	VIBRO		6	0	5
3	D A W	3:1 BFS:OPC	211	26	VIBRO		34	2	28
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO		33	2	16
5A-1	ELEMT MERCURY	VES	36	5	AGITATED	8	192	307	320
5A-2	MERCURY CONT	VES	567	71	VIBRO		140	224	295
5B	REACT METALS	VES	64	8	AGITATED	14	20	32	54
5C-1	ELEMENT LEAD	VES	125	16	VIBRO		407	651	667
5C-2	LEAD CONT	VES	6	1	VIBRO		1	2	2
5D	MISC METALS	9:1 BFS:OPC	643	80	VIBRO		814	40	120
6	ABSORB CHEM	VES	785	98	AGITATED	174	230	368	640
7	INCIN ASH	9:1 BFS:OPC	365	46	AGITATED	183	139	7	235
8	SOILS	9:1 BFS:OPC	404	51	AGITATED	202	181	9	261
	TOTAL		14516	1815		3153	6342	7434	12402

TABLE 6-23 COMBINED GROUT AND THERMOSET POLYMER PROCESS OPERATING COST

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DISPOSAL COST (K-$/YR)	SECONDARY TREATMENT COST ($/YR)	TOTAL OPERATING COST (K-$/YR)
1A	183H SLD LIQ	667	444	0	444
1B	183H CRYSTAL	624	416	0	416
1C	183H SLUDGE	814	542	0	542
1D	183H MISC	76	51	0	51
2A	C018 SALT	7624	5078	0	5078
2B	ION EX RESIN	411	274	0	274
2C	L045 SLUDGE	939	625	0	625
2D	R O FILTER	39	26	0	26
3	D A W	211	141	0	141
4	CONST DEBRIS	116	77	0	77
5A-1	ELEMT MERCURY	36	24	0	24
5A-2	MERCURY CONT	567	378	0	378
5B	REACT METALS	64	43	0	43
5C-1	ELEMENT LEAD	125	83	0	83
5C-2	LEAD CONT	6	4	0	4
5D	MISC METALS	643	428	0	428
6	ABSORB CHEM	785	523	0	523
7	INCIN ASH	365	243	0	243
8	SOILS	404	269	0	269
	TOTAL	14516	9668	0	9668

TABLE 6-24 COMBINED GROUT AND THERMOSET POLYMER PROCESS TOTAL COST

	INITIAL EXPENSES (K-$)	ANNUAL EXPENSES (K-$/YR)
PLANT AND CAPITAL EQUIPMENT:		
SPECIAL WASTE PRETREAT	1180	N/A
SPECIAL WASTE REPACK	276	N/A
SIZE REDUCE/HOMOGENIZE PRETREAT	2741	N/A
SIZE REDUCE/HOMOGENIZE REPACK	695	N/A
VIBRO-MIXING STATION	570	N/A
STIR-MIXING STATION	591	N/A
POLYMER/ADDITIVE STORAGE	607	N/A
POLYMER/ADDITIVE PREMIX	30	N/A
BULK GROUT STORAGE	518	N/A
CURE/STORAGE/SHIPPING (NOTE 1)	2800	N/A
RAW MATERIAL COST	N/A	12402
OPERATING COST	N/A	9668
TOTAL EXPENSES	10008	22070

NOTES : (1) INCLUDES $ 883K BUILDING FLOOR SPACE COSTS FOR CURE/STORAGE

C. Plant/Capital Equipment

1. Plant and capital equipment includes each device or system identified by a block on the applicable block flow diagram. Cost bases were data from the WRAP 2A CDR [10] proportioned to match the throughputs and residence times of the process option under evaluation. Plant and capital equipment costs are presented on **Table 6-24.**

6.3 Alternatives Considered But Not Evaluated

6.3.1 Alternatives Screened From Formal Evaluation

A. All alternatives considered in this study as a single means of waste immobilization (i.e. grout, thermoplastic polymer, and thermoset polymer) will be evaluated. Furthermore, two alternatives combining methods (i.e. grout and thermoplastic, and grout and thermoset) will be evaluated. For the dual processes the feedstream split between polymer and grout used in the CDR has been considered for the VES/grout case and for the polyethylene/grout case. However, for the polyethylene/grout case a second alternative has been considered based on processing size reduced wastes suitable for vibro-infilling in grout and processing particulate wastes suitable for putting through an extruder in polyethylene.

B. Before undertaking a formal analysis of all the options, a direct comparison between the two polyethylene/grout processes was performed so that only one of these processes need be included in the formal evaluation. (The CDR split process (vibro/agitated) will be called Case 1 and the vibro-infill/extruder only case will be called Case 2.) The relative merits of each process are discussed below:

1. <u>Process Hazards</u>

   a. Both cases will be using the same binder materials and, with the exception of in-drum agitated mixing for Case 2, similar equipment. Hence, both cases are rated the same in terms of process hazards.

2. <u>Operability</u>

   a. In terms of operability Case 2 is the better option as it only involves two processes compared with four in Case 1. It also rates higher as only one grout formulation will be required, whereas in Case 1 any number of formulations could be required to immobilize waste sludges and soils using agitated mixing. Also, Case 1 will require the use of a unit operation for preheating and drying waste in-drum for the polyethylene vibro in-filling operation.

3. <u>Maintainability and Reliability</u>

   a. Although similar equipment will be used in both options. Case 1 will require substantially more equipment to operate four processes than Case 2 with only two processes. Hence, when considering the whole process rather than individual items of equipment, Case 2 will be more reliable and will require fewer maintenance operations.

4. Demonstrated Technology/Development Requirements

   a. There is very little difference in terms of demonstrated technology between the two options. However, in terms of development requirements, vibro-infilling with polyethylene would need some development work to prove that the hot polyethylene could fully penetrate the waste and not leave more than 10% void space in the drum. Due to the waste acting as a heat sink, the polyethylene will tend to set up in the upper levels of the drum. In order to overcome this, the waste would either have to be heated or the drum would have to be filled in stages so that each separate layer was fully encapsulated. In view of these requirements, Case 2 is considered to be the better option in this category.

5. Capital Cost

   a. Details of the capital cost of each option are given in **Tables 6-16 and 6-20**. The total capital cost of Case 1 will be $8,901K and Case 2 will be $7,717K.

6. Raw Material/Operating Cost

   a. Details of the raw material/operating costs are given in **Tables 6-16 and 6-20**. The raw material/operating cost for Case 1 will be $8,591K and for Case 2 will be $7,784K.

7. Flexibility

   a. In terms of flexibility, Case 1 is the better option as, although both processes can treat all currently identified wastes, Case 1 having four different processes provides greater flexibility to handle future waste streams.

8. Waste Minimization

   a. Details of the waste loadings achievable for each process are given in **Tables 6-13 and 6-17**. From these tables it can be seen that there is very little difference between the two processes in terms of number of product drums produced.

9. Conclusion

   a. From the above discussion of the two polyethylene/grout processes it can be seen that Case 2 is the better option for most of the evaluation criteria and is only surpassed by Case 1 in terms of process flexibility. On this basis, Case 2 will be used as the polyethylene/grout process for formal evaluation and Case 1 will not be considered further in this study.

6.4 Evaluation of Alternatives

6.4.1 Process Hazards

A. Details of the process hazards associated with each of the individual binders are discussed in Sections 6.2.1.6, 6.2.2.6 and 6.2.3.6. From these sections it can be deduced that, in relative terms, VES is the most hazardous binder because of its toxic and flammable nature and because of the potential of blockages in the process due to premature setting of the polymer requiring the use of extremely hazardous solvents for maintenance. Grout is the best option as the binder materials are non-toxic, the process equipment is tried and tested and therefore, process failures and hence maintenance operation will be minimized. Polyethylene is also relatively free from hazards as the binder raw material will be in the form of polymer pellets and therefore, will not present a hazard to human health. However, polyethylene rates worse than grout for hazards as extruders will operate at higher temperatures than grout process equipment hence increasing the risk of operator injury. Also, there is a moderate fire risk associated with polyethylene products which is not associated with grout products.

B. Considering the dual binder processes; the fact that the amount of polymer is reduced in the plant and is replaced with grout means that the VES/grout process will rate better than VES alone and similarly the polyethylene/grout process will rate better than polyethylene alone. Though VES/grout will present more process hazards than polyethylene alone and polyethylene/grout will present more process hazards than grout alone.

C. Based on the above evaluation, the relative scores of the processes are as follows:

Grout only	5
Grout/Polyethylene	4
Polyethylene only	3
Grout/VES	2
VES only	1

6.4.2 Operability

A. Details of the operability issues associated with each individual binder are discussed in Sections 6.2.1.4, 6.2.2.4, 6.2.3.4, 6.2.4.1 and 6.2.5.1. From these sections it can be deduced that, in relative terms polyethylene is the best process in terms of operability as it involves the least number of process operations, there are no binder formulations to adjust, the binder has an unlimited shelf life and plant clean out operations are simple. VES has the potential to cause most operability problems, mainly due to the need to ensure that all pipework and bends are completely free of polymer when processing has been completed. VES also rates lower because of the metering accuracy required when preparing the binder material. Potentially, there could be a percentage of binder batches which have to be disposed of because the formulations are incorrect. Both VES and polyethylene rate the same in terms of secondary waste treatment as both will require similar off-gas/condensate treatment equipment. Grout rates better than VES as it is a tried and tested technology, including clean-out of vessels and pipework. Binder formulations are easily adjusted and the metering accuracy required when preparing a batch of grout is less precise than that required for VES.

B. The dual binder processes are rated lower because of process complexity. The number of process steps will be greater because of housing the two processes in the plant and the economies of scale for each individual process will have been lost. However, the operability problems associated with formulating and handling VES will outweigh the increased operability requirements of the combined polyethylene/grout process.

C. Based on the above evaluation the relative scores of the processes are as follows:

Polyethylene only	5
Grout only	4
Grout/Polyethylene	3
VES only	2
VES/Grout	1

6.4.3 Maintainability and Reliability

A. Details of the maintainability and reliability requirements associated with each individual binder are discussed in Sections 6.2.1.5, 6.2.2.5 and 6.2.3.5. From these sections it can be deduced that in relative terms, grout is the best process in terms of maintainability and reliability as the equipment to be used has been tried and tested by BNFL in the UK at its radioactive waste encapsulation plants. As it is proposed to use very similar equipment for the VES process to that used for the grout process, this also scores highly, though because of the fact that VES will potentially cause more maintenance problems due to the polymer setting up in process vessels and pipework, it is rated lower than grout. Polyethylene is rated lower than grout and VES because it requires the use of an extruder which appears to have a lower reliability than other mixers[37]

B. The dual binder processes are rated lower again because of the amount of equipment required to operate two processes. However, the item of equipment that will require most maintenance is the extruder, hence the polyethylene only process will still rate worse than both the dual processes and the polyethylene/grout process will rate worse than the VES/grout process.

C. Based on the above evaluation, the relative scores of the processes are as follows:

Grout only	5
VES only	4
Grout/VES	3
Grout/Polyethylene	2
Polyethylene only	1

6.4.4 Demonstrated Technology/Development Requirements

A. Details of waste immobilization history giving demonstrated technology and development requirements for each of the individual binders are discussed in Sections 6.2.1.2, 6.2.2.2 and 6.2.3.2. From these sections it can be deduced that there is significantly more experience in using grout to immobilize wastes that there is with either of the other binders. Experience using VES and polyethylene is very limited, though the fact that immobilization using extrusion of waste with polyethylene or other similar thermoplastic binders such as bitumen has been demonstrated on a commercial scale while VES has been largely only tested in the laboratory means that polyethylene must rate higher than VES.

B. Considering the dual binder processes; the fact that the amount of polymer is reduced in the plant and is replaced with grout means that the VES/grout process will rate better than VES alone and similarly the polyethylene/grout process will rate better than polyethylene alone.

C. Based on the above evaluation, the relative scores of the processes are as follows:

Grout only	5
Grout/Polyethylene	4
Polyethylene	3
Grout/VES	2
VES	1

6.4.5 Capital Cost

A. Details of the capital cost of each process are given in Sections 6.2.1.7, 6.2.2.7, 6.2.3.7 and 6.2.4.2 and 6.2.5.2. From these sections it can be seen that the relative scores of the process are as follows:

		Total Equipment Cost ($K)
Polyethylene only	5	6,834
Polyethylene/Grout	4	7,717
VES only	4	8,655
VES/Grout	3	10,008
Grout only	1	12,192

6.4.6 Raw Materials/Operating Costs

A. Details of the raw material/operating costs for each process are given in Sections 6.2.1.7, 6.2.2.7, 6.2.3.7 and 6.2.4.2 and 6.2.5.2. From these sections it can be seen that the relative scores of the processes are as follows:

		Annual Raw Mat/Oper. Cost ($K/Yr)
Polyethylene only	5	7,672
Polyethylene/Grout	5	7,874
VES/Grout	3	22,070
VES only	3	22,474
Grout	1	33,557

6.4.7 Flexibility

A. Details of flexibility of each binder to meet or exceed current waste acceptance criteria for multiple waste feedstreams is given in previous sections discussing feedstream applicability and process operations. From these sections it can be deduced that, in relative terms, the dual binder processes are more flexible than the single binder processes as not only will they be able to treat all currently identified waste streams, but future waste streams which may be incompatible with one of the binders may be compatible with the other binder. Of the dual processes the grout/VES process is the best option as either binder can be used for both vibro-mixing and agitated mixing for compatible wastes.

TABLE 6–25 EVALUATION SUMMARY FOR IMMOBILIZATION PROCESSES

EVALUATION CRITERIA	WEIGHT	GROUT		VES		PE		GROUT & VES		GROUT & PE	
		RAW	WT	RAW	WT	RAW	WT	RAW	WT	RAW	WT
PROCESS HAZARDS	15%	5	0.75	1	0.15	3	0.45	2	0.30	4	0.60
OPERABILITY	15%	4	0.60	2	0.30	5	0.75	1	0.15	3	0.45
MAINT. & RELIAB.	10%	5	0.50	4	0.40	1	0.10	3	0.30	2	0.20
DEMONSTRATED TECH.	15%	5	0.75	1	0.15	3	0.45	2	0.30	4	0.60
CAPITAL COST	10%	1	0.10	4	0.40	5	0.50	3	0.30	4	0.40
RAW MAT./OPER. COST	15%	1	0.15	3	0.45	5	0.75	3	0.45	5	0.75
FLEXIBILITY	10%	3	0.30	2	0.20	1	0.10	5	0.50	4	0.40
WASTE MINIMIZATION	10%	1	0.10	3	0.30	5	0.50	3	0.30	5	0.50
FINAL WEIGHTED SCORE	100%		3.25		2.35		3.60		2.60		3.90

B. Of the three single binder processes, grout is the best option as it offers both vibro-mixing and agitated mixing and because there are a wide range of formulations possible to allow its use on a variety of waste types. The VES process is rated higher than polyethylene as it offers both vibro-mixing and agitated mixing. Though it scores less than grout because, based on current Waste Form Qualification testing, there is a doubt as to what waste loadings are achievable when heavy metals are present in the waste. Polyethylene is scored lowest because of the predicted problems with product quality when vibro-infilling is used with this binder.

C. Based on the above evaluation, the relative scores of the processes are an follows:

Grout/VES	5
Grout/Polyethylene	4
Grout only	3
VES only	2
Polyethylene	1

6.4.8 Waste Minimization

A. Details of the waste loadings achievable for each process and hence the number of product drums produced each year are given in previous sections dealing with material balance throughput in the process operations description.

B. Based on the above sections the relative scores of the processes are as follows:

		Total Daily Drum Throughput
Polyethylene only	5	50
Polyethylene/Grout	5	51
VES only	3	81
VES/Grout	3	83
Grout	1	135

6.5 Recommended Option

A. The relative scores for each evaluation criteria are summarized in **Table 6-31**. Based on this evaluation the recommended option is the polyethylene/grout dual process.

7.0 DISCUSSION OF PREFERRED ALTERNATIVE

7.1 Sensitivity Analysis

7.1.1 Waste Loadings

A. The study to this point has assumed waste loadings based on previous immobilization experience with other waste types. These assumptions may prove to be incorrect when development work with WRAP 2A waste feedstreams is completed. For this reason a sensitivity analysis has been performed to investigate the effect of waste loading on the evaluation. Two waste loadings have been assumed for the sensitivity analysis, they are nominally 25 wt % and 60 wt %. The only deviation from these waste loadings is where the drum weight limit of 1000 lb[39] or where the fill volume of 6.66 ft^3 would be exceeded. In these cases the maximum allowable waste loading has been used. The impact of these changes on the mass balances for each option is shown in **Tables 7-1 to 7-13**.

B. From **Table 7-1** it can be seen that where a low waste loading is selected for all waste feedstreams, the grout only option is the best option followed by VES/grout. The polyethylene only option produces the most drums. The reason for this is that in this sensitivity analysis, the waste loadings are determined on a weight percent basis and grout is the most dense of the binders followed by VES and polyethylene is the lightest. Hence, when the waste loading is artificially fixed at a low value, a higher weight of waste can be put in each grout drum than in drums using other binders.

C. At high waste loadings the difference in binder densities between VES and polyethylene means that VES is the best option out of the two polymers. However, grout, which is still the best option, is little better than other options as the waste loading in grout is frequently limited by the maximum allowable drum weight (1000 lb[39]).

D. In summary, the drum throughput at fixed waste loadings is dependant on the density of the binder except in circumstances where the total weight of the product will exceed the maximum allowable drum weight. In reality, waste loadings will be dependant on waste type and hence the study case throughputs probably give the best indication of which binder option is likely to be most suitable for WRAP 2A.

TABLE 7-1 WASTE LOADING SENSITIVITY ANALYSIS - SUMMARY

PROCESS OPTION	LOW WASTE LOADING CASE**		HIGH WASTE LOADING CASE***		STUDY CASE	
	DRUMS/DAY	AVE WASTE LOADING*	DRUMS/DAY	AVE WASTE LOADING*	DRUMS/DAY	AVE WASTE LOADING*
GROUT ONLY	78	24.4 %	38	49.8 %	135	14.8 %
VES ONLY	109	25.0 %	39	59.5 %	81	31.9 %
PE ONLY	121	25.0 %	41	59.5 %	50	51.7 %
VES/GROUT	98	GRT-24.0 % VES-25.0 %	40	GRT-40.6 % VES-60.0 %	83	GRT-29.9 % VES-28.6 %
PE/GROUT CASE 1	107	GRT-24.0 % PE-25.0 %	42	GRT-40.6 % PE-60.0 %	51	GRT-48.3 % PE-52.9 %
PE/GROUT CASE 2	111	GRT-23.6 % PE-25.0 %	42	GRT-40.7 % PE-59.1 %	51	GRT-35.0 % PE-50.4 %

* The maximum allowable weight of a product drum is 1000 lb[40]. Hence, the maximum waste loading for certain feedstreams has to be restricted to maintain the total drum weight below this figure. Waste loadings are given as weight % of final product.

** Low waste loading based upon a target value of 25 wt %.

*** High waste loading based upon a target value of 60 wt %.

TABLE 7-2 GROUT ONLY PROCESS MASS BALANCE – LOW WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	25	9:1 BFS:OPC	122	183333	124	2668	2.29
1B	183H CRYSTAL	60	1300	60	140	25	9:1 BFS:OPC	122	173333	126	2480	2.13
1C	183H SLUDGE	69	1400	69	100	25	9:1 BFS:OPC	122	214667	115	3347	2.87
1D	183H MISC	60	385	75	105	25	9:1 BFS:OPC	122	51333	117	789	0.68
2A	C018 SALT	88	10460	88	111	25	ENVIROSTONE	80	2045511	86	42811	36.73
2B	ION EX RESIN	55	2140	55	77	25	9:1 BFS:OPC	122	261556	106	4430	3.80
2C	L045 SLUDGE	75	3050	75	140	25	3:1 PFA:OPC	116	508333	121	7575	6.50
2D	R O FILTER	30	350	40	50	25	3:1 BFS:OPC	143	23333	98	430	0.37
3	D A W	30	2100	45	58	25	3:1 BFS:OPC	143	140000	105	2405	2.06
4	CONST DEBRIS	40	1155	60	100	25	3:1 BFS:OPC	143	102667	129	1429	1.23
5A1	MERCURY #	30	313	30	408	21	9:1 BFS:OPC	122	26809	142	320	0.27
5A2	MERCURY CONT	22	4256	40	58	25	9:1 BFS:OPC	122	208071	95	3922	3.37
5B	REACT METAL #	200	147	200	240	25	9:1 BFS:OPC	122	65333	139	847	0.73
5C1	ELEM LEAD #	83	846	83	710	18	9:1 BFS:OPC	122	245206	142	2819	2.42
5C2	LEAD CONT	58	44	80	105	25	9:1 BFS:OPC	122	5671	117	87	0.07
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	25	3:1 BFS:OPC	143	340000	125	4903	4.21
7	INCIN ASH	35	2300	35	90	25	9:1 BFS:OPC	122	178889	112	2874	2.47
8	SOILS	90	680	90	90	25	9:1 BFS:OPC	122	136000	112	2189	1.88
	TOTAL		+ 34058						5272009		90612	78

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-3 GROUT ONLY PROCESS MASS BALANCE – HIGH WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	60	9:1 BFS:OPC	122	40741	127	1087	0.93
1B	183H CRYSTAL	60	1300	60	140	46	9:1 BFS:OPC	122	67826	129	1310	1.12
1C	183H SLUDGE	69	1400	69	100	60	9:1 BFS:OPC	122	47704	108	1495	1.28
1D	183H MISC	60	385	75	105	60	9:1 BFS:OPC	122	11407	111	347	0.30
2A	C018 SALT	88	10460	88	111	60	ENVIROSTONE	80	454558	96	15963	13.70
2B	ION EX RESIN	55	2140	55	77	60	9:1 BFS:OPC	122	58123	90	2173	1.86
2C	L045 SLUDGE	75	3050	75	140	53	3:1 PFA:OPC	116	150262	127	3390	2.91
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	0.23
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	1.21
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	0.66
5A1	MERCURY #	30	313	30	408	21	9:1 BFS:OPC	122	26809	142	320	0.27
5A2	MERCURY CONT	22	4256	40	58	51	9:1 BFS:OPC	122	66637	78	2354	2.02
5B	REACT METAL #	200	147	200	240	29	9:1 BFS:OPC	122	52296	142	703	0.60
5C1	ELEM LEAD #	83	846	83	710	18	9:1 BFS:OPC	122	245206	142	2819	2.42
5C2	LEAD CONT	58	44	80	105	60	9:1 BFS:OPC	122	1260	111	38	0.03
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	60	3:1 BFS:OPC	143	75556	106	2412	2.07
7	INCIN ASH	35	2300	35	90	33	9:1 BFS:OPC	122	121066	109	2234	1.92
8	SOILS	90	680	90	90	60	9:1 BFS:OPC	122	30222	100	1015	0.87
	TOTAL		+ 34058						1883943		44384	38

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-4 POLYETHYLENE ONLY PROCESS MASS BALANCE– LOW WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	25	POLYETHYLENE	57	247500	66	4977	4.27
1B	183H CRYSTAL	60	1300	60	140	25	POLYETHYLENE	57	234000	67	4662	4.00
1C	183H SLUDGE	69	1400	69	100	25	POLYETHYLENE	57	289800	64	6050	5.19
1D	183H MISC	60	385	75	105	25	POLYETHYLENE	57	69300	64	1436	1.23
2A	C018 SALT	88	10460	88	111	25	POLYETHYLENE	57	2761440	65	56739	48.68
2B	ION EX RESIN	55	2140	55	77	25	POLYETHYLENE	57	353100	61	7723	6.63
2C	L045 SLUDGE	75	3050	75	140	25	POLYETHYLENE	57	686250	67	13673	11.73
2D	R O FILTER	30	350	40	50	25	POLYETHYLENE	57	31500	55	763	0.65
3	D A W	30	2100	45	58	25	POLYETHYLENE	57	189000	57	4402	3.78
4	CONST DEBRIS	40	1155	60	100	25	POLYETHYLENE	57	138600	64	2894	2.48
5A1	MERCURY	30	313	30	408	25	POLYETHYLENE	57	28170	73	517	0.44
5A2	MERCURY CONT	22	4256	40	58	25	POLYETHYLENE	57	280896	57	6542	5.61
5B	REACT METALS	200	147	200	240	25	POLYETHYLENE	57	88200	70	1670	1.43
5C1	ELEM LEAD #	83	846	83	710	25	POLYETHYLENE	57	210654	74	3795	3.26
5C2	LEAD CONT	58	44	80	105	25	POLYETHYLENE	57	7656	64	159	0.14
5D	MISC METALS #	200	607	200	450	25	POLYETHYLENE	57	364200	73	6659	5.71
6	ABSORB CHEM	90	1700	90	90	25	POLYETHYLENE	57	459000	63	9753	8.37
7	INCIN ASH	35	2300	35	90	25	POLYETHYLENE	57	241500	63	5131	4.40
8	SOILS	90	680	90	90	25	POLYETHYLENE	57	183600	63	3901	3.35
	TOTAL		+ 34058						6864366		141446	121

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-5 POLYETHYLENE ONLY PROCESS MASS BALANCE- HIGH WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	60	POLYETHYLENE	57	55000	86	1600	1.37
1B	183H CRYSTAL	60	1300	60	140	60	POLYETHYLENE	57	52000	88	1469	1.26
1C	183H SLUDGE	69	1400	69	100	60	POLYETHYLENE	57	64400	77	2096	1.80
1D	183H MISC	60	385	75	105	60	POLYETHYLENE	57	15400	79	490	0.42
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	16.35
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	2.49
2C	L045 SLUDGE	75	3050	75	140	60	POLYETHYLENE	57	152500	88	4309	3.70
2D	R O FILTER	30	350	40	50	60	POLYETHYLENE	57	7000	53	333	0.29
3	D A W	30	2100	45	58	60	POLYETHYLENE	57	42000	58	1823	1.56
4	CONST DEBRIS	40	1155	60	100	60	POLYETHYLENE	57	30800	77	1002	0.86
5A1	MERCURY	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	0.11
5A2	MERCURY CONT	22	4256	40	58	60	POLYETHYLENE	57	62421	58	2709	2.32
5B	REACT METALS	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	0.40
5C1	ELEM LEAD #	83	846	83	710	60	POLYETHYLENE	57	46812	127	920	0.79
5C2	LEAD CONT	58	44	80	105	60	POLYETHYLENE	57	1701	79	54	0.05
5D	MISC METALS #	200	607	200	450	60	POLYETHYLENE	57	80933	120	1690	1.45
6	ABSORB CHEM	90	1700	90	90	60	POLYETHYLENE	57	102000	73	3489	2.99
7	INCIN ASH	35	2300	35	90	50	POLYETHYLENE	57	80115	70	2300	1.97
8	SOILS	90	680	90	90	60	POLYETHYLENE	57	40800	73	1396	1.20
	TOTAL		+ 34058						1551863		48244	41

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-6 VES ONLY PROCESS MASS BALANCE – LOW WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	25	VES POLYMER	64	247500	74	4477	3.84
1B	183H CRYSTAL	60	1300	60	140	25	VES POLYMER	64	234000	74	4190	3.59
1C	183H SLUDGE	69	1400	69	100	25	VES POLYMER	64	289800	71	5465	4.69
1D	183H MISC	60	385	75	105	25	VES POLYMER	64	69300	71	1296	1.11
2A	C018 SALT	88	10460	88	111	25	VES POLYMER	64	2761440	72	51159	43.89
2B	ION EX RESIN	55	2140	55	77	25	VES POLYMER	64	353100	67	7010	6.01
2C	L045 SLUDGE	75	3050	75	140	25	VES POLYMER	64	686250	74	12287	10.54
2D	R O FILTER	30	350	40	50	25	VES POLYMER	64	31500	60	699	0.60
3	D A W	30	2100	45	58	25	VES POLYMER	64	189000	63	4020	3.45
4	CONST DEBRIS	40	1155	60	100	25	VES POLYMER	64	138600	71	2614	2.24
5A1	MERCURY	30	313	30	408	25	VES POLYMER	64	28170	82	460	0.39
5A2	MERCURY CONT	22	4256	40	58	25	VES POLYMER	64	280896	63	5975	5.13
5B	REACT METALS	200	147	200	240	25	VES POLYMER	64	88200	79	1492	1.28
5C1	ELEM LEAD #	83	846	83	710	25	VES POLYMER	64	210654	83	3369	2.89
5C2	LEAD CONT	58	44	80	105	25	VES POLYMER	64	7656	71	143	0.12
5D	MISC METALS #	200	607	200	450	25	VES POLYMER	64	364200	82	5923	5.08
6	ABSORB CHEM	90	1700	90	90	25	VES POLYMER	64	459000	69	8825	7.57
7	INCIN ASH	35	2300	35	90	25	VES POLYMER	64	241500	69	4643	3.98
8	SOILS	90	680	90	90	25	VES POLYMER	64	183600	69	3530	3.03
	TOTAL		+ 34058						6864366		127575	109

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-7 VES ONLY PROCESS MASS BALANCE – HIGH WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	60	VES POLYMER	64	55000	92	1488	1.26
1B	183H CRYSTAL	60	1300	60	140	60	VES POLYMER	64	52000	95	1364	1.17
1C	183H SLUDGE	69	1400	69	100	60	VES POLYMER	64	64400	82	1966	1.69
1D	183H MISC	60	385	75	105	60	VES POLYMER	64	15400	84	459	0.39
2A	C018 SALT	88	10460	88	111	60	VES POLYMER	64	613653	86	17818	15.29
2B	ION EX RESIN	55	2140	55	77	60	VES POLYMER	64	78467	71	2747	2.36
2C	L045 SLUDGE	75	3050	75	140	60	VES POLYMER	64	152500	95	4001	3.43
2D	R O FILTER	30	350	40	50	60	VES POLYMER	64	7000	55	319	0.27
3	D A W	30	2100	45	58	60	VES POLYMER	64	42000	60	1738	1.49
4	CONST DEBRIS	40	1155	60	100	60	VES POLYMER	64	30800	82	940	0.81
5A1	MERCURY	30	313	30	408	60	VES POLYMER	64	6260	130	120	0.10
5A2	MERCURY CONT	22	4256	40	58	60	VES POLYMER	64	62421	60	2583	2.22
5B	REACT METALS	200	147	200	240	60	VES POLYMER	64	19600	115	427	0.37
5C1	ELEM LEAD #	83	846	83	710	60	VES POLYMER	64	46812	142	826	0.71
5C2	LEAD CONT	58	44	80	105	60	VES POLYMER	64	1701	84	51	0.04
5D	MISC METALS #	200	607	200	450	60	VES POLYMER	64	80933	133	1526	1.31
6	ABSORB CHEM	90	1700	90	90	60	VES POLYMER	64	102000	78	3283	2.82
7	INCIN ASH	35	2300	35	90	47	VES POLYMER	64	89943	74	2291	1.97
8	SOILS	90	680	90	90	60	VES POLYMER	64	40800	78	1313	1.13
	TOTAL		+ 34058						1561691		45261	39

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-8 POLYETHYLENE AND GROUT PROCESS MASS BALANCE – LOW WASTE LOADING CASE 1

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	25	POLYETHYLENE	57	247500	66	4977	4.27
1B	183H CRYSTAL	60	1300	60	140	25	POLYETHYLENE	57	234000	67	4662	4.00
1C	183H SLUDGE	69	1400	69	100	25	POLYETHYLENE	57	289800	64	6050	5.19
1D	183H MISC	60	385	75	105	25	9:1 BFS:OPC	122	51333	117	789	0.68
2A	C018 SALT	88	10460	88	111	25	POLYETHYLENE	57	2761440	65	56739	48.68
2B	ION EX RESIN	55	2140	55	77	25	POLYETHYLENE	57	353100	61	7723	6.63
2C	L045 SLUDGE	75	3050	75	140	25	3:1 PFA:OPC	116	508333	121	7575	6.50
2D	R O FILTER	30	350	40	50	25	3:1 BFS:OPC	143	23333	98	430	0.37
3	D A W	30	2100	45	58	25	3:1 BFS:OPC	143	140000	105	2405	2.06
4	CONST DEBRIS	40	1155	60	100	25	3:1 BFS:OPC	143	102667	129	1431	1.23
5A1	MERCURY #	30	313	30	408	25	POLYETHYLENE	57	28170	73	517	0.44
5A2	MERCURY CONT	22	4256	40	58	25	POLYETHYLENE	57	280896	57	6542	5.61
5B	REACT METAL #	200	147	200	240	25	POLYETHYLENE	57	88200	70	1670	1.43
5C1	ELEM LEAD #	83	846	83	710	25	POLYETHYLENE	57	210654	74	3795	3.26
5C2	LEAD CONT	58	44	80	105	25	POLYETHYLENE	57	7656	64	159	0.14
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	25	POLYETHYLENE	57	459000	63	9753	8.37
7	INCIN ASH	35	2300	35	90	25	9:1 BFS:OPC	122	178889	112	2874	2.47
8	SOILS	90	680	90	90	25	9:1 BFS:OPC	122	136000	112	2189	1.88
	TOTAL		+ 34058						6462935		124565	107

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-9 POLYETHYLENE AND GROUT PROCESS MASS BALANCE – HIGH WASTE LOADING CASE 1

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD UQ	100	825	100	130	60	POLYETHYLENE	57	55000	86	1600	1.37
1B	183H CRYSTAL	60	1300	60	140	60	POLYETHYLENE	57	52000	88	1469	1.26
1C	183H SLUDGE	69	1400	69	100	60	POLYETHYLENE	57	64400	77	2096	1.80
1D	183H MISC	60	385	75	105	60	9:1 BFS:OPC	122	11407	111	347	0.30
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	16.35
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	2.49
2C	L045 SLUDGE	75	3050	75	140	53	3:1 PFA:OPC	116	150262	127	3390	2.91
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	0.23
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	1.21
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	0.66
5A1	MERCURY #	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	0.11
5A2	MERCURY CONT	22	4256	40	58	60	POLYETHYLENE	57	62421	58	2709	2.32
5B	REACT METAL #	200	147	200	240	60	POLYETHYLENE	57	19600	105	468	0.40
5C1	ELEM LEAD #	83	846	83	710	60	POLYETHYLENE	57	46812	127	920	0.79
5C2	LEAD CONT	58	44	80	105	60	POLYETHYLENE	57	1701	79	54	0.05
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	60	POLYETHYLENE	57	102000	73	3489	2.99
7	INCIN ASH	35	2300	35	90	33	9:1 BFS:OPC	122	121066	109	2234	1.92
8	SOILS	90	680	90	90	60	9:1 BFS:OPC	122	30222	100	1015	0.87
	TOTAL		+ 34058						1849541		48612	42

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-10 POLYETHYLENE AND GROUT PROCESS MASS BALANCE – LOW WASTE LOADING CASE 2

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	25	9:1 BFS:OPC	122	183333	124	2663	2.29
1B	183H CRYSTAL	60	1300	60	140	25	POLYETHYLENE	57	234000	67	4662	4.00
1C	183H SLUDGE	69	1400	69	100	25	POLYETHYLENE	57	289800	64	6050	5.19
1D	183H MISC	60	385	75	105	25	9:1 BFS:OPC	122	51333	117	789	0.68
2A	C018 SALT	88	10460	88	111	25	POLYETHYLENE	57	2761440	65	56739	48.68
2B	ION EX RESIN	55	2140	55	77	25	POLYETHYLENE	57	353100	61	7723	6.63
2C	L045 SLUDGE	75	3050	75	140	25	POLYETHYLENE	57	686250	67	13673	11.73
2D	R O FILTER	30	350	40	50	25	3:1 BFS:OPC	143	23333	98	430	0.37
3	D A W	30	2100	45	58	25	3:1 BFS:OPC	143	140000	105	2405	2.06
4	CONST DEBRIS	40	1155	60	100	25	3:1 BFS:OPC	143	102667	129	1431	1.23
5A1	MERCURY #	30	313	30	408	25	POLYETHYLENE	57	28170	73	517	0.44
5A2	MERCURY CONT	22	4256	40	58	25	9:1 BFS:OPC	122	208071	96	3917	3.36
5B	REACT METAL #	200	147	200	240	25	POLYETHYLENE	57	88200	70	1670	1.43
5C1	ELEM LEAD #	83	846	83	710	25	POLYETHYLENE	57	210654	74	3795	3.26
5C2	LEAD CONT	58	44	80	105	25	9:1 BFS:OPC	122	5671	117	87	0.07
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	25	POLYETHYLENE	57	459000	63	9753	8.37
7	INCIN ASH	35	2300	35	90	25	POLYETHYLENE	57	241500	63	5131	4.40
8	SOILS	90	680	90	90	25	POLYETHYLENE	57	183600	63	3901	3.35
	TOTAL		+ 34058						6612086		129623	111

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-11 POLYETHYLENE AND GROUT PROCESS MASS BALANCE – HIGH WASTE LOADING CASE 2

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	60	9:1 BFS:OPC	122	40741	127	1085	0.93
1B	183H CRYSTAL	60	1300	60	140	60	POLYETHYLENE	57	52000	88	1469	1.26
1C	183H SLUDGE	69	1400	69	100	60	POLYETHYLENE	57	64400	77	2096	1.80
1D	183H MISC	60	385	75	105	60	9:1 BFS:OPC	122	11407	111	347	0.30
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	16.35
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	2.49
2C	L045 SLUDGE	75	3050	75	140	60	POLYETHYLENE	57	152500	88	4309	3.70
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	0.23
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	1.21
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	0.66
5A1	MERCURY #	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	0.11
5A2	MERCURY CONT	22	4256	40	58	51	9:1 BFS:OPC	122	66637	78	2352	2.02
5B	REACT METAL #	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	0.40
5C1	ELEM LEAD #	83	846	83	710	60	POLYETHYLENE	57	46812	127	920	0.79
5C2	LEAD CONT	58	44	80	105	60	9:1 BFS:OPC	122	1260	111	38	0.03
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	60	POLYETHYLENE	57	102000	73	3489	2.99
7	INCIN ASH	35	2300	35	90	50	POLYETHYLENE	57	80500	70	2307	1.98
8	SOILS	90	680	90	90	60	POLYETHYLENE	57	40800	73	1396	1.20
	TOTAL		+ 34058						1811306		49097	42

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-12 VES AND GROUT PROCESS MASS BALANCE – LOW WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	25	VES POLYMER	65	247500	74	4442	3.81
1B	183H CRYSTAL	60	1300	60	140	25	VES POLYMER	65	234000	75	4157	3.57
1C	183H SLUDGE	69	1400	69	100	25	VES POLYMER	65	289800	71	5424	4.65
1D	183H MISC	60	385	75	105	25	9:1 BFS:OPC	122	51333	117	789	0.68
2A	C018 SALT	88	10460	88	111	25	VES POLYMER	65	2761440	73	50776	43.57
2B	ION EX RESIN	55	2140	55	77	25	VES POLYMER	65	353100	68	6961	5.97
2C	L045 SLUDGE	75	3050	75	140	25	3:1 PFA:OPC	116	508333	121	7575	6.50
2D	R O FILTER	30	350	40	50	25	3:1 BFS:OPC	143	23333	98	430	0.37
3	D A W	30	2100	45	58	25	3:1 BFS:OPC	143	140000	105	2405	2.06
4	CONST DEBRIS	40	1155	60	100	25	3:1 BFS:OPC	143	102667	129	1431	1.23
5A1	MERCURY * #	30	313	30	408	25	VES POLYMER	65	28170	82	456	0.39
5A2	MERCURY CONT	22	4256	40	58	25	VES POLYMER	65	280896	63	5936	5.09
5B	REACT METAL #	200	147	200	240	25	VES POLYMER	65	88200	79	1479	1.27
5C1	ELEM LEAD #	83	846	83	710	25	VES POLYMER	65	210654	84	3340	2.87
5C2	LEAD CONT	58	44	80	105	25	VES POLYMER	65	7656	72	142	0.12
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	25	VES POLYMER	65	459000	70	8762	7.52
7	INCIN ASH	35	2300	35	90	25	9:1 BFS:OPC	122	178889	112	2874	2.47
8	SOILS	90	680	90	90	25	9:1 BFS:OPC	122	136000	112	2189	1.88
	TOTAL		+ 34058						6462935		113855	98

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-13 VES AND GROUT PROCESS MASS BALANCE – HIGH WASTE LOADING

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/DAY)
1A	183H SLD LIQ	100	825	100	130	60	VES POLYMER	65	55000	93	1481	1.27
1B	183H CRYSTAL	60	1300	60	140	60	VES POLYMER	65	52000	96	1357	1.16
1C	183H SLUDGE	69	1400	69	100	60	VES POLYMER	65	64400	82	1957	1.68
1D	183H MISC	60	385	75	105	60	9:1 BFS:OPC	122	11407	111	347	0.30
2A	C018 SALT	88	10460	88	111	60	VES POLYMER	65	613653	87	17733	15.22
2B	ION EX RESIN	55	2140	55	77	60	VES POLYMER	65	78467	72	2736	2.35
2C	L045 SLUDGE	75	3050	75	140	53	3:1 PFA:OPC	116	150262	127	3390	2.91
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	0.23
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	1.21
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	0.66
5A1	MERCURY #	30	313	30	408	60	VES POLYMER	65	6260	131	119	0.10
5A2	MERCURY CONT	22	4256	40	58	60	VES POLYMER	65	62421	61	2575	2.21
5B	REACT METAL #	200	147	200	240	60	VES POLYMER	65	19600	116	424	0.36
5C1	ELEM LEAD #	83	846	83	710	60	VES POLYMER	65	46812	143	819	0.70
5C2	LEAD CONT	58	44	80	105	60	VES POLYMER	65	1701	84	50	0.04
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	3.68
6	ABSORB CHEM	90	1700	90	90	60	VES POLYMER	65	102000	78	3269	2.81
7	INCIN ASH	35	2300	35	90	33	9:1 BFS:OPC	122	121066	109	2234	1.92
8	SOILS	90	680	90	90	60	9:1 BFS:OPC	122	30222	100	1015	0.87
	TOTAL		+ 34058						1849541		46232	40

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

7.1.2 Paddle Costs

A. There are two paddles designs which have been identified in the study: a high speed, high shear impeller for VES binder and a low speed gate paddle based on the BNFL paddle design for use with grout. The VES paddle is priced at $222 per paddle and the grout paddle is priced at $500 per paddle. The high cost of the grout paddle is perceived to have a significant effect on the evaluation of raw material/operating cost. Hence a sensitivity analysis has been performed to determine the implications of this cost on the overall evaluation.

B. From **Table 7-14** it can be seen that the ranking order for the process options if a $900 grout paddle is used is similar to the study case ($500 per paddle) for both the total paddle cost and total raw material cost. If a $100 grout paddle is used the grout only option moves up to fourth out of the six options for both the total paddle cost and the total raw material cost, with the other options staying in approximately the same relative order. The assumption that the grout paddle is only going to cost $100 when the VES paddle costs $222 is probably unrealistic. However, even on this basis the overall ranking order when all the evaluation criteria are considered is still the same as in the study, though in relative terms the grout only option scores much higher at the expense of the two options involving VES.

C. In summary, the cost of the grout paddle will not affect the findings of the study.

TABLE 7-14 PADDLE COST SENSITIVITY ANALYSIS - SUMMARY

PROCESS OPTION	$100 GROUT PADDLE		$900 GROUT PADDLE		$500 GROUT PADDLE	
	COST OF PADDLES	TOTAL RAW MATERIAL COST	COST OF PADDLES	TOTAL RAW MATERIAL COST	COST OF PADDLES	TOTAL RAW MATERIAL COST
GROUT ONLY	$2,124	$9,408	$19,113	$26,398	$10,619	$17,903
VES ONLY	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE	$2,695	$13,032
PE ONLY	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE	$0	$1,930
VES/GROUT	$2,487	$11,693	$3,853	$13,059	$3,153	$12,402
PE/GROUT CASE 1	$171	$1,968	$1,537	$3,334	$854	$2,651
PE/GROUT CASE 2	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE	$0	$1,899

TABLE 7-15 GROUT PROCESS RAW MATERIAL COST ($100 GROUT PADDLE)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	GROUT FORMULATION	DRY MIX REQUIREMENT (K-LBS/YR)	OPC COST ($/YR)	BFS COST ($/YR)	PFA COST ($/YR)	MODIFIED GYPSUM COST ($/YR)	TOTAL RAW MATERIAL COST (K-$/YR)
1A	183H SLD LIQ	401	50	VIBRO		9:1 BFS:OPC	183	732	8235			59
1B	183H CRYSTAL	372	47	AGITATED	37	9:1 BFS:OPC	173	692	7785			82
1C	183H SLUDGE	503	63	AGITATED	50	9:1 BFS:OPC	215	860	9675			124
1D	183H MISC	76	10	VIBRO		9:1 BFS:OPC	26	104	1170			11
2A	C018 SALT	16794	2099	AGITATED	1679	MOD.GYPSUM	6137				4081105	7880
2B	ION EX RESIN	810	101	AGITATED	81	9:1 BFS:OPC	349	1396	15705			199
2C	L045 SLUDGE	939	117	AGITATED	94	3:1 PFA:OPC	508	5080		6858		223
2D	R O FILTER	39	5	VIBRO		3:1 BFS:OPC	6	60	225			5
3	D A W	211	26	VIBRO		3:1 BFS:OPC	34	340	1275			28
4	CONST DEBRIS	116	15	VIBRO		3:1 BFS:OPC	33	330	1238			16
5A-1	ELEMT MERCURY	48	6	AGITATED	5	9:1 BFS:OPC	365	1460	16425			29
5A-2	MERCURY CONT	353	44	VIBRO		9:1 BFS:OPC	67	268	3015			47
5B	REACT METALS	105	13	AGITATED	11	9:1 BFS:OPC	52	208	2340			26
5C-1	ELEMENT LEAD	423	53	VIBRO		9:1 BFS:OPC	2098	8392	94410			156
5C-2	LEAD CONT	6	1	VIBRO		9:1 BFS:OPC	2	8	90			1
5D	MISC METALS	643	80	VIBRO		9:1 BFS:OPC	814	3256	36630			120
6	ABSORB CHEM	897	112	AGITATED	90	3:1 BFS:OPC	453	4530	16968			223
7	INCIN ASH	365	46	AGITATED	37	9:1 BFS:OPC	139	558	6255			89
8	SOILS	404	51	AGITATED	40	9:1 BFS:OPC	181	724	8145			100
	TOTAL	23505	2938		2124		11835	28996	229605	6858	4081105	9408

TABLE 7-16 GROUT PROCESS RAW MATERIAL COST ($900 GROUT PADDLE)

FEEDSTREAM	FEEDSTREAM DESCRIPTION	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	GROUT FORMULATION	DRY MIX REQUIREMENT (K-LBS/YR)	OPC COST ($/YR)	BFS COST ($/YR)	PFA COST ($/YR)	MODIFIED GYPSUM COST ($/YR)	TOTAL RAW MATERIAL COST (K-$/YR)
1A	183H SLD LIQ	401	50	VIBRO		9:1 BFS:OPC	183	732	8235			59
1B	183H CRYSTAL	372	47	AGITATED	335	9:1 BFS:OPC	173	692	7785			390
1C	183H SLUDGE	503	63	AGITATED	453	9:1 BFS:OPC	215	860	9675			526
1D	183H MISC	76	10	VIBRO		9:1 BFS:OPC	26	104	1170			11
2A	C018 SALT	16794	2099	AGITATED	15115	MOD.GYPSUM	6137				4081105	21295
2B	ION EX RESIN	810	101	AGITATED	729	9:1 BFS:OPC	349	1396	15705			847
2C	L045 SLUDGE	939	117	AGITATED	845	3:1 PFA:OPC	508	5080		6858		974
2D	R O FILTER	39	5	VIBRO		3:1 BFS:OPC	6	60	225			5
3	D A W	211	26	VIBRO		3:1 BFS:OPC	34	340	1275			28
4	CONST DEBRIS	116	15	VIBRO		3:1 BFS:OPC	33	330	1238			16
5A-1	ELEMT MERCURY	48	6	AGITATED	43	9:1 BFS:OPC	365	1460	16425			67
5A-2	MERCURY CONT	353	44	VIBRO		9:1 BFS:OPC	67	268	3015			47
5B	REACT METALS	105	13	AGITATED	95	9:1 BFS:OPC	52	208	2340			110
5C-1	ELEMENT LEAD	423	53	VIBRO		9:1 BFS:OPC	2098	8392	94410			156
5C-2	LEAD CONT	6	1	VIBRO		9:1 BFS:OPC	2	8	90			1
5D	MISC METALS	643	80	VIBRO		9:1 BFS:OPC	814	3258	36630			120
6	ABSORB CHEM	897	112	AGITATED	807	3:1 BFS:OPC	453	4530	16988			941
7	INCIN ASH	365	46	AGITATED	329	9:1 BFS:OPC	139	556	6255			381
8	SOILS	404	51	AGITATED	364	9:1 BFS:OPC	181	724	8145			423
	TOTAL	23505	2938		19113		11835	28996	229605	6858	4081105	26398

TABLE 7-17 COMBINED GROUT AND THERMOPLASTIC POLYMER PROCESS RAW MATERIAL COST (CASE 1) ($100 GROUT PADDLE)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	PE	421	53	VIBRO		124	42	95
1B	183H CRYSTAL	PE	392	49	EXTRUSION		117	40	89
1C	183H SLUDGE	PE	527	66	EXTRUSION		145	49	115
1D	183H MISC	9:1 BFS:OPC	76	10	VIBRO		26	1	11
2A	C018 SALT	PE	2862	358	EXTRUSION		614	209	567
2B	ION EX RESIN	PE	436	55	EXTRUSION		78	27	81
2C	L045 SLUDGE	3:1 PFA:OPC	939	117	AGITATED	94	508	12	223
2D	R O FILTER	3:1 BFS:OPC	39	5	VIBRO		6	0	5
3	D A W	3:1 BFS:OPC	211	26	VIBRO		34	2	28
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO		33	2	16
5A-1	ELEMT MERCURY	PE	20	3	EXTRUSION		85	29	31
5A-2	MERCURY CONT	PE	407	51	VIBRO		62	21	72
5B	REACT METALS	PE	70	9	EXTRUSION		20	7	16
5C-1	ELEMENT LEAD	PE	114	14	VIBRO		321	109	123
5C-2	LEAD CONT	PE	7	1	VIBRO		1	0	1
5D	MISC METALS	9:1 BFS:OPC	643	80	VIBRO		814	40	120
6	ABSORB CHEM	PE	860	108	EXTRUSION		230	78	186
7	INCIN ASH	9:1 BFS:OPC	365	46	AGITATED	37	139	7	89
8	SOILS	9:1 BFS:OPC	404	51	AGITATED	40	181	9	100
	TOTAL		8909	1114		171	3538	683	1968

TABLE 7-18 COMBINED GROUT AND THERMOPLASTIC POLYMER PROCESS RAW MATERIAL COST (CASE 1) ($900 GROUT PADDLE)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	PE	421	53	VIBRO		124	42	95
1B	183H CRYSTAL	PE	392	49	EXTRUSION		117	40	89
1C	183H SLUDGE	PE	527	66	EXTRUSION		145	49	115
1D	183H MISC	9:1 BFS:OPC	76	10	VIBRO		26	1	11
2A	C018 SALT	PE	2862	358	EXTRUSION		614	209	567
2B	ION EX RESIN	PE	436	55	EXTRUSION		78	27	81
2C	L045 SLUDGE	3:1 PFA:OPC	939	117	AGITATED	845	508	12	974
2D	R O FILTER	3:1 BFS:OPC	39	5	VIBRO		6	0	5
3	D A W	3:1 BFS:OPC	211	26	VIBRO		34	2	28
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO		33	2	16
5A-1	ELEMT MERCURY	PE	20	3	EXTRUSION		85	29	31
5A-2	MERCURY CONT	PE	407	51	VIBRO		62	21	72
5B	REACT METALS	PE	70	9	EXTRUSION		20	7	16
5C-1	ELEMENT LEAD	PE	114	14	VIBRO		321	109	123
5C-2	LEAD CONT	PE	7	1	VIBRO		1	0	1
5D	MISC METALS	9:1 BFS:OPC	643	80	VIBRO		814	40	120
6	ABSORB CHEM	PE	860	108	EXTRUSION		230	78	186
7	INCIN ASH	9:1 BFS:OPC	365	46	AGITATED	329	139	7	381
8	SOILS	9:1 BFS:OPC	404	51	AGITATED	364	181	9	423
	TOTAL		8909	1114		1537	3538	683	3334

TABLE 7-19 COMBINED GROUT AND THERMOSET POLYMER PROCESS RAW MATERIAL COST ($100 GROUT PADDLE)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	VES	672	84	VIBRO		248	397	481
1B	183H CRYSTAL	VES	629	79	AGITATED	140	234	374	593
1C	183H SLUDGE	VES	821	103	AGITATED	182	290	464	749
1D	183H MISC	9:1 BFS:OPC	69	9	VIBRO		26	1	10
2A	C018 SALT	VES	7682	960	AGITATED	1705	2761	4418	7083
2B	ION EX RESIN	VES	412	52	AGITATED	91	78	125	268
2C	L045 SLUDGE	3:1 PFA:OPC	1045	131	AGITATED	105	508	12	247
2D	R O FILTER	3:1 BFS:OPC	48	6	VIBRO		6	0	6
3	D A W	3:1 BFS:OPC	226	28	VIBRO		34	2	30
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO		33	2	16
5A-1	ELEMT MERCURY	VES	36	5	AGITATED	8	192	307	320
5A-2	MERCURY CONT	VES	570	71	VIBRO		140	224	295
5B	REACT METALS	VES	64	8	AGITATED	14	20	32	54
5C-1	ELEMENT LEAD	VES	126	16	VIBRO		407	651	667
5C-2	LEAD CONT	VES	6	1	VIBRO		1	2	2
5D	MISC METALS	9:1 BFS:OPC	203	25	VIBRO		814	40	65
6	ABSORB CHEM	VES	790	99	AGITATED	175	230	368	642
7	INCIN ASH	9:1 BFS:OPC	346	43	AGITATED	35	139	7	85
8	SOILS	9:1 BFS:OPC	316	40	AGITATED	32	181	9	80
	TOTAL		14177	1772		2487	6342	7434	11693

TABLE 7-20 COMBINED GROUT AND THERMOSET POLYMER PROCESS RAW MATERIAL COST ($900 GROUT PADDLE)

FEEDSTREAM NUMBER	FEEDSTREAM DESCRIPTION	BINDER SELECTED	DRUMS SHIPPED (DRUMS/YR)	DRUM COST (K-$/YR)	MIXER TYPE	PADDLE COST (K-$/YR)	BINDER REQUIREMENT (K-LBS/YR)	BINDER COST (K-$/YR)	TOTAL RAW MATERIALS COST (K-$/YR)
1A	183H SLD LIQ	VES	672	84	VIBRO		248	397	481
1B	183H CRYSTAL	VES	629	79	AGITATED	140	234	374	593
1C	183H SLUDGE	VES	821	103	AGITATED	182	290	464	749
1D	183H MISC	9:1 BFS:OPC	69	9	VIBRO		26	1	10
2A	C018 SALT	VES	7682	960	AGITATED	1705	2761	4418	7083
2B	ION EX RESIN	VES	412	52	AGITATED	91	78	125	268
2C	L045 SLUDGE	3:1 PFA:OPC	1045	131	AGITATED	941	508	12	1083
2D	R O FILTER	3:1 BFS:OPC	48	6	VIBRO		6	0	6
3	D A W	3:1 BFS:OPC	226	28	VIBRO		34	2	30
4	CONST DEBRIS	3:1 BFS:OPC	116	15	VIBRO		33	2	16
5A-1	ELEMT MERCURY	VES	36	5	AGITATED	8	192	307	320
5A-2	MERCURY CONT	VES	570	71	VIBRO		140	224	295
5B	REACT METALS	VES	64	8	AGITATED	14	20	32	54
5C-1	ELEMENT LEAD	VES	126	16	VIBRO		407	651	667
5C-2	LEAD CONT	VES	6	1	VIBRO		1	2	2
5D	MISC METALS	9:1 BFS:OPC	203	25	VIBRO		814	40	65
6	ABSORB CHEM	VES	790	99	AGITATED	175	230	368	642
7	INCIN ASH	9:1 BFS:OPC	346	43	AGITATED	311	139	7	361
8	SOILS	9:1 BFS:OPC	316	40	AGITATED	284	181	9	333
	TOTAL		14177	1772		3853	6342	7434	13059

7.1.3 Feedstream Datasheets

A. The waste throughputs and physical/chemical properties used in the study are based on information generated for the CDR. Recently, WHC have prepared some draft feedstream datasheets[32] which differ somewhat from the study. This sensitivity analysis is being performed to assess the impact of the new data on the throughput of product drums through WRAP 2A.

B. The draft feedstream datasheet numbers are lower than the study numbers as they are based on an annual throughput of 29000 ft^3 where as the study numbers are based on an annual throughput of 34058 ft^3. The range from smallest to largest throughput has been reduced, though the ranking order is similar apart from the fact that the polyethylene/grout case 2 has now taken over from the polyethylene only case as the process which produces least product drums.

C. In summary, the draft feedstream datasheets will not affect the findings of the study, that is, a polyethylene/grout process is the best process for WRAP 2A.

TABLE 7-21 FEEDSTREAM DATA SENSITIVITY ANALYSIS - SUMMARY

PROCESS OPTION	PRODUCT DRUM THROUGHPUT (DRUMS/YR)	
	DRAFT FEEDSTREAM DATASHEETS	STUDY ASSUMPTIONS
PE ONLY	8,736	8,169
GROUT ONLY	13,780	23,507
VES ONLY	10,635	14,176
PE/GROUT CASE 1	8,784	8,909
PE/GROUT CASE 2	8,474	8,963
VES/GROUT	11,045	14,518

TABLE 7–22 GROUT ONLY PROCESS (CDR) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	9:1 BFS:OPC	122	183333	124	2668	401
1B	183H CRYSTAL	60	1300	60	140	25	9:1 BFS:OPC	122	173333	126	2480	372
1C	183H SLUDGE	69	1400	69	100	25	9:1 BFS:OPC	122	214667	115	3347	503
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	10	ENVIROSTONE	80	6136533	82	111847	16794
2B	ION EX RESIN	55	2140	55	77	20	9:1 BFS:OPC	122	348741	109	5397	810
2C	L045 SLUDGE	75	3050	75	140	30	3:1 PFA:OPC	116	395370	122	6255	939
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	21	9:1 BFS:OPC	122	26809	142	320	48
5A2	MERCURY CONT	22	4256	40	58	51	9:1 BFS:OPC	122	66637	78	2354	353
5B	REACT METAL #	200	147	200	240	30	9:1 BFS:OPC	122	52045	142	700	105
5C1	ELEM LEAD #	83	846	83	710	18	9:1 BFS:OPC	122	245206	142	2819	423
5C2	LEAD CONT	58	44	80	105	55	9:1 BFS:OPC	122	1547	112	41	6
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	20	3:1 BFS:OPC	143	453333	128	5971	897
7	INCIN ASH	35	2300	35	90	30	9:1 BFS:OPC	122	139136	110	2434	365
8	SOILS	90	680	90	90	20	9:1 BFS:OPC	122	181333	114	2692	404
	TOTAL		+ 34058						9077960		156554	23507

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-23 GROUT ONLY PROCESS (KRUGER) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	115	469	115	130	25	9:1 BFS:OPC	122	119914	124	1745	262
1B	183H CRYSTAL	108	752	108	140	25	9:1 BFS:OPC	122	180583	126	2584	388
1C	183H SLUDGE	100	778	100	100	25	9:1 BFS:OPC	122	172936	115	2697	405
1D1	183H GRIT	100	32	100	105	40	9:1 BFS:OPC	122	3561	114	70	11
1D2	183H MISC	44	37	59	100	40	9:1 BFS:OPC	122	1824	112	37	6
2A	C018 SALT	62	5240	62	111	10	ENVIROSTONE	80	2165891	82	39476	5927
2B	ION EX RESIN	54	329	54	77	20	9:1 BFS:OPC	122	52638	109	815	122
2C	L045 SLUDGE	140	3205	140	140	30	3:1 PFA:OPC	116	775550	122	12270	1842
5A1	MERCURY #	30	9	30	408	21	9:1 BFS:OPC	122	799	142	10	1
5A2	MERC SOLN	66	25	66	66	51	9:1 BFS:OPC	122	1195	85	39	6
5A3	MERC CONTAM	36	42	48	70	51	9:1 BFS:OPC	122	1065	88	33	5
5C1	ELEM LEAD #	83	607	83	710	18	9:1 BFS:OPC	122	175864	142	2022	304
5C2	LEAD SOLN	26	12	26	26	55	9:1 BFS:OPC	122	182	40	14	2
5C3	LEAD CONTAM	35	97	47	70	55	9:1 BFS:OPC	122	2054	87	71	11
7	INCIN ASH	175	1666	175	175	30	9:1 BFS:OPC	122	503853	134	7241	1087
9A	SLUDGE	68	3394	68	68	20	9:1 BFS:OPC	122	683828	105	10961	1646
9B	SOLIDS	31	10401	41	62	51	3:1 BFS:OPC	143	229470	86	7367	1106
9C	LIQUIDS	37	358	37	37	20	9:1 BFS:OPC	122	39209	84	792	119
	BOXED WASTE	100	1547	133	62	51	3:1 BFS:OPC	143	110088	86	3534	531
	TOTAL		+ 29000						4157910		69122	13780

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-24 POLYETHYLENE ONLY PROCESS (CDR) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	40	POLYETHYLENE	57	123750	74	2806	421
1B	183H CRYSTAL	60	1300	60	140	40	POLYETHYLENE	57	117000	75	2610	392
1C	183H SLUDGE	69	1400	69	100	40	POLYETHYLENE	57	144900	69	3508	527
1D	183H MISC	60	385	75	105	60	POLYETHYLENE	57	15400	79	490	74
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	2862
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	436
2C	L045 SLUDGE	75	3050	75	140	40	POLYETHYLENE	57	343125	75	7654	1149
2D	R O FILTER	30	350	40	50	60	POLYETHYLENE	57	7000	53	333	50
3	D A W	30	2100	45	58	70	POLYETHYLENE	57	27000	58	1560	234
4	CONST DEBRIS	40	1155	60	100	70	POLYETHYLENE	57	19800	82	809	122
5A1	MERCURY	30	313	408	408	60	POLYETHYLENE	57	6260	116	133	20
5A2	MERCURY CONT	22	4256	40	58	60	POLYETHYLENE	57	62421	58	2709	407
5B	REACT METALS	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	70
5C1	ELEM LEAD #	83	846	83	710	65	POLYETHYLENE	57	37478	142	756	114
5C2	LEAD CONT	58	44	80	105	70	POLYETHYLENE	57	1094	84	43	7
5D	MISC METALS #	200	607	200	450	69	POLYETHYLENE	57	55310	142	1240	186
6	ABSORB CHEM	90	1700	90	90	40	POLYETHYLENE	57	229500	67	5726	860
7	INCIN ASH	35	2300	35	90	50	POLYETHYLENE	57	80500	70	2307	346
8	SOILS	90	680	90	90	40	POLYETHYLENE	57	91800	67	2291	344
	TOTAL		+ 34058						2074059		57405	8619

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-25 POLYETHYLENE ONLY PROCESS (KRUGER) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	115	469	115	130	40	POLYETHYLENE	57	80942	74	1835	276
1B	183H CRYSTAL	108	752	108	140	40	POLYETHYLENE	57	121894	75	2719	408
1C	183H SLUDGE	100	778	100	100	40	POLYETHYLENE	57	116732	69	2826	424
1D1	183H GRIT	100	32	100	105	60	POLYETHYLENE	57	2137	79	68	10
1D2	183H MISC	44	37	59	100	60	POLYETHYLENE	57	1094	77	36	5
2A	C018 SALT	62	5240	62	111	60	POLYETHYLENE	57	216589	80	6727	1010
2B	ION EX RESIN	54	329	54	77	60	POLYETHYLENE	57	11844	68	439	66
2C	L045 SLUDGE	140	3205	140	140	40	POLYETHYLENE	57	673067	75	15013	2254
5A1	MERCURY #	30	9	30	408	60	POLYETHYLENE	57	187	118	4	1
5A2	MERC SOLN	66	25	66	66	60	POLYETHYLENE	57	1119	62	45	7
5A3	MERC CONTAM	36	42	48	70	60	POLYETHYLENE	57	997	64	39	6
5C1	ELEM LEAD #	83	607	83	710	65	POLYETHYLENE	57	27118	142	547	82
5C2	LEAD SOLN	26	12	26	26	70	POLYETHYLENE	57	128	31	14	2
5C3	LEAD CONTAM	35	97	47	70	70	POLYETHYLENE	57	1452	66	74	11
7	INCIN ASH	175	1666	175	175	60	POLYETHYLENE	57	194343	96	5075	762
9A	SLUDGE	68	3394	68	68	40	POLYETHYLENE	57	346188	61	9467	1422
9B	SOLIDS	31	10401	41	62	65	POLYETHYLENE	57	173615	60	8246	1238
9C	LIQUIDS	37	358	37	37	40	POLYETHYLENE	57	19850	47	706	106
	BOXED WASTE	100	1547	133	62	60	POLYETHYLENE	57	103123	60	4304	646
	TOTAL		+ 29000						2092419		58184	8736

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7–26 VES ONLY PROCESS (CDR) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	VES POLYMER	64	247500	74	4477	672
1B	183H CRYSTAL	60	1300	60	140	25	VES POLYMER	64	234000	74	4190	629
1C	183H SLUDGE	69	1400	69	100	25	VES POLYMER	64	289800	71	5465	821
1D	183H MISC	60	385	75	105	60	VES POLYMER	64	15400	84	459	69
2A	C018 SALT	88	10460	88	111	25	VES POLYMER	64	2761440	72	51159	7682
2B	ION EX RESIN	55	2140	55	77	60	VES POLYMER	64	78467	71	2747	412
2C	L045 SLUDGE	75	3050	75	140	40	VES POLYMER	64	343125	82	6960	1045
2D	R O FILTER	30	350	40	50	60	VES POLYMER	64	7000	55	319	48
3	D A W	30	2100	45	58	70	VES POLYMER	64	27000	60	1505	226
4	CONST DEBRIS	40	1155	60	100	70	VES POLYMER	64	19800	86	769	116
5A1	MERCURY	30	313	30	408	40	VES POLYMER	64	14085	97	242	36
5A2	MERCURY CONT	22	4256	40	58	40	VES POLYMER	64	140448	62	3795	570
5B	REACT METALS	200	147	200	240	60	VES POLYMER	64	19600	115	427	64
5C1	ELEM LEAD #	83	846	83	710	60	VES POLYMER	64	47597	141	838	126
5C2	LEAD CONT	58	44	80	105	70	VES POLYMER	64	1094	88	41	6
5D	MISC METALS #	200	607	200	450	64	VES POLYMER	64	69781	141	1353	203
6	ABSORB CHEM	90	1700	90	90	40	VES POLYMER	64	229500	73	5263	790
7	INCIN ASH	35	2300	35	90	47	VES POLYMER	64	90777	74	2304	346
8	SOILS	90	680	90	90	40	VES POLYMER	64	91800	73	2105	316
	TOTAL		+ 34058						4728214		94415	14176

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7–27 VES ONLY PROCESS (KRUGER) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	115	469	115	130	25	VES POLYMER	64	161884	74	2928	440
1B	183H CRYSTAL	108	752	108	140	25	VES POLYMER	64	243787	74	4365	655
1C	183H SLUDGE	100	778	100	100	25	VES POLYMER	64	233463	71	4402	661
1D1	183H GRIT	100	32	100	105	60	VES POLYMER	64	2137	84	64	10
1D2	183H MISC	44	37	59	100	60	VES POLYMER	64	1094	82	33	5
2A	C018 SALT	62	5240	62	111	25	VES POLYMER	64	974651	72	18057	2711
2B	ION EX RESIN	54	329	54	77	60	VES POLYMER	64	11844	71	415	62
2C	L045 SLUDGE	140	3205	140	140	40	VES POLYMER	64	673067	82	13653	2050
5A1	MERCURY #	30	9	30	408	40	VES POLYMER	64	420	97	7	1
5A2	MERC SOLN	66	25	66	66	40	VES POLYMER	64	2519	65	65	10
5A3	MERC CONTAM	36	42	48	70	40	VES POLYMER	64	2244	67	56	8
5C1	ELEM LEAD #	83	607	83	710	60	VES POLYMER	64	33574	142	592	89
5C2	LEAD SOLN	26	12	26	26	70	VES POLYMER	64	128	32	14	2
5C3	LEAD CONTAM	35	97	47	70	70	VES POLYMER	64	1452	68	71	11
7	INCIN ASH	175	1666	175	175	60	VES POLYMER	64	194343	104	4683	703
9A	SLUDGE	68	3394	68	68	40	VES POLYMER	64	346188	66	8768	1317
9B	SOLIDS	31	10401	45	62	65	VES POLYMER	64	173615	63	7896	1186
9C	LIQUIDS	37	358	37	37	40	VES POLYMER	64	19850	50	666	100
	BOXED WASTE	100	1547	133	62	60	VES POLYMER	64	103123	63	4096	615
	TOTAL		+ 29000						3179384		70829	10635

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-28 POLYETHYLENE AND GROUT PROCESS (CDR) – WASTE LOADINGS CASE 1

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	40	POLYETHYLENE	57	123750	74	2806	421
1B	183H CRYSTAL	60	1300	60	140	40	POLYETHYLENE	57	117000	75	2610	392
1C	183H SLUDGE	69	1400	69	100	40	POLYETHYLENE	57	144900	69	3508	527
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	2862
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	436
2C	L045 SLUDGE	75	3050	75	140	30	3:1 PFA:OPC	116	395370	122	6255	939
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	20
5A2	MERCURY CONT	22	4256	40	58	60	POLYETHYLENE	57	62421	58	2709	407
5B	REACT METAL #	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	70
5C1	ELEM LEAD #	83	846	83	710	65	POLYETHYLENE	57	37478	142	756	114
5C2	LEAD CONT	58	44	80	105	70	POLYETHYLENE	57	1094	84	43	7
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	40	POLYETHYLENE	57	229500	67	5726	860
7	INCIN ASH	35	2300	35	90	30	9:1 BFS:OPC	122	139136	110	2434	365
8	SOILS	90	650	90	90	20	9:1 BFS:OPC	122	181333	114	2692	404
	TOTAL		+ 34058						2609898		59332	8909

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-29 POLYETHYLENE AND GROUT PROCESS (KRUGER) – WASTE LOADINGS CASE 1

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	115	469	115	130	40	POLYETHYLENE	57	80942	75	1835	276
1B	183H CRYSTAL	108	752	108	140	40	POLYETHYLENE	57	121894	75	2719	408
1C	183H SLUDGE	100	778	100	100	40	POLYETHYLENE	57	116732	69	2826	424
1D1	183H GRIT	100	32	100	105	40	9:1 BFS:OPC	122	3561	114	70	11
1D2	183H MISC	44	37	59	100	40	9:1 BFS:OPC	122	1824	112	37	5
2A	C018 SALT	62	5240	62	111	60	POLYETHYLENE	57	216589	80	6727	1010
2B	ION EX RESIN	54	329	54	77	60	POLYETHYLENE	57	11844	68	439	66
2C	L045 SLUDGE	140	3205	140	140	25	3:1 PFA:OPC	116	997136	121	14810	2224
5A1	MERCURY #	30	9	30	408	60	POLYETHYLENE	57	187	118	4	1
5A2	MERC SOLN	66	25	66	66	60	POLYETHYLENE	57	1119	62	45	7
5A3	MERC CONTAM	36	42	48	70	60	POLYETHYLENE	57	997	64	39	6
5C1	ELEM LEAD #	83	607	83	710	65	POLYETHYLENE	57	27118	142	547	82
5C2	LEAD SOLN	26	12	26	26	70	POLYETHYLENE	57	128	31	14	2
5C3	LEAD CONTAM	35	97	47	70	70	POLYETHYLENE	57	1452	66	74	11
7	INCIN ASH	175	1666	175	175	30	9:1 BFS:OPC	122	503853	134	7241	1087
9A	SLUDGE	68	3394	68	68	40	POLYETHYLENE	57	346188	61	9467	1422
9B	SOLIDS	31	10401	41	62	51	3:1 BFS:OPC	143	229470	86	7367	1106
9C	LIQUIDS	37	358	37	37	40	POLYETHYLENE	57	19850	47	706	106
	BOXED WASTE	100	1547	133	62	51	3:1 BFS:OPC	143	110088	86	3534	531
	TOTAL		+ 29000						2790971		58500	8784

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-30 POLYETHYLENE AND GROUT PROCESS (CDR) – WASTE LOADINGS CASE 2

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	9:1 BFS:OPC	122	183333	124	2663	400
1B	183H CRYSTAL	60	1300	60	140	40	POLYETHYLENE	57	117000	75	2610	392
1C	183H SLUDGE	69	1400	69	100	40	POLYETHYLENE	57	144900	69	3508	527
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	60	POLYETHYLENE	57	613653	80	19058	2862
2B	ION EX RESIN	55	2140	55	77	60	POLYETHYLENE	57	78467	68	2905	436
2C	L045 SLUDGE	75	3050	75	140	40	POLYETHYLENE	57	343125	75	7654	1149
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	60	POLYETHYLENE	57	6260	118	133	20
5A2	MERCURY CONT	22	4256	40	58	51	9:1 BFS:OPC	122	66637	78	2352	353
5B	REACT METAL #	200	147	200	240	60	POLYETHYLENE	57	19600	105	466	70
5C1	ELEM LEAD #	83	846	83	710	65	POLYETHYLENE	57	37313	143	754	113
5C2	LEAD CONT	58	44	80	105	55	9:1 BFS:OPC	122	1547	112	41	6
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	40	POLYETHYLENE	57	229500	67	5726	860
7	INCIN ASH	35	2300	35	90	50	POLYETHYLENE	57	80115	70	2300	345
8	SOILS	90	680	90	90	40	POLYETHYLENE	57	91800	67	2291	344
	TOTAL		34058 +						2473185		59691	8963

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7-31 POLYETHYLENE AND GROUT PROCESS (KRUGER) – WASTE LOADINGS CASE 2

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	115	469	115	130	25	9:1 BFS:OPC	122	119914	124	1742	262
1B	183H CRYSTAL	108	752	108	140	40	POLYETHYLENE	57	121894	75	2719	408
1C	183H SLUDGE	100	778	100	100	40	POLYETHYLENE	57	116732	69	2826	424
1D1	183H GRIT	100	32	100	105	60	POLYETHYLENE	57	2137	79	68	10
1D2	183H MISC	44	37	59	100	40	9:1 BFS:OPC	122	1824	112	37	5
2A	C018 SALT	62	5240	62	111	60	POLYETHYLENE	57	216589	80	6727	1010
2B	ION EX RESIN	54	329	54	77	60	POLYETHYLENE	57	11844	68	439	66
2C	L045 SLUDGE	140	3205	140	140	40	POLYETHYLENE	57	673067	75	15013	2254
5A1	MERCURY #	30	9	30	408	60	POLYETHYLENE	57	187	118	4	1
5A2	MERC SOLN	66	25	66	66	60	POLYETHYLENE	57	1119	62	45	7
5A3	MERC CONTAM	36	42	48	70	51	9:1 BFS:OPC	122	1065	88	33	5
5C1	ELEM LEAD #	83	607	83	710	65	POLYETHYLENE	57	27118	142	547	82
5C2	LEAD SOLN	26	12	26	26	70	POLYETHYLENE	57	128	31	14	2
5C3	LEAD CONTAM	35	97	47	70	55	9:1 BFS:OPC	122	2054	87	71	11
7	INCIN ASH	175	1666	175	175	60	POLYETHYLENE	57	194343	96	5075	762
9A	SLUDGE	68	3394	68	68	40	POLYETHYLENE	57	346188	61	9467	1422
9B	SOLIDS	31	10401	45	62	51	3:1 BFS:OPC	143	229470	86	7367	1106
9C	LIQUIDS	37	358	37	37	40	POLYETHYLENE	57	19850	47	706	106
	BOXED WASTE	100	1547	133	62	51	3:1 BFS:OPC	143	110088	86	3534	531
	TOTAL		+ 29000						2195609		56434	8474

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7–32 VES AND GROUT PROCESS (CDR) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	100	825	100	130	25	VES POLYMER	65	247500	74	4442	667
1B	183H CRYSTAL	60	1300	60	140	25	VES POLYMER	65	234000	75	4157	624
1C	183H SLUDGE	69	1400	69	100	25	VES POLYMER	65	289800	71	5424	814
1D	183H MISC	60	385	75	105	40	9:1 BFS:OPC	122	25667	114	505	76
2A	C018 SALT	88	10460	88	111	25	VES POLYMER	65	2761440	73	50776	7624
2B	ION EX RESIN	55	2140	55	77	60	VES POLYMER	65	78467	72	2736	411
2C	L045 SLUDGE	75	3050	75	140	30	3:1 PFA:OPC	116	395370	122	6255	939
2D	R O FILTER	30	350	40	50	58	3:1 BFS:OPC	143	5632	69	263	39
3	D A W	30	2100	45	58	58	3:1 BFS:OPC	143	33793	77	1405	211
4	CONST DEBRIS	40	1155	60	100	51	3:1 BFS:OPC	143	32880	117	772	116
5A1	MERCURY #	30	313	30	408	40	VES POLYMER	65	14085	98	240	36
5A2	MERCURY CONT	22	4256	40	58	40	VES POLYMER	65	140448	62	3775	567
5B	REACT METAL #	200	147	200	240	60	VES POLYMER	65	19600	116	424	64
5C1	ELEM LEAD #	83	846	83	710	60	VES POLYMER	65	47597	142	831	125
5C2	LEAD CONT	58	44	80	105	70	VES POLYMER	65	1094	89	41	6
5D	MISC METALS #	200	607	200	450	20	9:1 BFS:OPC	122	361963	142	4285	643
6	ABSORB CHEM	90	1700	90	90	40	VES POLYMER	65	229500	73	5231	785
7	INCIN ASH	35	2300	35	90	30	9:1 BFS:OPC	122	139136	110	2434	365
8	SOILS	90	680	90	90	20	9:1 BFS:OPC	122	181333	114	2692	404
	TOTAL		+ 34058						5239306		96688	14518

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

TABLE 7–33 VES AND GROUT PROCESS (KRUGER) – WASTE LOADINGS

		INCOMING WASTE		PRETREATMENT		FINAL TREATMENT				PRODUCT		
STREAM NO.	STREAM DESCRIPTION	WASTE BULK DENSITY (LB/CF)	WASTE VOLUME (CF/YR)	TREATED BULK DENSITY (LB/CF)	TREATED PARTICLE DENSITY (LB/CF)	WASTE LOADING (WT%)	BINDER FORMULATION	BINDER FORMULATION DENSITY (LB/CF)	DRY MIX REQUIREMENT (LB/YR)	PRODUCT DENSITY (LB/CF)	PRODUCT VOLUME (CF/YR)	DRUMS SHIPPED (DRUMS/YR)
1A	183H SLD LIQ	115	469	115	130	25	VES POLYMER	65	161884	74	2906	436
1B	183H CRYSTAL	108	752	108	140	25	VES POLYMER	65	243787	75	4331	650
1C	183H SLUDGE	100	778	100	100	25	VES POLYMER	65	233463	71	4370	656
1D1	183H GRIT	100	32	100	105	40	9:1 BFS:OPC	122	3561	114	70	11
1D2	183H MISC	44	37	59	100	40	9:1 BFS:OPC	122	1824	112	37	6
2A	C018 SALT	62	5240	62	111	25	VES POLYMER	65	974651	73	17922	2691
2B	ION EX RESIN	54	329	54	77	60	VES POLYMER	65	11844	72	413	62
2C	L045 SLUDGE	140	3205	140	140	25	3:1 PFA:OPC	116	997136	121	14810	2224
5A1	MERCURY #	30	9	30	408	40	VES POLYMER	65	420	98	7	1
5A2	MERC SOLN	66	25	66	66	40	VES POLYMER	65	2519	65	64	10
5A3	MERC CONTAM	36	42	48	70	40	VES POLYMER	65	2244	67	56	8
5C1	ELEM LEAD #	83	607	83	710	60	VES POLYMER	65	33574	143	587	88
5C2	LEAD SOLN	26	12	26	26	70	VES POLYMER	65	128	32	14	2
5C3	LEAD CONTAM	35	97	47	70	70	VES POLYMER	65	1452	68	71	11
7	INCIN ASH	175	1666	175	175	30	9:1 BFS:OPC	122	503853	134	7255	1089
9A	SLUDGE	68	3394	68	68	25	9:1 BFS:OPC	122	512871	102	9083	1364
9B	SOLIDS	31	10401	45	62	51	3:1 BFS:OPC	143	229470	86	7367	1106
9C	LIQUIDS	37	358	37	37	40	VES POLYMER	65	19950	50	663	100
	BOXED WASTE	100	1547	133	62	51	3:1 BFS:OPC	143	110088	86	3534	531
	TOTAL		+ 29000						4044619		73559	11045

NOTES: + THIS TOTAL ASSUMES THAT ALL WASTE STREAMS ARE PROCESSED SIMULTANEOUSLY AND NOT AS CAMPAIGNS
THE AMOUNT OF WASTE PER DRUM IS LIMITED BY WEIGHT FOR THESE WASTE STREAMS

7.2 Total Estimated Cost (TEC) for Recommended Option

7.2.1 Introduction

A. A Rough Order of Magnitude (ROM) TEC was developed for 2 options presented in this study. These options include:

- Grout + PE - Case 2 (recommended option)
- Grout + VES

B. The purpose of the ROM cost estimates are twofold. One is to determine the differential capital cost advantage of one option over the others. The second is to determine if the Grout and PE option is bound by the CDR cost baseline of $81 million TEC.

C. In order to perform a differential cost comparison on an equal basis, the Grout/PE and Grout/VES option installed cost estimates are based upon the drum throughputs and waste fractions presented in Sections 6.2.4 and 6.2.5 of this study. This results in an increase of drum throughputs for the Grout/VES option over the CDR baseline. The capital cost impact of this throughput increase is primarily in the plant equipment (D account) and the Instrument & Controls (G account). This is primarily due to the additional waste/binder mixing equipment required to achieve the additional 78 percent throughput requirements over the CDR baseline.

7.2.2 TEC Basis

A. These estimates were developed based upon factoring the 7/31/92 WRAP Module 2A baseline CDR estimate. The factoring method was essentially the same as that used to estimate the major plant and capital equipment initial expenses shown previously for the option comparisons. The factoring basis for most "D" account process equipment handling waste or treated waste was drum throughput as compared to the CDR baseline. The associated building space requirement for these process areas was also factored based upon drum throughput.

B. Building costs (accounts A, B, C, H, & J) were developed based upon factors tied to building floor space or volume. Some process support systems (decontamination, off-gas treatment) were factored based upon process enclosure size. Process utility systems were not factored but were evaluated and adjusted if a particular utility (e.g. N_2 gas) was not required for the process. Piping, electrical, and instruments/controls costs were factored from rationing the total "D" account costs (without sales tax). The only exception was the piping estimate for the PE + Grout case which was factored after excluding piping associated with the VES polymer storage and solidification process.

C. Explanation of the cost estimate basis and factoring method is given in **Appendix A.**

7.2.3 TEC Results

A. The ROM TEC estimate for the Grout and PE preferred option indicates on **Table 7-35** that it is less than the $81 million CDR cost baseline by about $1.1 million (refer to **Table 7-34**). If the Grout/PE case was evaluated on the same throughput/waste loading basis as the CDR grout-VES configuration, the ROM TEC for Grout/PE would be considerably less than the $79,946,000.

B. Using the study throughput and waste loading basis, as specified in Section 6.2.4, results in a ROM differential TEC cost between the two options as follows:

•	Grout + PE	$79,946,000
•	Grout + VES	$94,197,000
		$14,251,000

C. A further breakdown of the plant equipment installed costs is itemized in **Table 7-39**. This table shows a cost comparison for each process system as derived through factoring previously described. However, there are not direct comparisons to every individual CDR process system, particularly the polymer storage, mixing and cure/storage systems. This is because the CDR VES polymer cost estimate was updated in the latter phases with overall cost adders for below ground solvent storage facilities and additional segregated cure/storage facilities. **Tables 7-37 and 7-38** show the differences between each estimating account.

7.3 Conclusion

A. The sensitivity analyses shows that the evaluation process is not significantly affected by changes in waste loading, waste throughput or paddle cost and that the polyethylene/grout process is the best process for the WRAP 2A feedstreams.

B. The ROM cost analysis shows a clean cost differential advantage of the Grout/PE option over the Grout/VE option, when compared using the study throughput/waste loading basis. It also demonstrates the Grout/PE option cost is bound by the CDR cost baseline, even when using the study throughputs and waste loadings.

TABLE 7

Client: USDOE RICHLAND OPERATION OFFICE
Project: WRAP MODULE 2A CDR ESTIMATE
Location: HANFORD, WA
Job No.: 6237.008

Raytheon Engineers & Constructors, Inc.
Western Operations
GROUT + PE II CASE
Rev No.: 1

Date: 16-Jul-93
Priced By: RDS

ACCT	DESCRIPTION	MANHOURS	LABOR	MATERIAL	SUBS	TOTAL
A	EARTHWORK	5,936	154,979	27,417	65,012	$247,407
B	CONCRETE	21,890	583,731	384,079		$967,810
C	STRUCTURES	6,386	195,279	583,101		$778,379
D	PLANT EQUIPMENT	44,233	1,285,801	13,708,926	769,320	$15,762,048
E	PIPING	25,484	800,811	559,904	196,713	$1,557,428
F	ELECTRICAL	53,349	1,636,271	2,318,735		$3,955,005
G	INSTRUMENTS & CONTROLS	18,291	561,157	1,874,793	2,213,405	$4,649,355
H	PAINTING				412,080	$412,080
J	INSULATION				214,282	$214,282
K	BUILDINGS & ARCHITECTURAL	17,404	453,615	694,827	1,018,725	$2,167,167
L	DEMOLITION					
	ROUNDING	28	$357	$218	$463	$1,038
	DIRECT FIELD COST	193,000	$5,672,000	$20,150,000	$4,890,000	$30,712,000
	FIXED PRICE CONTRACTOR (PER KEH 44% ON DIRECT LABOR, 19 97% ON CONTRACTOR FURNISHED MAT'L – Not Including Major Equipment– and 12 31% on Subs)		2,496,000	1,287,000	602,000	$4,385,000
	KEH 3% G&A RATE		$245,000	$643,000	$165,000	$1,053,000
	INDIRECT FIELD COST		$2,741,000	$1,930,000	$767,000	$5,438,000
	TOTAL FIELD COST	193,000	$8,413,000	$22,080,000	$5,657,000	$36,150,000
	WBS 110000 DEFINITIVE DESIGN (INCLUDES TITLES I & II)					$7,804,000
	WBS 110000 PSAR CHAPTERS 4–7 A/E SUPPORT TO OPER. CONTR.				PER WHC	$476,000
	WBS 120000 TITLE III ENGINEERING				6.6% PER MOD 1	$2,386,000
	WBS 210000 CONSTRUCTION MANAGEMENT & ADMINISTRATION				8.1% PER MOD 1	$2,928,000
	WBS 330000 OPERATING CONTRACTOR SUPPORT				PER WHC	$140,000
	WBS 400000 OPERATING CONTRACTOR MANAGEMENT (TITLE I & OVERALL)				PER WHC	$1,852,000
	TOTAL FIELD AND HOME OFFICE					$51,736,000
V	CRAFT PREMIUM PAY	2.00%	OF DIRECT LABOR			$113,000
	TOTAL WITHOUT ESCALATION OR CONTINGENCY					$51,849,000
W	ESCALATION PER CONSTRUCTION SCHEDULE	23.49%	OVERALL			$12,181,000
	SUBTOTAL					$64,030,000
W	CONTINGENCY	24.86%	OVERALL			$15,916,000
	TOTAL ESTIMATED COST (TEC)					$79,946,000

TABLE 7-35

Client: USDOE RICHLAND OPERATION OFFICE
Project: WRAP MODULE 2A CDR ESTIMATE
Location: HANFORD, WA
Job No.: 6237.008

Raytheon Engineers & Constructors, Inc.
Western Operations
GROUT + VES CASE
Rev No.: 1

Date: 16-Jul-93
Priced By: RDS

ACCT	DESCRIPTION	MANHOURS	LABOR	MATERIAL	SUBS	TOTAL
A	EARTHWORK	6,379	166,799	35,408	68,912	$271,119
B	CONCRETE	23,543	628,618	431,947		$1,060,566
C	STRUCTURES	7,042	214,932	638,048		$852,980
D	PLANT EQUIPMENT	54,991	1,598,550	16,839,100	941,620	$19,379,270
E	PIPING	39,825	1,251,452	875,410	307,352	$2,434,214
F	ELECTRICAL	65,406	2,005,888	2,845,976		$4,851,865
G	INSTRUMENTS & CONTROLS	22,387	686,836	2,294,678	2,709,127	$5,690,642
H	PAINTING				436,800	$436,800
J	INSULATION				227,136	$227,136
K	BUILDINGS & ARCHITECTURAL	18,698	489,695	772,458	1,048,688	$2,310,841
L	DEMOLITION					
	ROUNDING	30	$228	($26)	$366	$568
	DIRECT FIELD COST	238,300	$7,043,000	$24,733,000	$5,740,000	$37,516,000
	FIXED PRICE CONTRACTOR (PER KEH 44% ON DIRECT LABOR, 19.97% ON CONTRACTOR FURNISHED MAT'L - Not Including Major Equipment- and 12.31% on Subs)		3,099,000	1,576,000	707,000	$5,382,000
	KEH 3% G&A RATE		$304,000	$789,000	$193,000	$1,286,000
	INDIRECT FIELD COST		$3,403,000	$2,365,000	$900,000	$6,668,000
	TOTAL FIELD COST	238,300	$10,446,000	$27,098,000	$6,640,000	$44,184,000
	WBS 110000 DEFINITIVE DESIGN (INCLUDES TITLES I & II)					$7,804,000
	WBS 110000 PSAR CHAPTERS 4-7 A/E SUPPORT TO OPER. CONTR.				PER WHC	$476,000
	WBS 120000 TITLE III ENGINEERING				6.6% PER MOD 1	$2,916,000
	WBS 210000 CONSTRUCTION MANAGEMENT & ADMINISTRATION				8.1% PER MOD 1	$3,579,000
	WBS 330000 OPERATING CONTRACTOR SUPPORT				PER WHC	$140,000
	WBS 400000 OPERATING CONTRACTOR MANAGEMENT (TITLE I & OVERALL)				PER WHC	$1,852,000
	TOTAL FIELD AND HOME OFFICE					$60,951,000
V	CRAFT PREMIUM PAY	2.00%	OF DIRECT LABOR			$141,000
	TOTAL WITHOUT ESCALATION OR CONTINGENCY					$61,092,000
W	ESCALATION PER CONSTRUCTION SCHEDULE	23.49%	OVERALL			$14,352,000
	SUBTOTAL					$75,444,000
W	CONTINGENCY	24.86%	OVERALL			$18,753,000
	TOTAL ESTIMATED COST (TEC)					$94,197,000

BLE 7-36

Client: USDOE RICHLAND OPERATION OFFICE
Project: WRAP MODULE 2A CDR ESTIMATE
Location: HANFORD, WA
Job No.: 6237.008

Raytheon Engineers & Constructors, Inc.
Western Operations
BASE CASE
Rev No.: 0

Date: 15-Jul-93
Priced By: RDS

ACCT	DESCRIPTION	MANHOURS	LABOR	MATERIAL	SUBS	TOTAL
A	EARTHWORK	5,604	145,848	15,073	63,106	$224,027
B	CONCRETE	20,631	548,672	327,678		$876,350
C	STRUCTURES	5,702	175,120	529,701		$704,821
D	PLANT EQUIPMENT	43,190	1,255,492	13,945,783	792,467	$15,993,742
E	PIPING	33,170	1,043,137	711,378	258,687	$2,013,182
F	ELECTRICAL	54,652	1,676,723	2,366,418		$4,043,141
G	INSTRUMENTS & CONTROLS	18,841	578,041	1,931,200	2,280,000	$4,789,241
H	PAINTING				400,000	$400,000
J	INSULATION				208,000	$208,000
K	BUILDINGS & ARCHITECTURAL	15,704	405,226	581,860	998,750	$1,985,836
L	DEMOLITION					
	ROUNDING	(494)	($259)	($91)	$10	($340)
	DIRECT FIELD COST	197,000	$5,828,000	$20,409,000	$5,001,000	$31,238,000
	FIXED PRICE CONTRACTOR (PER KEH 44% ON DIRECT LABOR, 19.97% ON CONTRACTOR FURNISHED MAT'L - Not Including Major Equipment- and 12.31% on Subs)		2,564,000	1,291,000	616,000	$4,471,000
	KEH 3% G&A RATE		$252,000	$651,000	$169,000	$1,072,000
	INDIRECT FIELD COST		$2,816,000	$1,942,000	$785,000	$5,543,000
	TOTAL FIELD COST	197,000	$8,644,000	$22,351,000	$5,786,000	$36,781,000
	WBS 110000 DEFINITIVE DESIGN (INCLUDES TITLES I & II)					$7,804,000
	WBS 110000 PSAR CHAPTERS 4-7 A/E SUPPORT TO OPER. CONTR.				PER WHC	$476,000
	WBS 120000 TITLE III ENGINEERING				6.6% PER MOD 1	$2,428,000
	WBS 210000 CONSTRUCTION MANAGEMENT & ADMINISTRATION				8.1% PER MOD 1	$2,979,000
	WBS 330000 OPERATING CONTRACTOR SUPPORT				PER WHC	$140,000
	WBS 400000 OPERATING CONTRACTOR MANAGEMENT (TITLE I & OVERALL)				PER WHC	$1,852,000
	TOTAL FIELD AND HOME OFFICE					$52,460,000
V	CRAFT PREMIUM PAY	2.00%	OF DIRECT LABOR			$117,000
	TOTAL WITHOUT ESCALATION OR CONTINGENCY					$52,577,000
W	ESCALATION PER CONSTRUCTION SCHEDULE	23.49%	OVERALL			$12,352,000
	SUBTOTAL					$64,929,000
W	CONTINGENCY	24.86%	OVERALL			$16,139,000
	TOTAL ESTIMATED COST (TEC)					$81,068,000

TABLE 7-37

GRAND TOTAL MODULE 2A CDR ESTIMATE INCLUDING GROUT + PE II OPTION

Client: USDOE RICHLAND OPERATION OFFICE
Project: WRAP MODULE 2A CDR ESTIMATE
Location: HANFORD, WA
Job No.: 6237.008

United Engineers & Constructors
Western Operations

REVISION 1

ACCT	DESCRIPTION	2A CDR TOTAL	GROUT+PE2 CHANGES	CONTINGENCY ADJUSTMENT	REVISED TOTAL
A	EARTHWORK	$224,027	$23,380		247,407
B	CONCRETE	$876,350	$91,460		967,810
C	STRUCTURES	$704,821	$73,558		778,379
D	PLANT EQUIPMENT	$15,993,742	($231,694)		15,762,048
E	PIPING	$2,013,182	($455,754)		1,557,428
F	ELECTRICAL	$4,043,141	($88,136)		3,955,005
G	INSTRUMENTS & CONTROLS	$4,789,241	($139,886)		4,649,355
H	PAINTING	$400,000	$12,080		412,080
J	INSULATION	$208,000	$6,282		214,282
K	BUILDINGS & ARCHITECTURAL	$1,985,836	$181,331		2,167,167
L	DEMOLITION				
	ROUNDING (ALL CONSTRUCTION PACKAGES	($340)	$1,378		1,038
	DIRECT FIELD COST	$31,238,000	($526,000)		$30,712,000
	FIXED PRICE CONTRACTOR MARKUP	$4,471,000	($86,000)		4,385,000
	CONSTRUCTION MGMT G&A	$1,072,000	($19,000)		1,053,000
	INDIRECT FIELD COST	$5,543,000	($105,000)		$5,438,000
	TOTAL FIELD COST	$36,781,000	($631,000)		$36,150,000
OTHER TEC ELEMENTS					
	SCHEDULE RESERVE	$7,804,000			7,804,000
110000	DEFINITIVE DESIGN – UE&C	$476,000			476,000
110000	PSAR CH 4-7 A/E SPT. TO OPER. CONTR.	$2,428,000	($42,000)		2,386,000
120000	TITLE III	$2,979,000	($51,000)		2,928,000
210000	CONSTRUCTION MGMT & ADMIN (KEH)	$140,000			140,000
330000	OPERATING CONTRACTOR SUPPORT (WHC)	$1,852,000			1,852,000
340000	OVERALL PROJECT MANAGEMENT (WHC)				
	TOTAL FIELD AND HOME OFFICE	$52,460,000	($724,000)		$51,736,000
V	CRAFT PREMIUM PAY	$117,000	($4,000)		113,000
W	ESCALATION	$12,352,000	($171,000)		12,181,000
	SUBTOTAL	$64,929,000	($899,000)		$64,030,000
W	CONTINGENCY	$16,139,000	($223,000)	$1,122,000	15,916,000
	TOTAL ESTIMATED COST (TEC)	$81,068,000	($1,122,000)	$1,122,000	$79,946,000

NOTE. OPTION COSTS ARE A ROM ESTIMATE DERIVED BY FACTORING THE 2A CDR ESTIMATE

TABLE 7-38 GRAND TOTAL MODULE 2A CDR ESTIMATE INCLUDING GROUT + VES OPTION

Client: USDOE RICHLAND OPERATION OFFICE
Project: WRAP MODULE 2A CDR ESTIMATE
Location: HANFORD, WA
Job No.: 6237.008

United Engineers & Constructors
Western Operations

REVISION 1

ACCT	DESCRIPTION	2A CDR TOTAL	GROUT+VES CHANGES	CONTINGENCY ADJUSTMENT	REVISED TOTAL
A	EARTHWORK	$224,027	$47,092		271,119
B	CONCRETE	$876,350	$184,216		1,060,566
C	STRUCTURES	$704,821	$148,159		852,980
D	PLANT EQUIPMENT	$15,993,742	$3,385,528		19,379,270
E	PIPING	$2,013,182	$421,032		2,434,214
F	ELECTRICAL	$4,043,141	$808,724		4,851,865
G	INSTRUMENTS & CONTROLS	$4,789,241	$901,401		5,690,642
H	PAINTING	$400,000	$36,800		436,800
J	INSULATION	$208,000	$19,136		227,136
K	BUILDINGS & ARCHITECTURAL	$1,985,836	$325,005		2,310,841
L	DEMOLITION				
	ROUNDING (ALL CONSTRUCTION PACKAGES	($340)	$908		568
	DIRECT FIELD COST	$31,238,000	$6,278,000		$37,516,000
	FIXED PRICE CONTRACTOR MARKUP	$4,471,000	$911,000		5,382,000
	CONSTRUCTION MGMT G&A	$1,072,000	$214,000		1,286,000
	INDIRECT FIELD COST	$5,543,000	$1,125,000		$6,668,000
	TOTAL FIELD COST	$36,781,000	$7,403,000		$44,184,000
OTHER TEC ELEMENTS					
	SCHEDULE RESERVE				
110000	DEFINITIVE DESIGN - UE&C	$7,804,000			7,804,000
110000	PSAR CH 4-7 A/E SPT. TO OPER. CONTR.	$476,000			476,000
120000	TITLE III	$2,428,000	$488,000		2,916,000
210000	CONSTRUCTION MGMT & ADMIN (KEH)	$2,979,000	$600,000		3,579,000
330000	OPERATING CONTRACTOR SUPPORT (WHC)	$140,000			140,000
340000	OVERALL PROJECT MANAGEMENT (WHC)	$1,852,000			1,852,000
	TOTAL FIELD AND HOME OFFICE	$52,460,000	$8,491,000		$60,951,000
V	CRAFT PREMIUM PAY	$117,000	$24,000		141,000
W	ESCALATION	$12,352,000	$2,000,000		14,352,000
	SUBTOTAL	$64,929,000	$10,515,000		$75,444,000
W	CONTINGENCY	$16,139,000	$2,614,000	($13,129,000)	18,753,000
	TOTAL ESTIMATED COST (TEC)	$81,068,000	$13,129,000	($13,129,000)	$94,197,000

NOTE. OPTION COSTS ARE A ROM ESTIMATE DERIVED BY FACTORING THE 2A CDR ESTIMATE

TABLE 7-39

PLANT EQUIPMENT COST BREAKDOWN COMPARISON			
	INSTALLED PLANT EQUIP COST ($K)		
PROCESS SYSTEM	CDR BASELINE	GROUT + VES	GROUT + PE-CASE2
GROUT STORAGE	279	518	406
VIBRO GROUT MIXING	581 (1)	340	273
STIRRED GROUT MIXING	337 (1)	388	N/A
POLYMER STORAGE	(2)	637	19
VIBRO POLYMER MIXING	1142 (1,2)	230	N/A
STIRRED POLYMER MIXING	(1,2)	203	N/A
EXTRUDED POLYMER MIXING	N/A	N/A	702
OPEN/SORT/SZ RED/HOMOG/REPACK	3222	3436	2889
SPECIAL WASTE PRETRT/REPACK	1420	1456	1416
MATL HNDLG/SHP&REC/CURE&STORE	1126	1917	1458
NDA	2662	3769	2883
OFFGAS TREATMENT	279	329	288
DECONTAMINATION	34	40	35
SECONDARY WASTE TREATMENT	139	139	139
AQUEOUS MAKEUP	25	25	25
UTILITIES	225	225	183
HVAC	3063	3701	3379
SAMPLING	452	452	452
TOTAL PLANT EQUIP COST (3)	14986	17805	14547

NOTES:
(1) Baseline grout & VES polymer mixing equipment costs include cure/storage costs.
(2) Baseline polymer storage, mixing, & cure storage lumped into single account.
(3) Total plant equipment costs are total installed equipment costs without sales tax added to the material cost.

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APPENDIX A
ROM COST ESTIMATE

RAYTHEON ENGINEERS AND CONSTRUCTORS, INC.
WESTERN OPERATIONS

ESTIMATE BASIS

Client:	U.S. DOE Richland Operations Office	**Project Manager:**	M.J. Wolters
Project:	WRAP Module 2A CDR	**Project Estimator:**	R. D. Smith
Location:	Hanford, WA	**Date:**	16 July 1993
Job No.:	6237.008	**REVISION:**	0

1.0 PURPOSE

The U.S. DOE Richland Operations Office (USDOE-RL) has requested that Raytheon Engineers & Constructors, Western Operations (RE&C) develop two options as defined in the Single Immobilization Study to allow comparison to the CDR Baseline TEC estimate. The desired accuracy of the associated Rough-Order-of-Magnitude estimates are +/- 25%. The construction work will not be performed or supervised by RE&C.

2.0 SCOPE

The two proposed options estimated are as follows:

1). Grout and VES Polymer Solidification Process (Grout + VES) as described in Section 6.2.5, of the Process Descriptions in the ACDR Single Immobilization Study.

2). Grout and Polyethylene Polymer Solidification Process (Grout + PE II) as described in Section 6.2.4, of the Process Descriptions in the ACDR Single Immobilization Study.

The cost estimates for these two options have been developed by factoring the 31 July 1992 WRAP Module 2A CDR Estimate (Base Case). Equipment account adjustments have been derived by factoring installed costs by the through-put process system flows for the two options as compared to the Base Case.

Other account adjustments have been based on necessary building area and volume adjustments.

3.0 COMPETITIVE ANALYSIS

None. RE&C has been requested to perform this systems analysis as part of the Single Immobilization Study.

4.0 CONSTRUCTION APPROACH

Construction has been assumed to be performed by the same Module 2A CDR fixed price contractor as in the 31 July 1992 estimate. A 2.0% of direct labor cost allowance for craft premium pay has been included, as in the 31 July 1992 estimate.

5.0 QUANTITY BASIS

Quantity takeoffs have not been performed. Cost derivation has been made based on factoring the previous estimate (see Pricing).

6.0 PRICING

The pricing for each account has been derived by factoring the 2A CDR costs from the 31 July 1992 estimate. Individual account adjustments were developed as follows:

OPTION 1 - GROUT + VES

A-Account (Earthwork) - Adjustment consists of 4% additional building area, 5% additional building volume (1.04 x 1.05), plus the earthwork portion of the lay and cure storage costs (2.84% x $883,000) that was formerly in the "D" equipment costs. The earthwork portion of the building has been extracted from the 31 July 1992 estimate building only costs.

B-Account (Concrete) - Adjustment consists of 4% additional building area, 5% additional building volume (1.04 x 1.05), plus the concrete portion of the lay and cure storage costs (11.12% x $883,000) that was formerly in the "D" equipment costs. The concrete portion of the building has been extracted from the 31 July 1992 estimate building only costs.

C-Account (Structures) - Adjustment consists of 4% additional building area, 5% additional building volume (1.04 x 1.05), plus the structures portion of the lay and cure storage costs (8.95% x $883,000) that was formerly in the "D" equipment costs. The structures portion of the building has been extracted from the 31 July 1992 estimate building only costs.

D-Account (Equipment) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($17,805,000/ ($15,993,742-1,009,064) = 1.19), plus the HVAC portion of the lay and cure storage costs (40.3% x $883,000) that was formerly in the "D" equipment costs. The HVAC portion of the building has been extracted from the 31 July 1992 estimate building only costs.

E-Account (Piping) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($17,805,000/ ($15,993,742-1,009,064) = 1.19), plus the building piping portion of the lay and cure storage costs (4.52% x $883,000) that was formerly in the "D" equipment costs. The piping portion of the building has been extracted from the 31 July 1992 estimate building only costs.

F-Account (Electrical) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($17,805,000/ ($15,993,742-1,009,064) = 1.19), plus the building electrical portion of the lay and cure storage costs (5.13% x $883,000) that was formerly in the "D" equipment costs. The electrical portion of the building has been extracted from the 31 July 1992 estimate building only costs.

G-Account (Instrumentation) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($17,805,000/ ($15,993,742-1,009,064) = 1.19).

H-Account (Painting) - Adjustment consists of 4% additional building area, 5% additional building volume (1.04 x 1.05), plus the painting portion of the lay and cure storage costs (0.25% x $883,000) that was formerly in the "D" equipment costs. The painting portion of the building has been extracted from the 31 July 1992 estimate building only costs.

J-Account (Insulation) - Adjustment consists of 4% additional building area, 5% additional building volume (1.04 x 1.05), plus the insulation portion of the lay and cure storage costs (0.25% x $883,000) that was formerly in the "D" equipment costs. The insulation portion of the building has been extracted from the 31 July 1992 estimate building only costs.

K-Account (Buildings & Architectural) - Adjustment consists of 5% additional building volume (1.05), plus the building portion of the lay and cure storage costs (24.24% x $883,000) that was formerly in the "D" equipment costs. The applicable portion of the building has been extracted from the 31 July 1992 estimate building only costs.

OPTION 2 - GROUT + PE II

A-Account (Earthwork) - Adjustment consists of 1% additional building area, 2% additional building volume (1.01 x 1.02), plus the earthwork portion of the lay and cure storage costs (2.84% x $554,000) that was formerly in the "D" equipment costs. The earthwork portion of the building has been extracted from the 31 July 1992 estimate building only costs.

B-Account (Concrete) - Adjustment consists of 1% additional building area, 2% additional building volume (1.01 x 1.02), plus the concrete portion of the lay and cure storage costs (11.12% x $554,000) that was formerly in the "D" equipment costs. The concrete portion of the building has been extracted from the 31 July 1992 estimate building only costs.

C-Account (Structures) - Adjustment consists of 1% additional building area, 2% additional building volume (1.01 x 1.02), plus the structures portion of the lay and cure storage costs (8.95% x $554,000) that was formerly in the "D" equipment costs. The structures portion of the building has been extracted from the 31 July 1992 estimate building only costs.

D-Account (Equipment) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($14,547,000/ ($15,993,742-1,009,064) = 0.97), plus the HVAC portion of the lay and cure storage costs (40.3% x $554,000) that was formerly in the "D" equipment costs. The HVAC portion of the building has been extracted from the 31 July 1992 estimate building only costs.

E-Account (Piping) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($14,547,000/ ($15,993,742-1,009,064) = 0.97), less the piping costs associated with the VES Polymer Storage & encapsulation ($435,000), plus the building piping portion of the lay and cure storage costs (4.52% x $554,000) that was formerly in the "D" equipment costs. The piping portion of the building has been extracted from the 31 July 1992 estimate building only costs.

F-Account (Electrical) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($14,547,000/ ($15,993,742-1,009,064) = 0.97), plus the building electrical portion of the lay and cure storage costs (5.13% x $554,000) that was formerly in the "D" equipment costs. The electrical portion of the building has been extracted from the 31 July 1992 estimate building only costs.

G-Account (Instrumentation) - Adjustment consists of the new total of the "D" installed equipment costs less the lay and cure storage costs, divided by the previous "D" installed equipment costs ($14,547,000/ ($15,993,742-1,009,064) = 0.97).

H-Account (Painting) - Adjustment consists of 1% additional building area, 2% additional building volume (1.01 x 1.02), plus the painting portion of the lay and cure storage costs (0.25% x $554,000) that was formerly in the "D" equipment costs. The painting portion of the building has been extracted from the 31 July 1992 estimate building only costs.

J-Account (Insulation) - Adjustment consists of 1% additional building area, 2% additional building volume (1.01 x 1.02), plus the insulation portion of the lay and cure storage costs (0.25% x $554,000) that was formerly in the "D" equipment costs. The insulation portion of the building has been extracted from the 31 July 1992 estimate building only costs.

K-Account (Buildings & Architectural) - Adjustment consists of 2% additional building volume (1.02), plus the building portion of the lay and cure storage costs (24.24% x $554,000) that was formerly in the "D" equipment costs. The applicable portion of the building has been extracted from the 31 July 1992 estimate building only costs.

7.0 LABOR COSTS

The field costs for craft labor and contractor management were developed as part of the 31 July 1993 estimate all-in wage rates. The construction effort has been based on a 40-hour work week.

8.0 SCHEDULE

This work has been assumed to be performed using the same construction schedule as in the 31 July 1992 estimate.

9.0 ESCALATION

All pricing and escalated wage rates are based on the same escalation markup (23.49%) as in the 31 July 1993 estimate.

10.0 RE&C SERVICES

The estimate includes the same dollar allowances for Title I and II design as in the 31 July 1993 estimate.

11.0 INDIRECTS

Indirects for the fixed price contractor, as in the previous estimate at 44% on direct material, 19.97% on contractor furnished material (not "D" account equipment), and 12.31% on subcontracts.

Sales Tax at 7.8% has been included on material.

A 3% Contractor G&A rate was applied, as in the previous estimate.

The same dollar allowances for PSAR, Operating Contractor Support and Operating Contractor Management were used from the previous estimate.

The same percentages for Title III Engineering (6.6%) and Construction Management & Administration (8.1%) have been applied, per the previous estimate.

12.0 CONTINGENCY

The same percentage was applied (24.86%) as in the previous estimate.

13.0 FEE/RISK PREMIUM

No contractor fees have been included in the estimate. Allowances for profit, performance and payment bonds and CIP compensation have not been included in the estimate.

14.0 FINANCING

Not included.

15.0 INCLUSIONS

- o "D" Installed costs factored based on through-put.
- o "E, F and G" Accounts similarly factored.
- o Other Direct Accounts factored from Area and Volume Changes.
- o Same parameters as 2A CDR 31 July 1993 estimate.

16.0 EXCLUSIONS

16.1 VES Polymer Storage and Delivery piping deleted.

16.2 Re-design of option systems or support facilities.

16.3 Detailed drawings of option systems.

16.4 Take-offs or detailed estimate of options.

16.5 All Construction Permits.

16.6 Contractor's profit, bond, and CIP costs.

17.0 ASSUMPTIONS AND QUALIFICATIONS

17.1 ROM estimate of option costs is sufficient to determine option selection.

17.2 Detailed estimate of selected option will be performed later at additional engineering cost.

Michael J. Wolters
Project Manager

Richard D. Smith
Estimator

WASTE RECEIVING AND PROCESSING FACILITY

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WASTE FORM QUALIFICATION TREATABILITY STUDY IMPACTS

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STUDY 1604-2
WASTE FORM QUALIFICATION TREATABILITY STUDY IMPACTS

Prepared by: R. L. Heath Date: 12/22/93

Reviewed by: K. D. Van Zanten Date: 12/22/93

Approved by: [illegible] Date: 1/7/94

Approved by: [illegible] Date: 1/7/94
Project Manager

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1.0 OBJECTIVE

This study will provide engineering support for the overall Waste Form Qualification (WFQ) program to be planned and implemented by Westinghouse Hanford Co (WHC[1]). The WFQ program will investigate final treatment of surrogate waste on a bench and pilot scale basis using grout, thermoset polymer, or thermoplastic polymer. Each treatment technology is to be evaluated by a separate testing program which defines the following testing sequence:

Phase I - Surrogate Waste/Binder Compatibility Testing

Phase II - Treated Waste Form Acceptance Testing

Phase III - Drum Scale Pilot Testing for Evaluation of Process and Equipment Scale-Up Parameters

1.1 Scope

A. Identify data and need dates required from WFQ testing to support preliminary and detailed design.

B. Review WFQ test plans and recommend test parameters which should be monitored during testing.

C. Witness WFQ testing at Hanford or vendor test sites and assist in evaluating test data.

D. Input recommendations to the design specifications and drawings used for procurement of full scale test equipment.

E. Develop upstream processing operations required to pretreat waste prior to final immobilization if requirement is identified during WFQ testing.

F. Estimate cure exotherm time and temperature as well as cooling time and temperature for the Vinyl Ester Styrene (VES) or Polyethylene (PE) polymerization operations. Develop recommendations for monitoring the stabilized monolith temperatures during curing/cooling. Also, recommend options which could potentially minimize cure storage time, inventory, or space requirements.

G. Perform a survey of hazardous waste Treatment Storage and Disposal (TSD) facilities to review design and operations that can be applied to the design of the WRAP 2A treatment facility.

H. Develop waste feedstream characterization logic diagrams and identify important waste physical and chemical property parameters which are required for the process design of the WRAP 2A treatment facility. These design document bases will be input to WHC for inclusion in the Supplemental Design Requirements Document (SDRD).

1.2 Background

A. An overall Waste Form Qualification (WFQ) test program was initiated by WHC in support of the Conceptual Design for the WRAP 2A facility[1]. This program deals with the treatability of surrogate waste via immobilization in a polymer or grout matrix. The polymer solidification system conceptual design was developed in the Conceptual Design Report (CDR[2]) based upon extrapolation of the technology from vendor experience with similar waste forms. Grout solidification proposed in the CDR was the result of extrapolation from BNFL technology and experience.

B. General uncertainties identified in the CDR for grout and polymer solidification included identification of acceptable formulation operating envelopes. This requires successful encapsulation of high soluble salt wastes satisfying the waste acceptance criteria mandated by the Washington Administrative Code[3]. Previous experience with solidification of these waste forms in grout or modified cement binders has not been successful at many DOE facilities.

C. The WFQ treatability test program for thermoset polymers was developed, in part, to test vinyl ester styrene (VES) resins on surrogate wastes containing soluble salts that represent problem waste streams for treatment in the WRAP 2A facility. The test program is divided into three phases ranging from general waste compatibility testing (already accomplished in Phase I) to treatment of specific surrogate waste forms and subsequent waste form acceptance testing by laboratory analyses (currently ongoing in Phase II). The final phase will involve full scale in-drum pilot testing so that process design parameters such as mixer power, curing time, curing exotherm and other design details can be evaluated for potential incorporation into detailed Title design.

D. Another ongoing WFQ treatability test program has been implemented to define the treatability of other specific surrogate waste forms using cement or grout. This program has attempted to solidify surrogate basin sandblast grits, incinerator ash, Liquid Effluent Treatment Facility (LETF) metal sludges, and LETF ammonium sulfate. Solidification binders tested included Types I, II, and III Portland cement, slag cement, and Envirostone gypsum based cement. Binder formulations have been defined for agitated mixing of these particulate wastes. Future work will involve development of cement or grout formulations for vibro grout mixing of size reduced wastes. Full scale testing will allow definition of process design parameters required for potential incorporation into detailed Title design.

E. A Waste Immobilization Demonstration (WID) test program is planned for the thermoplastic polymer treatment of high nitrate surrogate wastes. Technology exchanges with other DOE facilities such as Rocky Flats have shown success with encapsulating high nitrate salts in low density polyethylene binder. An extrusion pilot scale testing program has been proposed at Brookhaven National Lab. This program will develop compatibility and waste form acceptance criteria test data to allow scale-up to a pilot or drum scale demonstration plant.

1.3 Purpose and Needs

A. The purpose of the WFQ treatability impact study will be to define any impacts or modifications to the CDR concept that are defined by treatability testing. As the WFQ program proceeds, there may be treatability study recommendation for other types of immobilization binders. Evaluation of the treatability test results by the test program contractor, UE&C, and WHC will determine the need and direction of the future test work to allow successful incorporation into the overall WRAP 2A design.

2.0 SUMMARY

A. Feedstream logic flow diagrams were developed to provide specific decision requirements to determine the optimum processing treatment route. The characterization data requirements were specified for each of five generic feedstreams: sludges, dry particulate, ion exchange resins, debris/operating waste and special waste. Principal waste properties with respect to physical and chemical characteristics have been identified in the logic process.

B. WFQ testing needs required to support WRAP 2A advanced conceptual and title design were identified for those areas of the process that have significant uncertainties. These areas include the solidification pretreatment, solidification mixing, solidification curing and secondary waste systems. Specific test data, data needs dates, justification for the data, expected source of test data and impacts to the design if not received as scheduled are listed. However, the pretreatment of secondary waste system testing need requirements and schedules need dates are subject to change based upon initial test results from the primary solidification mixing and curing processes.

C. A number of Treatment, Storage and Disposal (TSDs) facilities were surveyed to gain an insight into technologies in use for commercial hazardous waste industries. Several TSDs were contacted that dealt in areas of hazardous waste incineration, stabilization or separations/recovery. Incineration technologies, such as those used at APTUS or USPCI provide Best Demonstrated Available Technology (BDAT) for organic wastes that have no viable alternative treatment technology. Ash stabilization is a concern resulting from those wastes which have high heavy metal concentrations that are subject to Land Disposal Restricted (LDR) Toxicity Characteristic Leaching Procedure (TCLP) requirements. General stabilization/solidification facilities provide chemical stabilization and or solidification to allow treatment of wastes containing metal cyanides, pentoxides, chromates, sulfates, sulfides, phosphates and nitrates. These wastes often result from commercial steel or metal finishing industries. Separations and recovery operations, such as mercury retorting, are currently offered by a number of facilities which reclaim mercury for reuse. These facilities were surveyed to gain insight into the design and operation of mercury retorts which are planned for use in the special waste treatment area.

D. Detailed calculations were performed to predict the cure exotherm temperatures associated with solidification of the WRAP 2A feedstreams (CDR characterization basis) in either VES resin or polyethylene polymer. Each polymer was loaded with waste at loadings recommended in the Single Immobilization Study. Assumptions were made for the heat transfer properties of the waste and actual published data was used for the binder physical properties and thermal characteristics. Maximum temperatures rises and cooling curves were estimated to compare VES resin and polyethylene binders. This information was used to provide recommendations for sizing and configuring the cure/storage area as well as methods of monitoring the drum temperature.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Recommendations

The following recommendations were made by deliverables provided in the WFQ Treatability Study.

1. Further contacts be initiated with permitting and regulatory agencies to remain updated with any changes to TCLP protocol or potential variances.

2. Integrate the design information obtained from mercury stabilization or recovery TSDs into the current special waste mercury evaporator process system design. This information may also be potentially extrapolated to the treatment of waste with trace mercury contamination by extrusion with polyethylene at moderately elevated temperatures. However, actual testing with vented extenders at multiple extrusion temperatures and residence times is recommended as the ultimate proof of principle.

3. Verify the polymer/waste exotherm and/or cooling rates predicted by calculation estimates using actual full drum scale testing. The actual test data is necessary to confirm assumptions made for waste and polymer physical and thermal properties, such as density, heat capacity and thermal conductivity. Also, a critical variable in the estimate for maximum cure exotherm temperature is the assumption of whether free moisture will vaporize. Moisture vaporization may also impact the quality of the final waste form. Only full drum scale testing will allow confirmation of assumptions used in this study.

4. Based upon the cure exotherm and rate of cooling calculation estimates, it is recommended that the VES polymer cure storage area be sized to allow 72 hours of residence time for all VES polymer/ waste drums. This will provide sufficient time for all drums to cool to a temperature of approximately 100°F. At a residence time of 48 hours, the CDR design basis, the average drum temperature is generally above 140°F for up to one half of the drums.

5. Based upon calculated results form the polyethylene/waste cooling case, it is recommended that the polyethylene storage and cooling area be sized to allow a 48 hour residence time. This recommendation is based upon the fact that most polyethylene/waste drums are cooled below 130°F, and in some cases below 100°F, after 48 hours.

6. It is recommended that the cure/store area utilize a stacker/retriever system to allow maximized use of floor area since drums could be stacked vertically in tiers 5 to 10 drums high. Stacked drums would also promote more natural convection for a faster rate of cooling.

7. Drum temperatures can be monitored by use of internal or external thermocouples. It is recommended for ease of use and to minimize spread of contamination, that external drum surface temperature be monitored through use of infrared pyrometers. This method will require test data correlations to establish maximum internal monolith temperatures as a function of drum wall temperature.

3.2 Conclusions

The WFQ Treatability Study has provided a number of recommendations for incorporation into the ACD based upon the current available information and engineering analysis. Some of the recommendations must be fully confirmed during follow-on Waste Immobilization Demonstration (WID) testing and may be incorporated into the design at a later date. Examples are polymer process selection based on WID TCLP testing with extruded polyethylene and waste loading determinations which are a primary process variable which impacts TCLP results and polymer/waste thermal characteristics.

4.0 UNCERTAINTIES

A. Waste Feedstream Physical and Chemical Properties

Assumptions were made for the waste feedstream physical and thermal properties including specific density, particle size, heat capacity and thermal conductivity since this information is not available, for the most part, from the WHC feedstream data sheets.[16] Chemical properties of the waste will potentially impact any pretreatment requirements for the waste which may, in turn, impact physical and/or thermal properties.

B. Waste Loadings

Waste loadings used for determining cure exotherm temperatures and rate of cooling were assumed to be those used in the Single Immobilization Study. Waste loadings in polymer must be confirmed through additional WFQ testing, especially for the polyethylene polymer binder.

C. Mercury Removal

Mercury removal from waste due to evaporation at moderate temperature with vacuum is assumed to be a viable process for special waste, such as bulk materials contaminated with elemental mercury. However, it is also assumed in this study that waste contaminated with other mercury compounds can be treated thermally for mercury removal. WHC testing by extrusion of polyethylene with waste containing trace concentrations of mercury must verify this assumption.

D. Treated Waste Form Quality

Assumptions are made throughout the study that the immobilized waste in polymer will satisfy waste form performance specifications with respect to TCLP, compressive strength, reactivity of stability, free liquid content and void space. For example, it is assumed that all free water in the waste is encapsulated or driven off as vapor. This assumption will dramatically impact not only the maximum cure temperature, but also the necessary provisions to handle water vapor or offgas during the polymer solidification or curing process. Again, this assumption must be confirmed through actual full size drum scale testing.

E. VES Resin Formulation

The cure/exotherm calculations were performed for VES resin and waste assuming formulation and reaction rate data extrapolated from test work performed by Stock Equipment Co. However, the type of VES resin, promoter and catalyst and the potential for interaction with waste chemical components may potentially impact the rate and extent of the polymer reaction. Such variances could dramatically impact the maximum cure exotherm temperature or the time to achieve that temperature. Any assumed adjustments to the formulation must be confirmed through WFQ testing.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC Requirements[4]

A. Criteria for developing an alternate method of pretreating waste that may be indicated by WFQ treatability test results are subject to the following Functional Design Criteria (FDC) requirements.

1. Capability shall be provided to track waste container contents entering the treatment areas to the exiting containers as required per the regulations.

2. Provisions shall be provided for bulk storage with ventilation and controlled delivery systems for dry and liquid agents to support treatment.

3. Handling of dry waste materials, if required, shall be by conveyance system.

4. Treated waste shall be packaged into new 55 gallon drums.

5. Capability shall be available for extracting samples for verification of successful treatment.

6. The capability to determine and control weight of containers of waste during treatment and addition of volume fillers as needed shall be provided.

7. Treatment of waste shall be non-thermal.

8. Treated waste shall have two days lag storage and capability of visual inspection during curing. The capability to extract liquid, on an infrequent basis, from the top of the curing drum shall also be provided.

5.1.2 Study Criteria

5.1.2.1 Phase II Treatability Testing Support

A. UE&C will provide support for the Phase I and II treatability test program that includes witnessing test specimen preparation and subsequent evaluation of laboratory test results.

B. Test specimen preparation at the vendor's facility will be witnessed and key process parameters will be recorded. The following is a partial listing of these parameters applicable for grout or polymer solidification:

1. Surrogate waste physical/chemical characteristics.

2. Binder formulation.

3. Mixing batch size.

4. Agitator type, speed, and power.

5. Gel and curing times.

6. Curing exotherm temperature.

7. Solidified waste physical observations.

   a. Mixing homogeneity.

   b. Free water formation.

   c. Other visual characteristics.

C. Some of the recorded process parameters (such as formulation, gel time, and curing exotherm temperative) will be evaluated with respect to potential impacts to the current CDR design concept. However parameters dealing with mixing conditions and curing times will not be applicable due to the small batch sizes.

D. Laboratory test results of the prepared specimens will be evaluated for all surrogate wastes. As an example, **Table 5-1** gives a summary of the laboratory tests planned to prove acceptance for thermoset polymer treated waste test methods, number of samples required and lab location.

5.1.2.2 Phase III Testing Recommendations

A. Recommendations for the Phase III portion of the WFQ treatability program will be based upon Phase II treatability test results.

B. UE&C will make recommendations for defining design parameters for the Phase III full size drum scale pilot test program. The process design parameters to be recommended for the test skid will include the following:

1. Mixer design details (supplied by Waste Mixing Technique Evaluation Study 1604-3)[5].

   a. Agitator prop design.

   b. Agitator shaft automatic detachment ("Lost Paddle" technique).

   c. Mixer speed/HP requirement for agitated mixing.

   d. Vibration frequency and HP input for vibrated mixing.

2. Binder/Additives formulation.

   a. Sequence of addition.

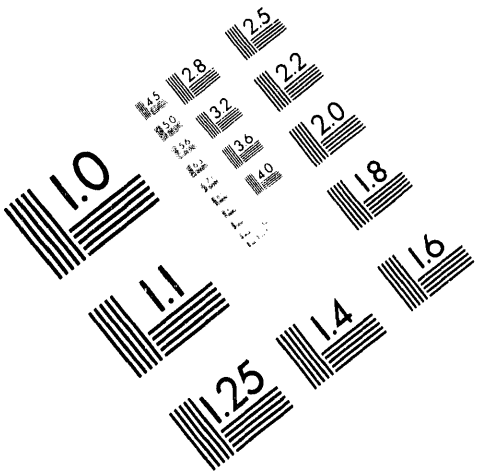
   b. Binder/additives types and quantities.

   c. Waste loading maximization.

   d. Viscosity adjustments, e.g., via additives.

TABLE 5-1
THERMOSET POLYMER TREATABILITY LABORATORY TESTING

Test Description	Test Method	# of Samples per Waste Form	Acceptance Criteria	Test Laboratory
Compressive Strength	ASTM D695	10	Compr strength > 60 psi	Stock Equip. Co.
Leachability/Immersion	AMS 16.1 ASTM D695	12 Total (6 with 6 without metal control	Leach index > 6 Compr strength > 60 psi after 90 days immersion	Stock Equip. Co.
Biodegradation	ASTM G21 & G22 ASTM D695	3	No biological growth compr strength > 60 psi	United States Testing Co.
Radiation Stability	ASTM D695	3	Compr strength > 60 psi after 10^8 rad dose	Phoenix Memorial Lab
Thermal Cycling	ASTM B553 ASTM D695 10 CFR 61	3	Compr strength > 60 psi after 30 thermal cycles	Stock Equip. Co.
Toxicity Characteristics	40 CFR 261 40 CFR 268.41 EPA 1311 (TCLP) EPA 6010	4	Toxic metals leachability below EPA limits	Stock Equip. Co.
Hazardous Characteristics	40 CFR 261	3	Not ignitable, reactive or corrosive	Stock Equip. Co.
Free Liquids/Control	ANS 55.1	Remainder	Free liquids < 0.5% Compr strength compared to leach/immersion samples after 90 day cure	Stock Equip. Co.



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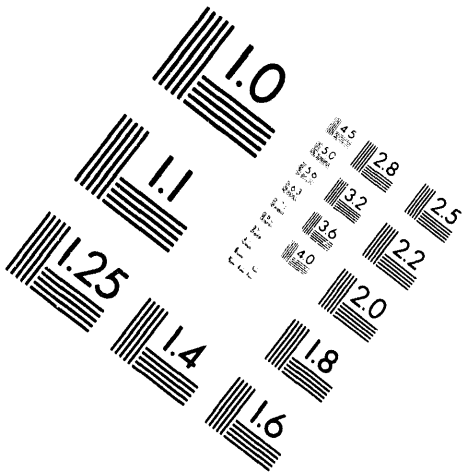

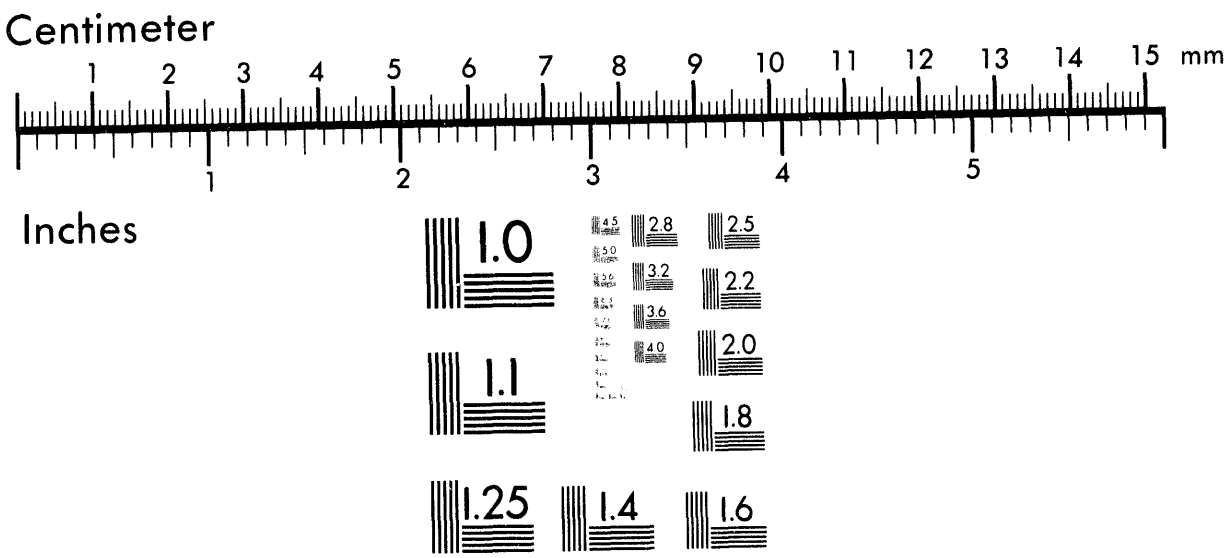

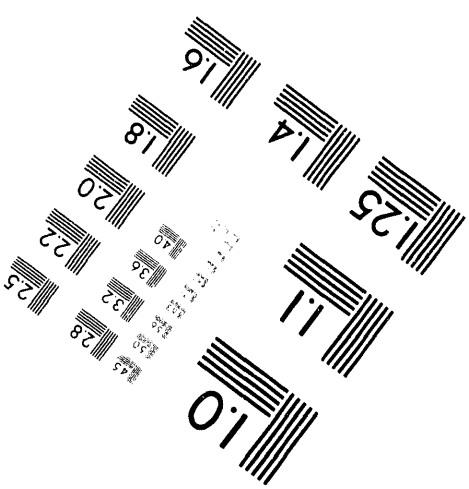

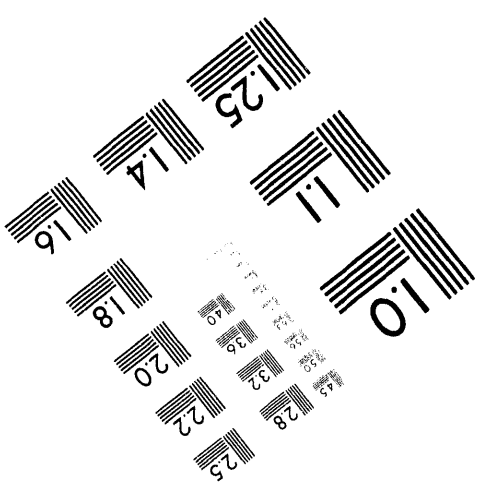

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3. Cure monitoring requirements.

   a. Temperature exotherm.

   b. Cure time.

   c. Off gas production characterization.

   d. Free water monitoring/removal.

   e. Waste volume expansion or contraction and container integrity.

4. Surrogate waste definition.

   a. Surrogate formulation development.

   b. Pretreatment requirements.

C. Detailed design drawings or specifications for the full size drum scale test unit which incorporate these design parameters are not within the scope of this study.

5.1.2.3 Design Concept Modifications

A. As test data results become available from the Phase I, II, and III testing, the data will be evaluated and recommendations will be produced. For example, if testing reveals problems with free water generation during curing recommendations will be made to eliminate or minimize free water formation by control of waste treatment parameters. An integrated system for post treatment to monitor stabilized waste curing and free water formation, if any, will be evaluated.

B. If satisfactorily treated waste quality cannot be obtained using the above final treatment process parameters, pretreatment options will be evaluated. These pre-treatment techniques can be subdivided into physical and chemical pre-treatment techniques. Physical pretreatment may include:

   1. Size Reduction

   2. Drying

   3. Dewatering

   Chemical pretreatment may include stabilization via:

   1. pH Adjustment

   2. Heavy Metal Complexing

5.2 ASSUMPTIONS

5.2.1 Status of WFQ Program Work

A. WHC is in process of developing or implementing the test plan for each of the three potential immobilization binders. Potential vendors or laboratories will be selected to perform the work in each phase of testing.

B. The grout screening testing program has been concluded for the initial group of surrogate wastes. Work is currently ongoing for full scale in-drum testing using a mixing system recommended in the Waste Mixing Technique Evaluation (Study 1604-3)[5]. The mixing tests are proceeding with surrogate binders and surrogate waste using the proprietary BNFL paddle design.

C. The Phase I and II testing for the vinyl ester styrene polymer has been completed and test results have been summarized in the Stock Equipment co. final reports issued in December 1992[6] and February 1993[7]. In summary, wastes surrogates developed to simulate the 183H basin sludges and crystalline solids as well as C018 LETF salts were successfully solidified with a VES resin to meet all waste form performance criteria except TCLP. Even at waste loadings as low as 25 wt%, TCLP results for those wastes containing mercury exceeded the regulatory limit using standard testing protocol. These waste forms passed TCLP for mercury only when size reduction of the treated waste was not attempted.

D. Recent economic analyses of the grout, VES, and polyethylene processes in the Single Immobilization Study[8] have re-emphasized the need for specific thermoplastic polymer test data with wastes similar to those at Hanford. A test program has been planned at the Rocky Flats Plant to treat high nitrate surrogate wastes with polyethylene in a pilot scale extruder. The current plan is for RFP to complete preparation of the treated samples by mid-August. The treated surrogates will be tested for TCLP and other product properties at appropriate laboratories determined by WHC.

5.2.2 Study Assumptions

A. The major initial assumption for the study is that surrogate wastes will be representative of the actual on-site waste at Hanford.

B. A second major assumption is that the treatability test results on the surrogate wastes can be extrapolated to other waste forms to be processed in WRAP 2A with similar problem constituents.

C. Finally, it is assumed that the treatability test performed on the relatively small scale 1 gallon batch sizes in Phase II will be similar to the full scale 55 gallon drum mixing operations and will allow representative test results.

6.0 STUDY DELIVERABLES

6.1 Waste Feedstream Characterization Data Requirements

A. The physical and chemical characteristics of waste feedstreams to be processed within the WRAP 2A facility are required to properly design the preliminary and final treatment processes. The primary waste characteristics which will determine the specific treatment steps are as follows:

1. Physical Characteristics

   - Physical Nature
     - Lumps or Aggregates
     - Friability
   - Particle Size
   - Moisture Content
   - Bulk Density
   - pH

2. Chemical Characteristics

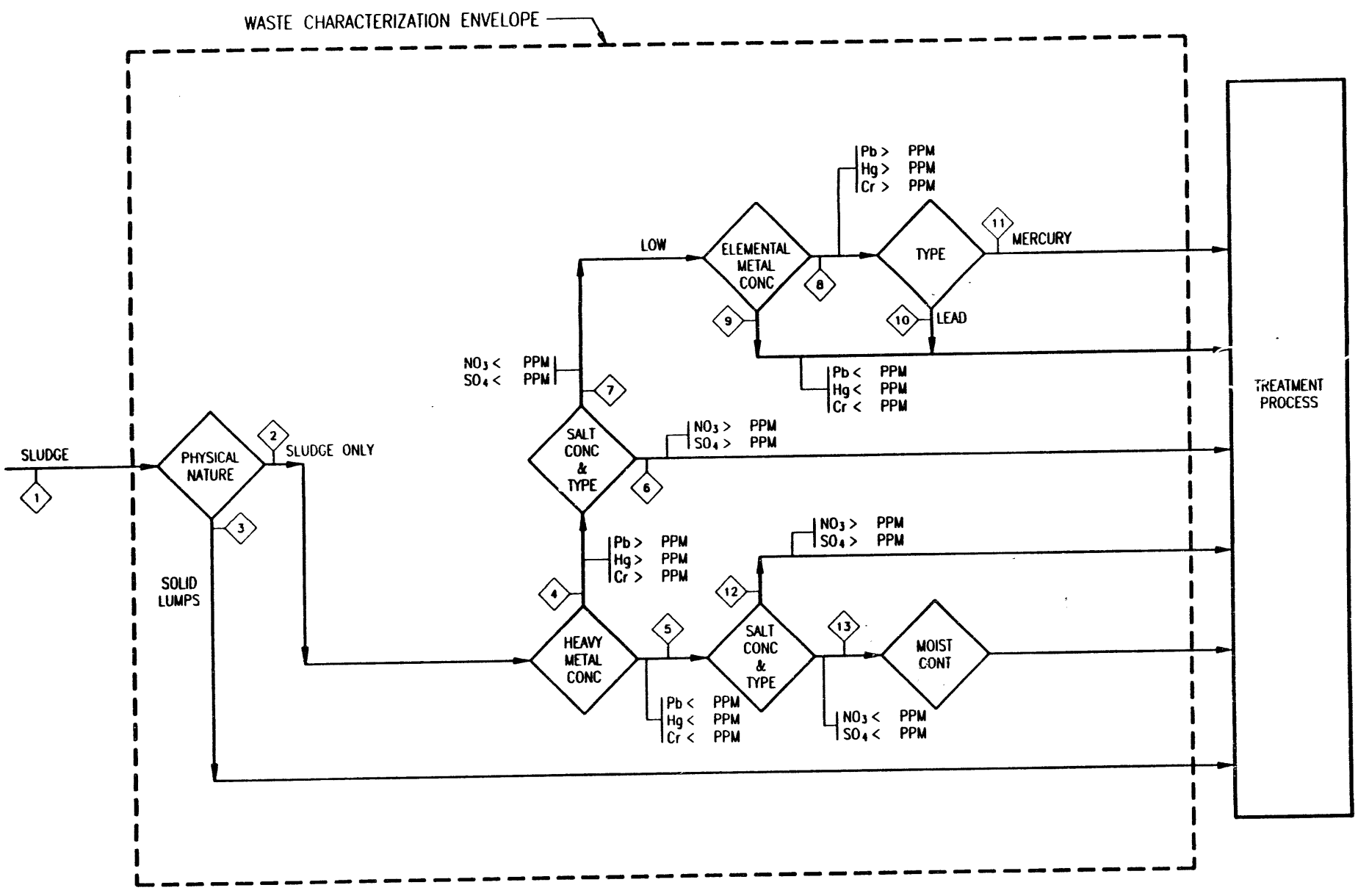
   - Organic Type and Concentration
   - Heavy Metal Type and Concentration
   - Salt Type and Concentration

B. In order to define the characterization data required for a specific feedstream, logic flow diagrams were developed. These diagrams were developed for splitting generic type waste feedstreams into specific feeds where specific processing unit operations could be recommended for design.

C. The feedstreams to WRAP 2A fall into three main categories; sludges/particulates, debris/operating wastes and special wastes. The sludges/particulates can be split further into wet sludges, dry particulates and ion exchange materials. In order to determine how these feedstreams would be processed in WRAP 2A and what binder would be used a series of logic diagrams were produced covering each waste type and identifying all the decision steps required to determine the process route.

D. The first main decision step determines whether the waste is suitable for shredding/direct repack followed by macroencapsulation or homogenization followed by agitated mixing with the binder. The subsequent decision steps determine the most appropriate binder or whether chemical pretreatment is required before immobilization. At each decision step the volume/mass of waste following each exit route is recorded on an attached table together with data used to determine the process route. The information from the logic diagrams/tables will be used to size the principal process equipment which will then be specified in the SDRD. Attached are the logic diagrams (**Figures 6-1** through **6-5**) and characterization tables (**Tables 6-1** through **6-5**) for each feedstream.

FIGURE
6-1



WRAP 2A WASTE FEED
CHARACTERIZATION LOGIC DIAGRAM

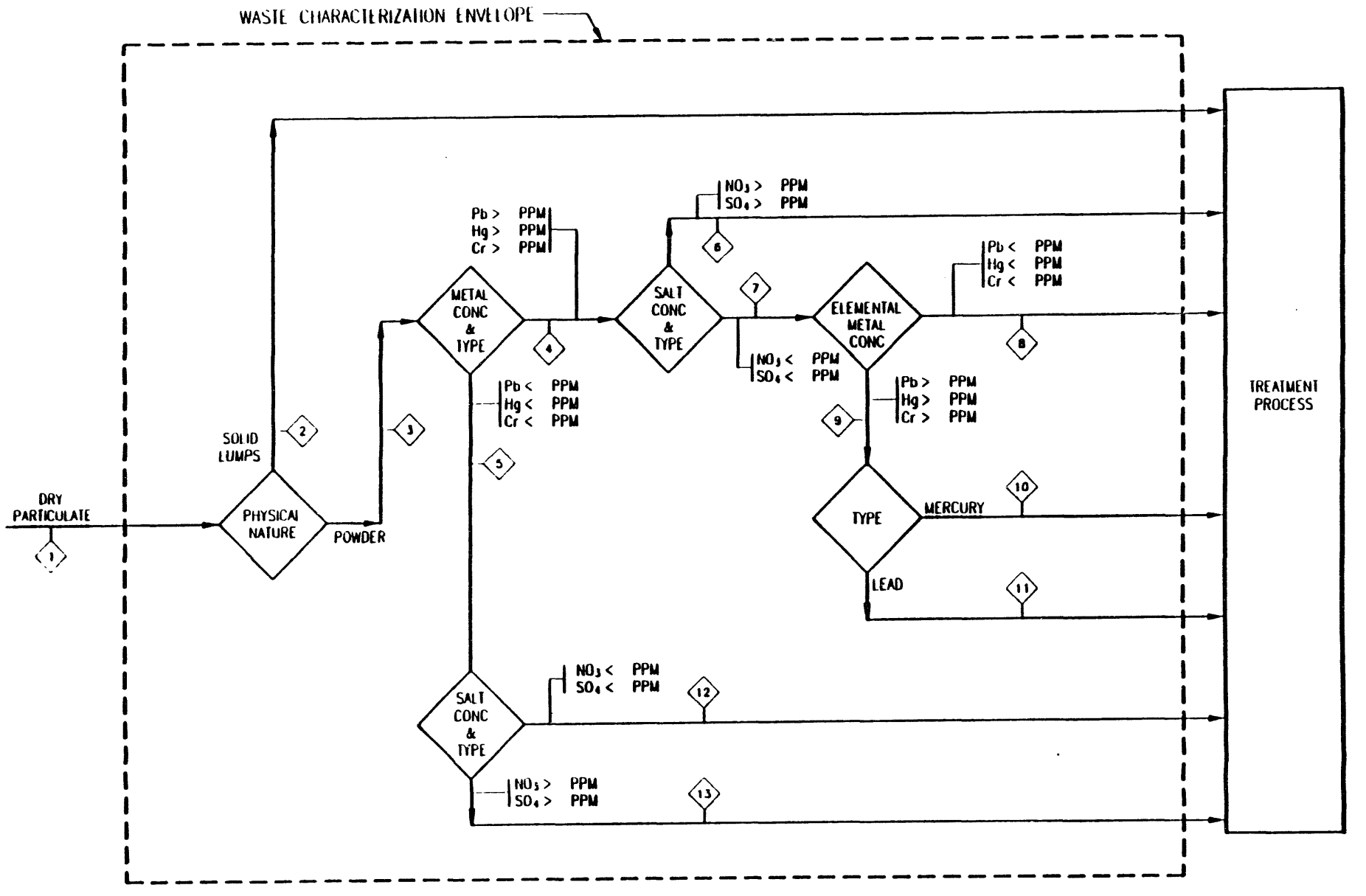
TABLE
6-1

SLUDGE

WASTE PARAMETER \ STREAM	1	2	3	4	5	6	7	8	9	10	11	12	13
VOLUME (ft^3)	45819	45819	-	11200	34619	-	11200	-	11200	-	-	34619	-
BULK DENSITY (lb/ft^3)	100-140	100-140	-	140	100	-	140	-	140	-	-	100	-
PARTICLE SIZE (MICRON)	UNKNOWN												
MOISTURE CONTENT (WT%)	35-80	35-80	-	70-80	35-51								
PH	>10	>10	-	>10	>10								
SALT CONCENTRATION													
NITRATE (%)	0-29	0-29	-			-	-					17-29	-
SULFATE (%)	0-5.3	0-5.3	-			-	-					1.3-5.3	-
HEAVY METAL CONCENTRATION													
MERCURY (PPM)	NOT ANALYZED												
LEAD (PPM)				-	14-80								
CHROMIUM (PPM)				-	210-530								
CONTAINER TYPE	55 GALLON DRUM												

WRAP 2A WASTE FEED CHARACTERIZATION TABLE

FIGURE
6-2



WRAP 2A WASTE FEED
CHARACTERIZATION LOGIC DIAGRAM

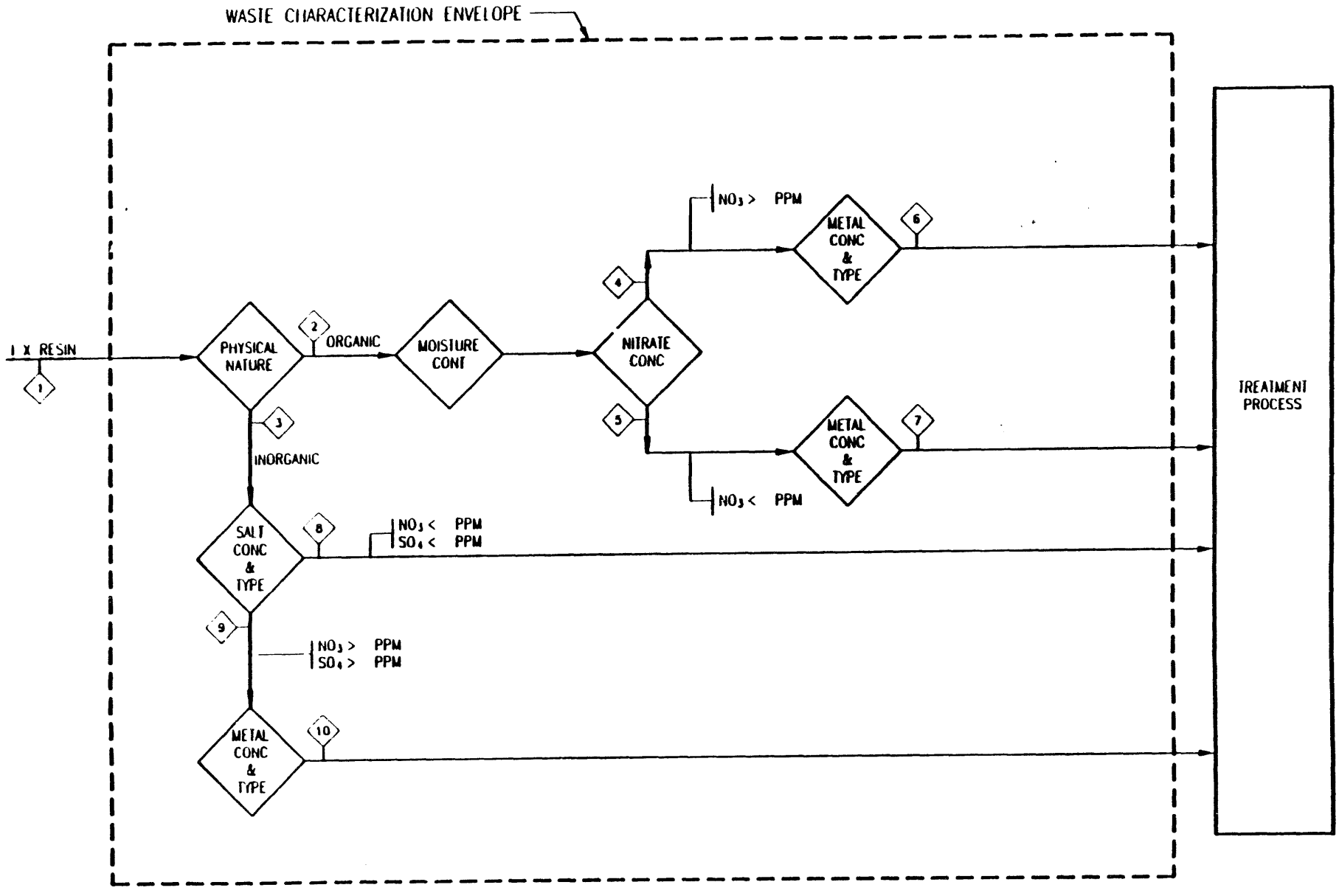
TABLE
6-2

DRY PARTICULATE

WASTE PARAMETER \ STREAM	1	2	3	4	5	6	7	8	9	10	11	12	13
VOLUME (ft^3)	424284	-	424284	-	424284	-	-	-	-	-	-	73700	350584
BULK DENSITY (lb/ft^3)	62-250	-	62-250	-	62-250	-	-	-	-	-	-	100-250	62-140
PARTICLE SIZE (MICRON)	VARIES												
SALT CONCENTRATION													
NITRATE (%)												LOW	HIGH
SULFATE (%)												LOW	HIGH
HEAVY METAL CONCENTRATION													
MERCURY (PPM)						-	LOW						
LEAD (PPM)						-	LOW						
CHROMIUM (PPM)						-	LOW						
CONTAINER TYPE	55 GALLON DRUM												

WRAP 2A WASTE FEED CHARACTERIZATION TABLE

FIGURE
6-3



WRAP 2A WASTE FEED
CHARACTERIZATION LOGIC DIAGRAM

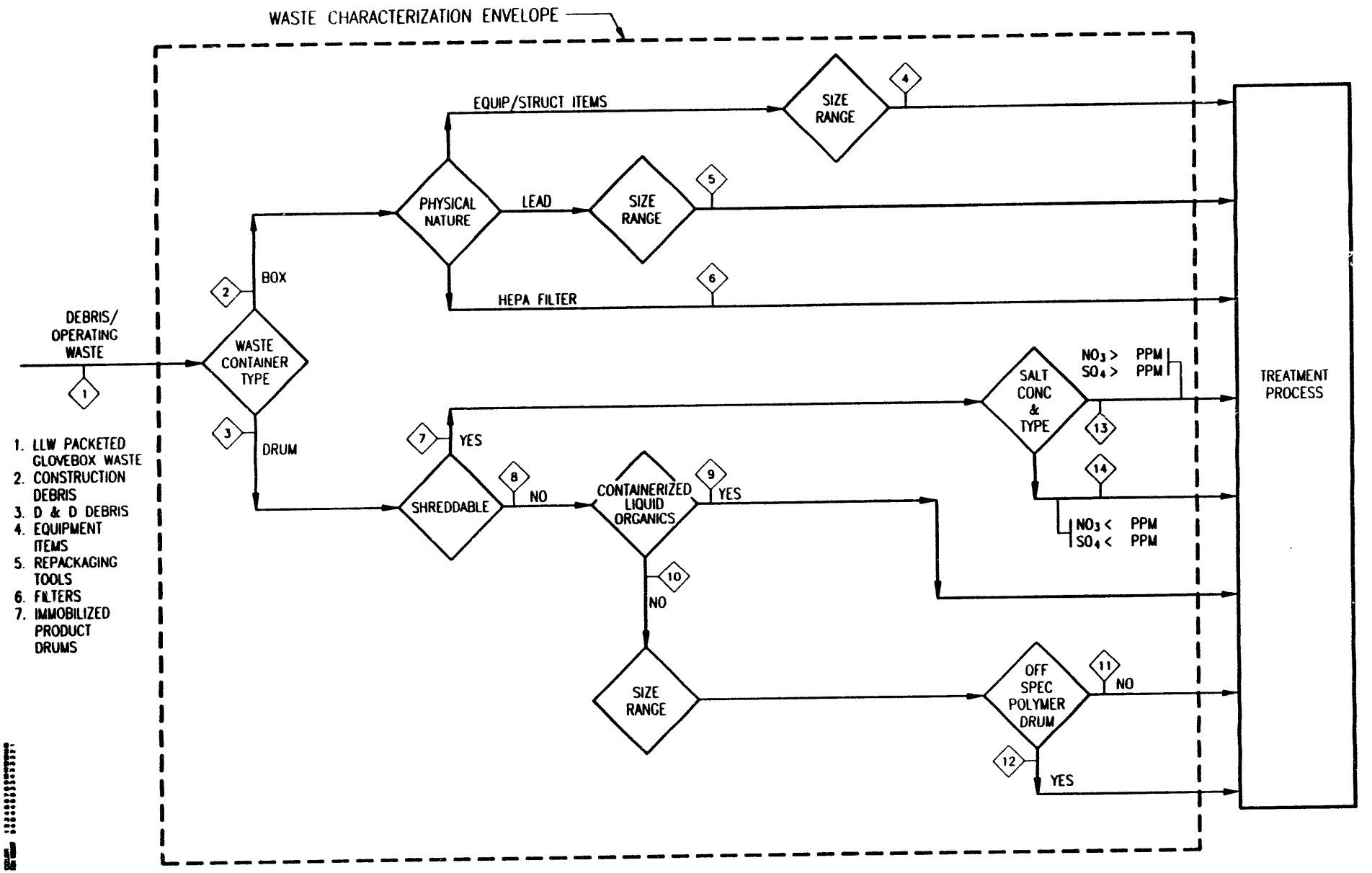
TABLE
6-3

IX RESIN

WASTE PARAMETER \ STREAM	1	2	3	4	5	6	7	8	9	10
VOLUME (ft^3)	14300	14300	-	-	14300	-	14300			
BULK DENSITY (lb/ft^3)	54	54	-	-	54	-	54			
PARTICLE SIZE (MICRON)	0.3-1.2	0.3-1.2	-	-	0.3-1.2	-	0.3-1.2			
MOISTURE CONTENT (WT%)	50-70	50-70	-	-	50-70	-	50-70			
SALT CONCENTRATION										
NITRATE (%)				-	LOW					
SULFATE (%)										
HEAVY METAL CONCENTRATION										
MERCURY (PPM)							95			
LEAD (PPM)							39			
CHROMIUM (PPM)							LOW			
CONTAINER TYPE	55 GALLON DRUMS									

WRAP 2A WASTE FEED CHARACTERIZATION TABLE

FIGURE
6-4



WRAP 2A WASTE FEED
CHARACTERIZATION LOGIC DIAGRAM

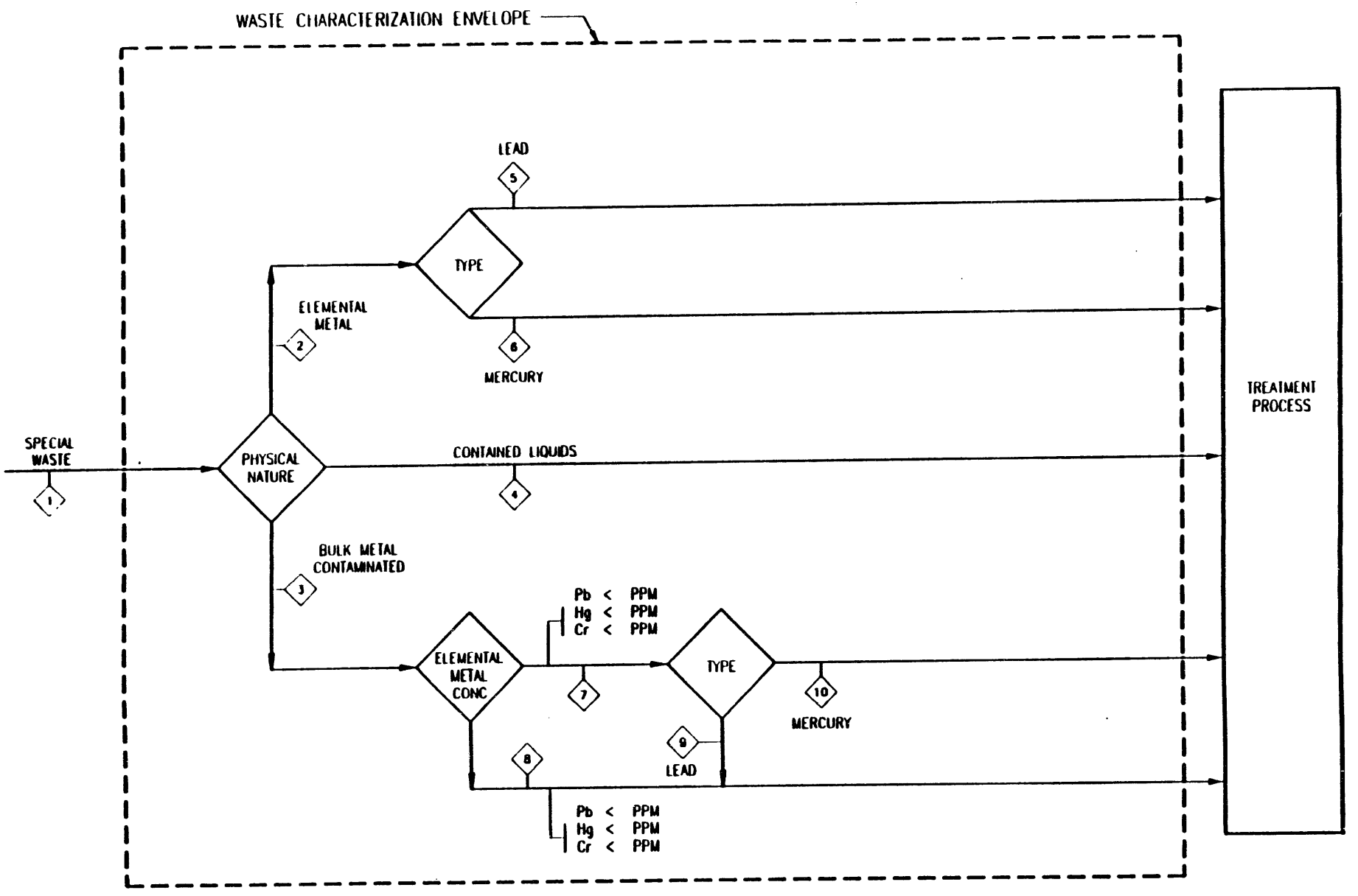
TABLE
6-4

DEBRIS/OPERATING WASTE

WASTE PARAMETER \ STREAM	1	2	3	4	5	6	7	8	9	10	11	12	13	14
VOLUME (ft^3)	305030	2240	302790	2240			302790	-					20512	282278
BULK DENSITY (lb/ft^3)	31-130	44		44			31-130	-					100-130	31
PARTICLE SIZE (MICRON)	GENERALLY LARGER THAN 2.5 IN.													
MOISTURE CONTENT (WT%)														
PH														
SALT CONCENTRATION														
NITRATE (%)													HIGH	LOW
SULFATE (%)													HIGH	LOW
LIQUID ORGANICS														
SOLVENT (TYPE & VOLUME)														
PHYSICAL NATURE														
EQUIP/STRUCT														
LEAD														
HEPA FILTER														
SHREDDABLE														
CONTAINER TYPE		4X8X5 BOXES	55 GAL DRUMS											

WRAP 2A WASTE FEED CHARACTERIZATION TABLE

FIGURE
6-5



WRAP 2A WASTE FEED
CHARACTERIZATION LOGIC DIAGRAM

TABLE
6-5

SPECIAL WASTE

WASTE PARAMETER \ STREAM	1	2	3	4	5	6	7	8	9	10
VOLUME (ft^3)	49800	26700	7600	15500	26300	400	7600	-	4700	2900
BULK DENSITY (lb/ft^3)										
PARTICLE SIZE (MICRON)										
MOISTURE CONTENT (WT%)										
PH										
SALT CONCENTRATION										
NITRATE (PPM)										
SULFATE (PPM)										
HEAVY METAL CONCENTRATION										
MERCURY (PPM)										
LEAD (PPM)										
CHROMIUM (PPM)										
ELEMENTAL LEAD (lbs)										
ELEMENTAL MERCURY (lbs)										
LIQUID ORGANICS										
SOLVENT (TYPE & VOLUME)										
SOLID PHYSICAL CHARACTERISTICS										
STEEL SECTION (L X W X H)(INS)										
WOOD (L X W X H)(INS)										
ROCK (L X W X H)(INS)										
CONCRETE (L X W X H)(INS)										
REBAR (N°)(INS)										
CONTAINER TYPE										

WRAP 2A WASTE FEED CHARACTERIZATION TABLE

6.2 WFQ Testing Needs to Support Design

A. The minimum test and design data required to support the design of the WRAP 2A facility have been defined for the waste mixing and post mixing final treatment areas. This data is broken down into the following:

1. Solidification Pretreatment

   - Process Design Variables
   - Equipment Design Parameters

2. Solidification Mixing

   - Process Design Variables
   - Equipment Design Parameters

3. Solidification Curing

   - Process Design Variables
   - Equipment Design Parameters

4. Solidification Secondary Waste

   - Process Design Variables
   - Equipment Design Parameters

B. The above test and design data is summarized on **Tables 6-6** through **6-8**. Each table describes the test or design data required, need date, and the anticipated source of data. The justification for the data and the design deliverable into which the data will be incorporated is given. The potential impact to the design deliverable schedule is also estimated based upon receiving late or incomplete data.

6.3 Survey of Treatment, Storage and Disposal Facilities

6.3.1 Purpose

A. This survey was undertaken to develop a database of industry contacts and technology associated with Treatment, Storage, and Disposal facilities (TSD's) for hazardous waste. The survey was initially directed at general technology applicable to treatment storage and disposal of any hazardous waste form via stabilization, solidification, or incineration. However, as the survey progressed, contacts were shifted toward technologies that might address specific problems associated with the WRAP 2A WFQ testing or design effort.

B. A specific technology that was addressed that has represented a problem area in the previous WFQ testing included stabilization of mercury to meet TCLP regulatory criteria. Also, technologies dealing with the removal of mercury from solid waste or water using BDAT was investigated. These methods include retorting and activated carbon/ion exchange resins.

TABLE 6-6
SOLIDIFICATION PRETREATMENT DESIGN DATA REQUIREMENT SUMMARY

DATA REQUIRED	DATA NEED DATE	DESIGN JUSTIFICATION	LATE DATA IMPACTS	DESIGN DELIVERABLE	SOURCE OF DATA	WHC RESPONSE DOCUMENT ID
PHYSICAL PRETREATMENT PROCESS VARIABLES						
Dewatering/Filtration/Drying/Absorption Free Water %	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Dewatering/Filtration/Drying/Absorption Particle Size	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Dewatering/Filtration/Drying/Absorption Specific Heat	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Size/Volume Reduction Particle Size	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Size/Volume Reduction Solids Friability	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
CHEMICAL PRETREATMENT PROCESS VARIABLES						
PH Adjustment Waste pH	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
PH Adjustment Target pH	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Heavy Metal Stabilization Heavy Metal Type	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Heavy Metal Stabilization Heavy Metal Concentration	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Soluble Salts Soluble Salt Type	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
Soluble Salts Soluble Salt Concentration	08/93	Reqd for Single Immobil & WFQ Study Assumption Verification	Delay in ACDR Submittal	Single Immobil & WFQ Study	WHC Waste Sampling or Judgement	
EQUIPMENT DESIGN PARAMETERS						
Dewatering/Filtration/Drying/Absorption	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Pretreatment Test Stand Data	
Size/Volume Reduction	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Pretreatment Test Stand Data	
PH Adjustment	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Pretreatment Test Stand Data	
Heavy Metal Stabilization	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Pretreatment Test Stand Data	
Soluble Salts	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Pretreatment Test Stand Data	

TABLE 6-7
SOLIDIFICATION MIXING DESIGN DATA REQUIREMENT SUMMARY

DATA REQUIRED	DATA NEED DATE	DESIGN JUSTIFICATION	LATE DATA IMPACTS	DESIGN DELIVERABLE	SOURCE OF DATA	WHC RESPONSE DOCUMENT ID
PROCESS VARIABLES						
Waste/Binder Ratio & Formulation	08/93	Required for CDR Baseline & Single Immobil Study Assump Verification	Delay in ACDR Submittal	Single Immobil Study	Waste/Binder Formulation Testing	
Mixing Time	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Proof of Prncpl Mixing Test Stand Data	
Mixing Volume	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Proof of Prncpl Mixing Test Stand Data	
Mixing Intensity/Power Input	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Mixing Temperature	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Fluid Vortex/Wave Height	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Waste/Binder Addition Sequence	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Proof of Prncpl Mixing Test Stand Data	
EQUIPMENT DESIGN PARAMETERS						
Agitator/Vibrator Type	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Agitator/Vibrator Diameter	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Agitator/Vibrator Speed or Frequency	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Agitator/Vibrator Location in Vessel	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Mixing Vessel Internals	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Mixing Vessel Geometry	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Agitator Starting Torque	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	

TABLE 6-8
SOLIDIFICATION CURING/SECONDARY WASTE DESIGN DATA REQUIREMENT SUMMARY

DATA REQUIRED	DATA NEED DATE	DESIGN JUSTIFICATION	LATE DATA IMPACTS	DESIGN DELIVERABLE	SOURCE OF DATA	WHC RESPONSE DOCUMENT ID
SOLIDIFICATION CURING PROCESS VARIABLES						
Binder Gel Time	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Waste/Binder Formulation Testing	
Binder Cure Time	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Waste/Binder Formulation Testing	
Curing Temp vs Time	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Waste/Binder Formulation Testing	
Binder/Waste Segregation Tendencies	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Waste/Binder Formulation Testing	
Treated Waste Volume Change During Curing/Cooling	08/94	Required for Detailed Equipment Specification	Delay in Title design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Strength Development During Curing/Cooling	08/93	Required for ACDR Time & Motion Study	Delay in ACDR Submittal	Witness Model	Waste/Binder Formulation Testing	
SECONDARY WASTE GENERATION PROCESS VARIABLES						
Free Liquid Quantity Formed During Curing/Cooling	08/93	Required for ACDR Single Immobil Study Material Balance Verification & WFQ Study Pre/Post Treatment	Delay in ACDR Submittal	Single Immobil & WFQ Studies	Observations During Formulation Testing	
Free Liquid Major Constituents Formed During Curing/Cooling	08/93	Required for ACDR Single Immobil Study Material Balance Verification & WFQ Study Pre/Post Treatment	Delay in ACDR Submittal	Single Immobil WFQ Studies	Observations During Formulation Testing	
Offgas Quantity Formed During Curing/Cooling	08/93	Required for ACDR Single Immobil Study Material Balance Verification & WFQ Study Pre/Post Treatment	Delay in ACDR Submittal	Single Immobil & WFQ Studies	Observations During Formulation Testing	
Offgas Major Constituents Formed During Curing/Cooling	08/93	Required for ACDR Single Immobil Study Material Balance Verification & WFQ Study Pre/Post Treatment	Delay in ACDR Submittal	Single Immobil WFQ Studies	Observations During Formulation Testing	
EQUIPMENT DESIGN PARAMETERS						
Cure/Storage Handling & Monitoring Equipment	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Offgas Handling & Monitoring Equipment	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	
Secondary Liquid Handling & Monitoring Equipment	08/94	Required for Detailed Equipment Specification	Delay in Title Design Equipment Specification	Equipment Specs	Mixing Optimization Test Stand Data	

6.3.2 Summary of Survey

A. See **Table 6-9** for a summary listing of each survey contact. A detailed discussion for each telephone contact of the surveyed companies is given in written telecons in **Appendix A.**

6.3.2.1 General Stabilization/Solidification TSDs

A. A number of facilities contacted provided services for stabilization of hazardous wastes followed by solidification for eventual land disposal. Although these facilities normally supplied the full range of services associated with a TSD, each facility was fairly specific upon what type of wastes they could treat based upon their previous experience. Most could handle moderate levels of heavy metals in the waste, including some Land Disposal Restricted (LDR) metals, if chemical stabilization such as hydroxide or sulfide precipitation was employed.

B. A majority of the TSDs used grouting or cementation as the solidification technique. As such, the accepted level of organics in the waste was usually low (<1.5%). However, the list of inorganic compounds treatable using these technologies (often listed as BDAT) was usually extensive including metal cyanides, pentoxides, chromates, sulfates, sulfides, phosphates, and nitrates.

C. Most of the TSDs contacted have been operating for quite some time. All have been in business for at least 10 years and each has developed a specific clientele base among waste generators. For example, Envirite has been in business for 18 years and principally serves the steel industry in the N.E. U.S. As such their treatment deals with wastes such acids, bases, cyanides, and other inorganic liquids and sludges resulting from the metal finishing industries.

D. Another TSD, Clean Harbors, operates multiple facilities throughout the U.S. and offers a full range of waste management capabilities such as waste treatment via incineration, chemical stabilization, liquid/liquid extraction as well as heavy metals or organics recovery. Heritage environmental services has been in operation for 15 years and offers services similar to Clean Harbors. They have experience in stabilizing heavy metals to meet TCLP by using aqueous pretreatment followed by cement based solidification.

E. The only facility surveyed which did not treat heavy metals to TCLP criteria was Stablex, Canada. Stablex treats waste to the province of Quebec regulatory criteria. These criteria allow leachability tests which are equivalent to the EP toxicity tests that have been replaced in favor of the TCLP tests by the EPA in the U.S. However, Stablex, Canada is owned and operated by Concord Resources Group, Inc. which also owns and operates the Highway 36 Land Development Co. in Colorado. As such Stablex is familiar with U.S. treatment regulatory criteria and is capable of providing chemical stabilization to meet these criteria.

TABLE 6-9

WFQ TSD SURVEY CONTACTS

Name of Company	Location	Telephone Contact	Technology	Comments
Stablex, Canada	Blainville, Quebec	Louise Tremblay (514) 430-9230	Chemical stabilization of inorganic and limited organic wastes followed by cementation solidification and disposal.	Uses similar technology to that used at Highway 36 facility. Treats to leachability tests equivalent to EP toxicity tests.
APTUS	Grantsville, Utah	Allen Carvo (801) 882-8873	Incineration of organics using BDAT. No stabilization of incinerator ash.	Inorganic wastes must be blended with organics to allow treatment. APTUS does not stabilize or dispose of ash themselves, they ship to USPCI or Highway 36.
USPCI	Clive, Utah and Lone Mountain, Oklahoma	Tom Nelson (303) 843-2774	Incineration via rotary kiln and burner kiln. Ash is treated and disposed at Utah site. Lone Mountain site offers chemical stabilization.	Aqueous and organic solvents with limited levels of chlorides and heavy metals are treated via incineration. Stabilization technologies include cyanide/sulfide oxidation, chrome reduction and neutralization.
Yenter Environmental Services	Longmont, Colorado	John Marshall (303) 278-1858	Yenter offers only consolidation and shipment capabilities for bulk waste. They are not a TSD facility.	Act only as a "broker" between waste generator and TSD facility.
Clean Harbors	Cincinnati, Ohio	Bill Dennison (513) 874-5888	Cementation	Multiple locations around country, each specializes to particular wastes.
Heritage Enviro. Services	Indianapolis, Indiana	Ann Hobland (317) 243-0811	Cementation	Aqueous treatment to precipitate LDRs.
Northwest Enviro Service	Seattle, Washington	Sue Thoman (206) 622-1090	Cementation (Kiln Dust)	LDRs chemically converted to hydroxides.
Envirite Corp.	Canton, Ohio	Bob Teeter (216) 456-6238	Cementation	Lime-based cement. Chemical reaction delists LDRs.
EG&G Rocky Flats Plant	Golden, Colorado	Andrea Faucette (303) 966-6420	Heavy metal stabilization, polyethylene encapsulation.	Lab and pilot scale PE extrusion experience with nitrate salts. Production scale test planned. No experience with Hg contam wastes. Extensive TCLP data available with other LDR metals.

TABLE 6-9 (CONTINUED)

WFQ TSD SURVEY CONTACTS				
Name of Company	**Location**	**Telephone Contact**	**Technology**	**Comments**
Mercury Refining, Inc.	Albany, NY	Barbara Sauer (518) 459-0820	Recovery of Hg from bulk waste using BDAT retorting.	Operates mainly as a pretreatment facility for mercury recovery. Chemical fixation or solidification is subcontracted to Chemical Waste Management.
Bethlehem Apparatus, Inc.	Hellertown, PA	John Boyle (215) 838-7034	Mercury recovery from bulk contaminated waste such as soils and sludges.	Facility uses "bell jar" dome batch reactor to retort Hg from waste in-drum. Designing a new facility using semi-continuous operation with increased efficiency. Ship treated waste to another facility for disposal.
Quicksilver Products	Brisbane, CA	Bob Roberts (415) 468-2000	Mercury recovery from mercury containing devices (thermometers, lamps, switches).	No experience with bulk wastes. No disposal capability.
Mercury Recovery Services	Los Angeles, CA	(818) 303-2053	Mercury recovery from mercury devices and crushed fluorescent bulbs.	Not a disposal facility.
Rohm & Haas Co.	Philadelphia, PA	Jim Wilson (215) 592-6712	Mercury removal from waste water using Duolite ion exchange resin.	Market Duolite GT-73 resin which removes mercury or other heavy metals. Resins are regenerable with 35% HCl mineral acids.

6.3.2.2 Incineration/Ash Stabilization TSDs

A. The BDAT for treatment of wastes with high organic content is most often incineration at temperatures sufficient to decompose the organic compounds to harmless gaseous byproducts such as CO_2 and water as well as an ash byproduct. The incinerator ash may be hazardous depending upon heavy metal content and may require stabilization prior to disposal.

B. Of the two incineration TSD facilities contacted (APTUS and USPCI), USPCI was the most versatile and complete. USPCI was capable of treating both solid waste and liquid waste with the highest range of inorganic content. USPCI also operates their own ash stabilization facility (at Grassy Mountain, Utah). The APTUS incineration facility operates a fairly small (15 lb/hr feedrate) unit and does not treat their ash. The ash is shipped to USPCI's Grassy Mountain or Colorado's Highway 36 stabilization facilities.

C. USPCI's Grassy Mountain facility is located in the Great Salt Lake Desert and maintains a Part B permit to dispose of RCRA, CERCLA, TSCA, and industrial wastes. USPCI also operates another treatment and landfill facility at the Grayback Mountain site, adjacent to the Grassy Mountain site, for treatment, storage, and disposal of PCB contaminated wastes. USPCI is also the operator for the Lone Mountain site in Oklahoma which is an EPA, Part B, permitted facility for chemical treatment and disposal of RCRA wastes.

6.3.2.3 Mercury Treatment/Recovery TSDs

A. A number of TSD facilities were surveyed which are capable of removing or recovering mercury from waste. The pretreated waste is then routed to other facilities for final solidification. None of the facilities surveyed were capable of directly solidifying wastes with large quantities of mercury contamination which could directly meet LDR disposal requirements.

B. In all cases the recovery of mercury from solid waste utilized evaporation or retorting which is considered BDAT if mercury concentration exceeds 260 ppm. A few of the facilities (Quicksilver Prod and Mercury Recovery Serv) limited the waste they treated to mercury containing devices such as thermometers, lamps, or switches. However, both Mercury Refining, Inc. and Bethlehem Apparatus, Inc. were capable of recovering mercury from other bulk contaminated wastes such as soils or sludges. Other types of bulk wastes containing high organics content (such as cellulose) were handled by use of high vacuum or inert atmosphere to limit the combustion potential. Retorting temperatures are traded against reactor residence times to provide maximum mercury recovery with minimum waste pyrolysis. Wastes that are relatively non-dense can be retorted in 55 gal drums. However, dense materials such as soils are spread upon trays to maximize surface area.

C. In some cases, trace quantities of other elemental metals can cause problems in the mercury condenser. Cadmium, lead, zinc, and other metals readily form an amalgam with mercury which can easily foul the heat exchangers. Also, the presence of high levels of chlorides or nitrates in the waste can cause excessive corrosion of the retorting equipment which is normally stainless steel construction.

D. Mercury removal from waste water can be accomplished using a selective ion exchange resin with thiol reaction sites. The only resin which is commercially available for this purpose is Duolite GT-73, marketed by Rhom & Haas. This resin will remove only ionic mercury forms. Metallic mercury must be converted to the ionic state via chlorination of the waste water at an acidic pH. The resin is fairly expensive ($850/ft^3) but can be regenerated with 35% HCL to allow reuse from 3 to 4 times.

E. Rocky Flats was contacted regarding their experience with solidification of radioactive waste using polyethylene thermoplastics. Previous contacts indicated that heavy metals had presented problems with TCLP and that pretreatment using calcium oxide was yielding some success. However, RFP has not tested any actual or surrogate waste with mercury to estimate whether chemical stabilization could be effective. Also, they have no documented data that would indicate whether elemental mercury or mercury salts could be volatilized during the PE extrusion process.

6.3.3 Recommendations for Future Work

A. These surveys were undertaken, in part, to give a general review of the state of technology for TSD facilities as well as provide permitting requirements. It is currently assumed that all waste forms for disposal containing LDR metals will need to meet current TCLP regulatory limits. Despite the fact that local variances are possible for specific waste forms (RFP extruded polyethylene waste progress per 6/17/93 telecon with A. Faucette TC93040.008), it is currently assumed that these exceptions will not apply to WRAP 2A. However, it is recommended that further contacts with permitting and regulatory agencies be undertaken to remain up to date with any Federal Register changes.

B. A number of TSD facilities surveyed dealt with specific waste treatment technologies regarding mercury stabilization or recovery. It is recommended that further contacts be made in this area because of the critical impact of past unsuccessful WFQ testing of mercury contaminated waste.

C. Finally, it is recommended that future WFQ work address the uncertainties with respect to treatment of mercury contaminated wastes with thermoplastic polymers. Previous work at RFP has not produced any data indicating the potential for vaporization of mercury or mercury compounds. Methods of pretreatment to stabilize mercury in the form of sulfide compounds should also be investigated.

6.4 Polymer Cure Exotherm/Cooling Estimates

6.4.1 Purpose

A. The purpose of this study is to 1) estimate the peak temperatures caused by polymerization of VES resin mixed with waste in drums, 2) estimate the peak temperatures when molten polyethylene is mixed with waste in drums (or alternately estimate the required polyethylene temperature and/or waste temperature when the mixture temperature is defined), 3) estimate the time required to reach peak VES exotherm temperatures before cooling begins and 4) estimate the cooling time required to cool mixtures of VES polymer or polyethylene and waste in drums. The total time to reach the exotherm (if present) and cool the drums down to a reasonable level where they can be handled safely will then be compared to the 48 hour cure time specified in the FDC. Recommendations for polymer cure time and temperature monitoring will also be presented.

6.4.2 Basis of Study

6.4.2.1 FDC Criteria

A. The FDC specifies that the polymer cure area has a minimum drum residence time of 48 hours.

6.4.2.2 Assumptions

A. General

1. Waste loadings with VES polymer or polyethylene were based on mass balances generated for the Single Immobilization Study, Rev. 2, dated 06/01/93[8].

2. The physical properties of the waste streams and binders were estimated from data available for bulk solids or manufacturer's published literature and are shown in **Table 6-10.**[9,10,11,12]

B. VES Polymer Exotherm Calculations (see **Appendix B**, Calculation of VES Polymer/Waste Exotherms)

1. The heat of reaction for VES resin is 111 BTU/lb of VES resin (based upon Stock Equipment Co. data and independent estimates).

2. Heat loss is not taken into account in the exotherm calculations.

3. VES resin and waste are mixed at 75°F.

4. The total time to reach the temperature exotherm and stabilize the temperature before cooling begins was estimated to be 10 hours based upon Stock Equipment Co. data. Potentially, the rate of reaction as well as the peak exotherm temperature can be adjusted by varying the type and quantity of promoter or catalyst in the formulation. However, the precise impact upon the cure exotherm and product quality must be evaluated through actual full size drum scale testing.

5. Peak exotherm temperatures for waste streams were calculated two ways: 1) by assuming that the water is free water and can be vaporized if the temperatures are sufficiently high or 2) by assuming that water is bound water and is not vaporized but is heated by an increase in sensible heat.

C. VES Polymer/Waste Drum Cooling Calculations (See **Appendix B**, Calculation of VES Polymer/Waste Cooling Curves)

1. Heat transfer is based on unsteady heat conduction in a solid infinite cylinder exposed to a constant temperature boundary condition.[13]

2. Drum diameter is 22.5 inches (55 gallon).

3. The thermal and physical properties (thermal conductivity, K; specific heat, Cp; density, ρ) of the drum contents were calculated as weighted averages of the VES polymer and waste. For some streams where the volume of waste was low due to very high waste density), the properties of 100% VES polymer were used.

TABLE 6-10

WASTE AND BINDERS PHYSICAL PROPERTY DATA						
Waste Feedstreams		Treated Bulk Density (lb/ft^3)	Treated Particle Density (lb/ft^3)	Heat Capacity (BTU/lb°F)	Thermal Conductivity (BTU/hr ft^2(°F/ft)	Moisture Content (Wt%)
Basin 183 Solid Liq	1A	100	130	0.2	0.3	10
Basin 183 Cryst Solids	1B	60	140	0.2	0.2	4
Basin 183 Sludge	1C	69	100	0.2	0.2	44
Basin 183 Misc	1D	75	105	0.2	0.2	--
C018 Salt	2A	88	111	0.25	0.3	10
Ion Exch Resin	2B	55	77	0.3	0.1	55
L045 Sludge	2C	75	140	0.1	0.2	75
RO Filter	2D	40	50	0.3	0.1	50
DAW	3	45	58	0.3	0.12	--
Const Debris	4	60	100	0.2	0.3	--
Amalgamated Mercury	5A1	408	408	0.05	1.0	--
Bulk Mercury	5A2	40	58	0.3	0.1	--
React Metals	5B	200	240	0.11	8	--
Elemental Lead	5C1	710	710	0.03	20	--
Bulk Lead	5C2	80	105	0.3	0.1	--
Misc Metals	5D	450	450	0.1	30	--
Absorb Chem	6	90	90	0.25	0.1	10
Incin Ash	7	35	90	0.3	0.3	
Soils	8	90	90	0.2	0.2	10
Binders						
VES Resin (Derakane 470-36)		65	65	0.29[1]	0.08	--
Polyethylene		57	57	0.55	0.19	--

NOTES: [1] Sensitivity Analysis Performed for Cp = 0.40 BTU/1b°F

4. The heat transfer coefficient was based on an uninsulated drum sitting in still air, the temperature differential between the drum bulk temperature and the ambient air temperature, and the product correction factor.[14] For drums filled with a semi-solid or solid material, the product correction factor was assumed to be 0.40 based on a comparison of the calculated cooling curve with measured temperature data taken from a Stock Equipment Company test report.[15]

5. Ambient air temperature was assumed to be 75°F.

D. Polyethylene/Waste Vibro Mixing Temperature Calculations (see Appendix B, Calculation of Polyethylene/Waste Vibro Mixing Equilibrium Temperatures)

1. Heat loss is not taken into account in the mixing temperature calculations.

2. Polyethylene at 450°F was added to cold waste at 60°F to determine mixture temperatures when one-third of the polyethylene was added at a time and then vibrated. The 450°F temperature is the maximum recommended temperature for low density polyethylene for extrusion processes. Higher temperatures may cause polymer degradation.

3. Water was assumed to be evaporated from waste containing water.

4. Based on the above calculations with polyethylene at 450°F and waste at 60°F, a drum heater was assumed to be needed to preheat the waste and drum from 60°F to 200°F before polyethylene was added.

5. The drum heater was sized by assuming the following:

- Capacity of 4 drums
- Electric air circulation heater
- Drum and waste heated from 60°F to 200°F
- All water evaporated
- Heat transfer coefficient of 2.1 BTU/hr ft^2 °F (natural air convection) to spherical chunks in a drum
- Drum residence time varies from less than one hour to about 6 hours
- Fresh air circulation of 300 CFM

E. Polyethylene/Waste Drum Cooling Calculations (see Appendix B, Calculation of Polyethylene/Waste Cooling Curves)

1. Heat transfer calculations were done using the same assumptions as for VES resin/waste, except the thermal and physical properties of polyethylene were used.

2. Cooling was assumed to begin immediately after the drum was filled with mixed polyethylene and waste.

3. Both extruded and vibro mixed drums were assumed to be cooled from 300°F in 75°F ambient air.

6.4.3 Summary

A. Peak exotherm temperatures for VES polymer/waste mixtures were estimated to range from 181° to 400°F as shown in **Table 6-11**. The heat of reaction for VES resin, originally estimated to be 111 BTU/lb of VES resin, was verified independently by analysis of test data received from Stock Equipment Company.[15] Cooling of hot solidified VES polymer and waste in 55 gallon drums was calculated by using cooling charts developed for the unsteady heat conduction in a solid infinite cylinder exposed to a constant temperature boundary condition.[13] Thermal and physical properties of the solidified mass in a drum were calculated from weighted averages of the properties of VES polymer and the specific waste in a drum. For macroencapsulation of lead where the volume of lead was small compared to the volume of VES polymer, the properties of the solidified mass were assumed to be those of 100% VES polymer. Cooling curves were developed for a range of peak temperatures and cooling rates, as illustrated by **Figure 6-6**. Based on results from Stock Equipment Company tests[15] of VES resin/salt mixtures, a 10 hour delay was added to the cooling curves to allow for the temperature exotherm to stabilize before cooling began. About 48 to 72 hours are required to cool the VES polymer/waste drums to below 130°F.

B. Peak temperatures reached when molten polyethylene at 450°F was vibro mixed with cold (60°F) waste in drums ranged from 197°F to 403°F as shown in **Table 6-12**. The calculations also indicated that adding polyethylene in one-third increments would generally cool the polyethylene/waste mixtures below the 250°F polyethylene solidification temperature, with the distinct possibility of having air pockets trapped in the polyethylene/waste matrix. Preheating the waste and drum to about 200°F using a drum heater was necessary to maintain the 250°F minimum mixture temperature. Polyethylene temperatures of 326°F to 450°F are required to 1) maintain a minimum mixture temperature of 250°F when one-third to two-thirds of the polyethylene is added and 2) to attain a minimum temp of 300°F when all of the polyethylene is added to waste preheated to 200°F. This is shown in **Table 6-13**.

C. Cooling of the 300°F polyethylene/waste mixtures in drums was calculated in the same manner as VES resin, except the thermal and physical properties of polyethylene were used. About 48 hours of cooling is considered adequate to cool the polyethylene/waste mixtures below 130°F as shown in **Figure 6-7**.

D. The recommended cure times for VES polymer/waste mixtures in drums is 72 hours and for polyethylene/waste mixtures in drums is 48 hours. This would make the size of polymer drum cure area vary as follows, based on the average drums per day throughput:

Single Immobilization Case	VES Polymer Only	VES/Grout	Polyethylene Only	Polyethylene/ Grout
Recommended Cure Time	72 hours	72/48 hours	48 hours	48/48 hours
Size of Polymer Drum Storage	244 drums	207 drums	100 drums	74 drums
Size of Grout Drum Storage	0 drums	27 drums	0 drums	27 drums
Size of Combined Drum Storage	244 drums	234 drums	100 drums	101 drums

TABLE 6-11
CALCULATION OF VES POLYMER/WASTE EXOTHERMS

Waste Stream No.	Water Content, wt%	Peak Exotherm * Temperature, °F
Agitated VES Polymer		
1B	4.0	333/362
1C	44.0	212/300
2A	10.0	264/336
2B	55.0	157 (no water vaporized)
2C	75.0	209 (no water vaporized)
5A1	0	400
5B	0	307
6	10.0	212/284
7	0	265
8	10.0	212/297
Vibro VES Polymer		
1A	10.0	276/351
1D	0	254
2D	50.0	160 (no water vaporized)
3	0	181
4	0	214
5A2	0	289
5C1	0	389
5C2	0	183
5D	0	302

* For waste streams containing water, the lower temperature was calculated assuming water is vaporized at 212°F while the higher temperature as calculated assuming no vaporization (sensible heat only).

FIGURE 6-6

RANGE OF COOLING CURVES FOR VES POLYMER/WASTE MIXTURES

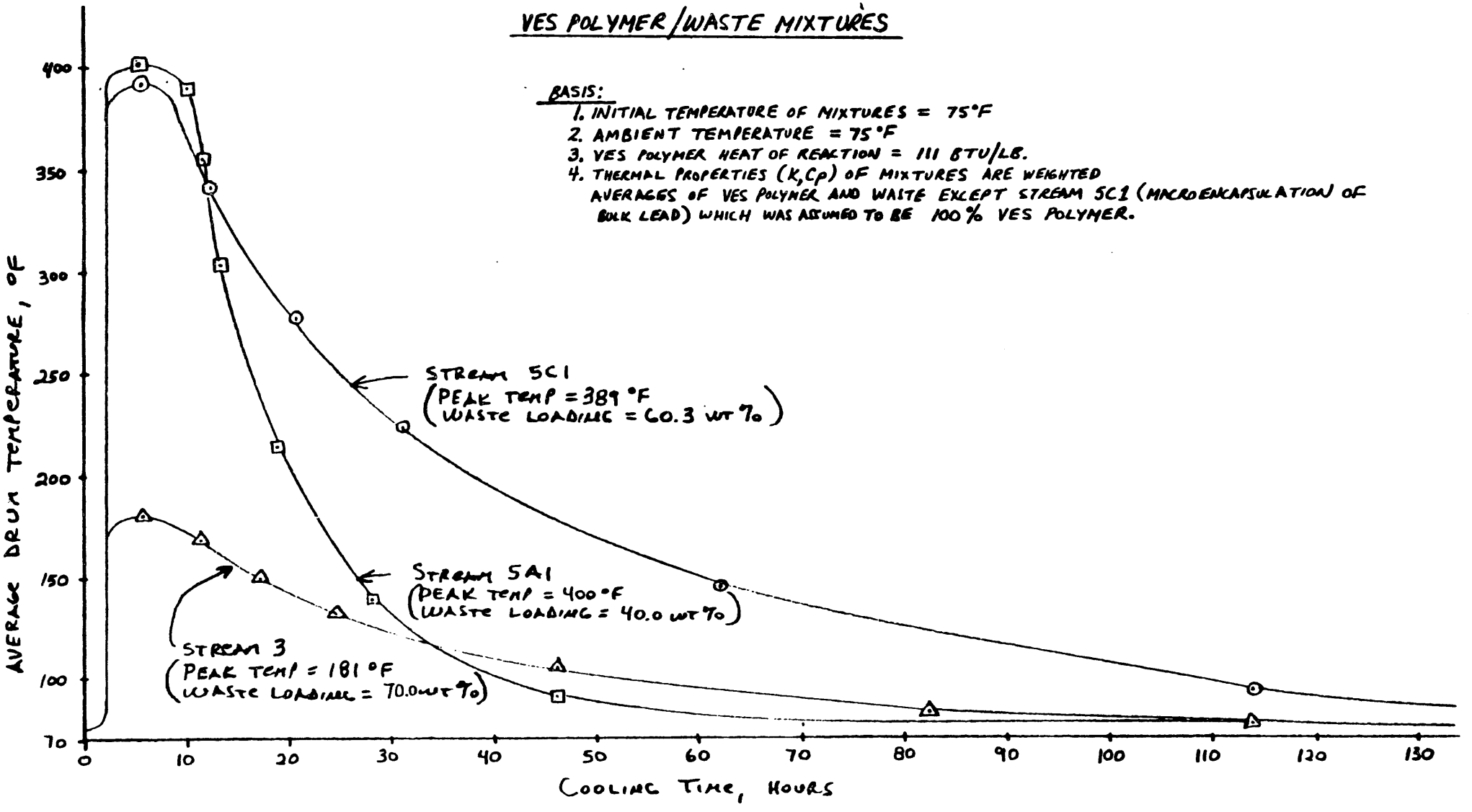


TABLE 6-12
CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Basis: Polyethylene @ 450°F, Waste and Drum @ 60°F (no drum heating)

Waste Stream No.	1/3 Polyethylene Added	2/3 Polyethylene Added	All Polyethylene Added
1D *	200°F	266°F	304°F
3 *	136°F	188°F	225°F
4 *	164°F	224°F	264°F
5A2 *	166°F	227°F	266°F
5C1 *	(Macroencapsulation - all polyethylene added at once)		403°F
5C2 *	138°F	190°F	227°F
5D *	229°F	296°F	332°F
1A (10% water)	212°F	220°F	277°F
2D (50% water)	120°F	163°F	197°F

* These waste streams contain no water.

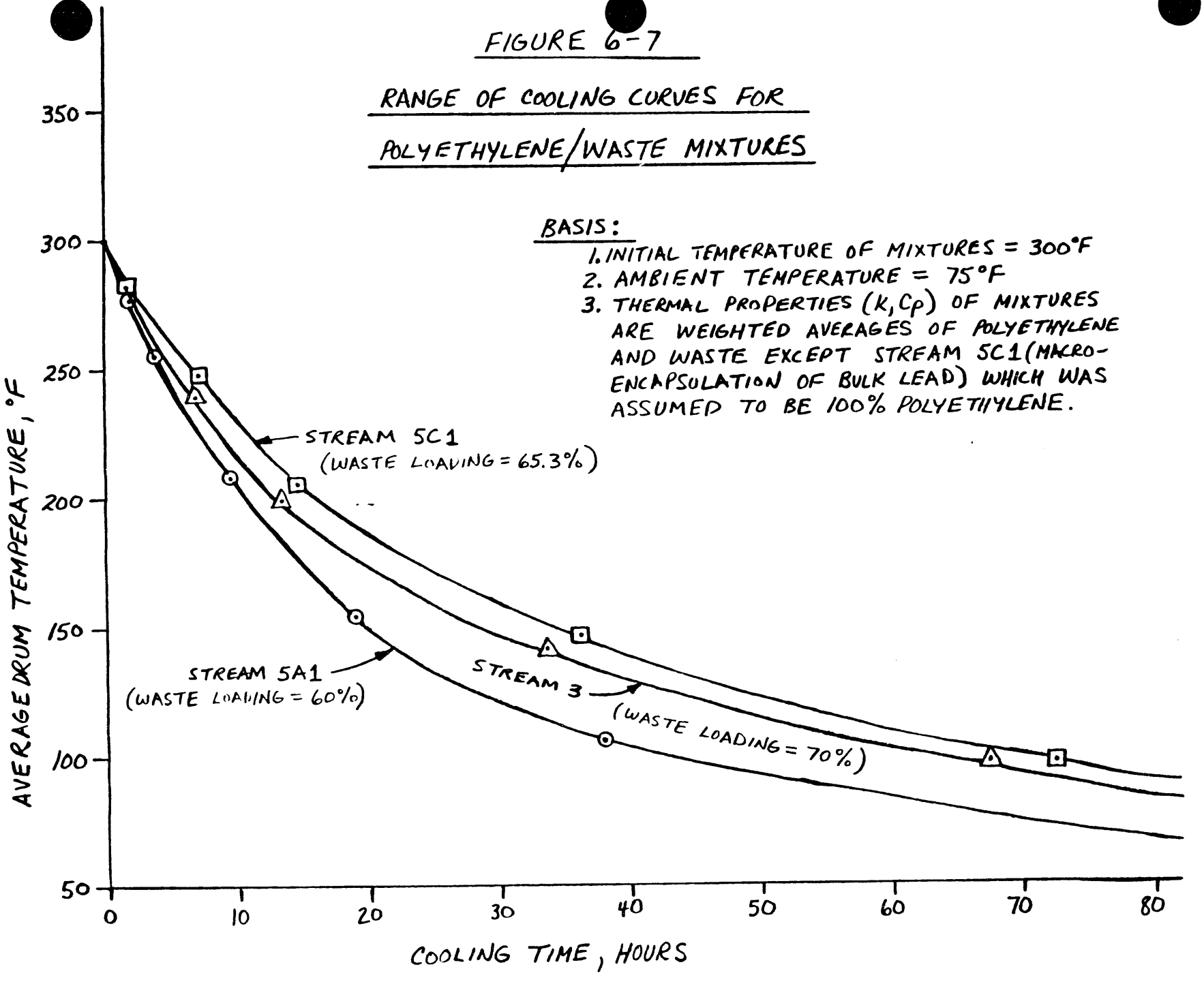
TABLE 6-13
CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES WITH WASTE PREHEATING

Waste Stream No.	Polyethylene Temp, °F	Preheated Waste and Drum, °F	Vibro Mixture Temperature, °F		
			1/3 Polyethylene Added	2/3 Polyethylene Added	All Polyethylene Added
1D	360°F	200°F	257°F	284°F	300°F
3	450°F	200°F	249°F	282°F	306°F
4	392°F	200°F	251°F	281°F	300°F
5A2	389°F	200°F	252°F	281°F	300°F
5C1	333°F	60°F*	(Macroencapsulation - all polyethylene added at once)		300°F
5C2	450°F	200°F	250°F	283°F	307°F
5D	344°F	200°F	262°F	287°F	300°F
1A**	326°F	200°F	271°F	291°F	300°F
2D**	349°F	200°F	261°F	287°F	300°F

* Waste preheating not required.
** Water assumed to be evaporated during preheating.

FIGURE 6-7

RANGE OF COOLING CURVES FOR POLYETHYLENE/WASTE MIXTURES



E. A stacker/retriever drum storage system is recommended based on minimal floor space, improved heat transfer capability due to vertical stacking of drums and the ability to directly interface with Automated Guided Vehicles (AGVs)

F. If intermittent temperature monitoring of the cooling drums is acceptable, portable infrared pyrometers are recommended. If continuous temperature monitoring of drums is required, clamp-on or magnetic thermocouples integrated with a data acquisition system are recommended.

6.4.4 Results

6.4.4.1 VES Polymer

A. VES Polymer Exotherms and Peak Temperatures

1. Heat of Reaction

a. The heat of reaction for VES polymer was estimated to be 111 BTU/lb VES resin based on Dow Chemical Company data.[11] This value was verified independently by calculating the heat of reaction from two test reports by Stock Equipment Company.[15] Salts and catalyzed VES resin were mixed in 55 gallon drums and the time and exotherm measured. These calculations indicated an average of 112.5 BTU/lb for VES resin. The heat of reaction of 111 BTU/lb of VES resin was thus felt to be reasonable for calculation of peak temperatures.

2. Calculation of Peak Temperatures for VES Polymer/Waste Mixtures

a. The peak temperatures reached when catalyzed VES polymer and proposed WRAP 2A waste streams are mixed were calculated using VES polymer and waste weight loadings per drum from the Single Immobilization Study[8] and VES polymer and waste stream heat capacity (Cp) values. This approach, and assuming no heat loss during exotherm, yields the maximum theoretical peak temperature for the mixture of waste and VES polymer. The physical properties (density, heat capacity, thermal conductivity, and moisture content) of the waste feedstreams and binders are given in **Table 6-10**.

b. A summary of the calculated peak temperatures for mixtures of VES polymer and waste feedstreams are shown in **Table 6-11**. When water is present in the feedstream, two values for the peak temperature are given. The first (or lower) value is the peak temperature calculated assuming the water in the waste is free water and can be vaporized. The second (or higher) value is the peak temperature calculated assuming the water in the waste is bound water and is not vaporized. In two of the waste streams containing water, there is insufficient heat in the mixture to reach the boiling point of water, and so no water vaporization is assumed.

3. Once the VES resin is catalyzed, there is a time delay of up to two hours before the resin polymerizes and exotherm begins. The temperature rise caused by the heat of reaction can cause the temperature to increase at a rate of up to 15°F per minute (according to Stock Equipment Company test reports).[15] After this fast increase in temperature, the temperature slows considerably and the peak temperature is reached four to eight hours after the resin is catalyzed. A total of

ten hours was assumed before significant cooling of the salt/VES resin mixture began. This "thermal inertia" was seen in the Stock Equipment Company test reports,[15] and was used in the calculation of the total heatup and cooldown curves for selected VES resin/waste mixtures.

B. Cooling of VES Polymer/Waste Mixtures in Drums

1. Calculation Procedure

a. Cooling of a drum containing a mixture of hot VES polymer and waste involves unsteady heat conduction in a solid. The heat loss for an infinite cylinder with a boundary condition To = constant is given in the book "Fundamentals of Heat Transfer" by Kutateladze in Figure 21, page 114.[13] The heat loss is defined as Q/Q_o where:

$Q_o = (M)(Cp)(T_{START} - To)$
$Q = (M)(Cp)(T - To)$
M = lbs in drum
Cp = BTU/lb°F
T_{START} = bulk (average) temperature of drum at start of cooling, °F
To = boundary condition, °F (in our case, ambient air temperature)
T = bulk (average) temperature of drum at time θ, °F

Thus, the ratio of $Q/Q_o = \dfrac{T - To}{T_{START} - To}$

Q/Q_o is a function of two dimensionless numbers in Figure 21,

the Biot number, $Bi = \dfrac{hR}{K,}$

and the Fourier number, $F_o = \dfrac{\alpha\theta}{R^2}$

where h = heat transfer coefficient, BTU/hr ft² °F
R = radius of cylinder (or drum), ft
K = thermal conductivity, BTU/hr ft² (°F/ft)
θ = time, hours
$\alpha = \dfrac{K}{Cp\,\rho}$
Cp = heat capacity, BTU/lb °F
ρ = density, lb/ft³

b. The K, Cp and ρ values used in the equations are generally weighted averages of the binder (VES polymer or polyethylene) and the waste.

c. This calculation method yields the bulk or average temperature of the drum. The surface temperature of the drum or the center line temperature of the drum can also be estimated from separate curves in Kutateladze's book using the Bi and Fo numbers.

2. Estimation of Heat Transfer Coefficients and Rates of Heat Transfer

a. One of the key variables in determining the heat loss in a drum is the heat transfer coefficient. Generally, the overall heat transfer coefficient for heat loss in still ambient air varies from 1 to 3 BTU/hr ft² °F. In the Tranter Heat

Transfer Manual,[14] page 70 the heat transfer coefficient U is given for heat loss from storage tanks as a function of air velocity, insulation, temperature differential between the product in the task and the air temperature and the product correction factor. For uninsulated tanks in still air, U values are given below:

ΔT, °F	U, BTU/hr ft^2 °F
60	1.8
100	2.1
200	2.7

b. The product correction factor ranges from 1.0 for watery solutions to 0.50 for asphalts and tars.

c. A trial and error approach was used to determine the product correction factor for semi-solid to solid binder/waste mixtures. Temperature data from Test Report No. 343 by Stock Equipment Company was used to determine the product correction factor.[15] The temperature increase and subsequent decrease due to loss of a mixture of waste salts and VES resin is shown in **Figure 6-8**. Using a product correction factor of 0.40, a cooling curve was generated using weighted average K, Cp and ρ values based on values of K. = 0.30 BTU/hr ft^2 (°F/ft), Cp = 0.19 BTU/lb °F and ρ = 69.4 lb/ft^3 for the waste salt. As shown in **Figure 6-8**, the calculated cooling curve matched fairly well with the measured temperature (measured by a thermocouple inside the drum). In this test, the drum reached a peak temperature of 226°F and the ambient temperature was 75°F.

d. Based on the above calculations, a product correction factor of 0.40 was used to calculate heat transfer coefficients and cooling curves for selected waste streams that represent a range of cooling rates. As discussed earlier, cooling was assumed to begin about ten hours after the catalyzed VES resin and waste were mixed. During this ten hour period, the drum would reach a peak temperature in 4 to 8 hours and would not start to decrease in temperature until about 10 hours. Five cooling curves were calculated using VES resin:

Stream No.	Peak Exotherm, °F
100% VES Resin	300°F (for comparison with polyethylene)
3	181°F
5A1	400°F
5C1	389°F
8	297°F

FIGURE 6-8

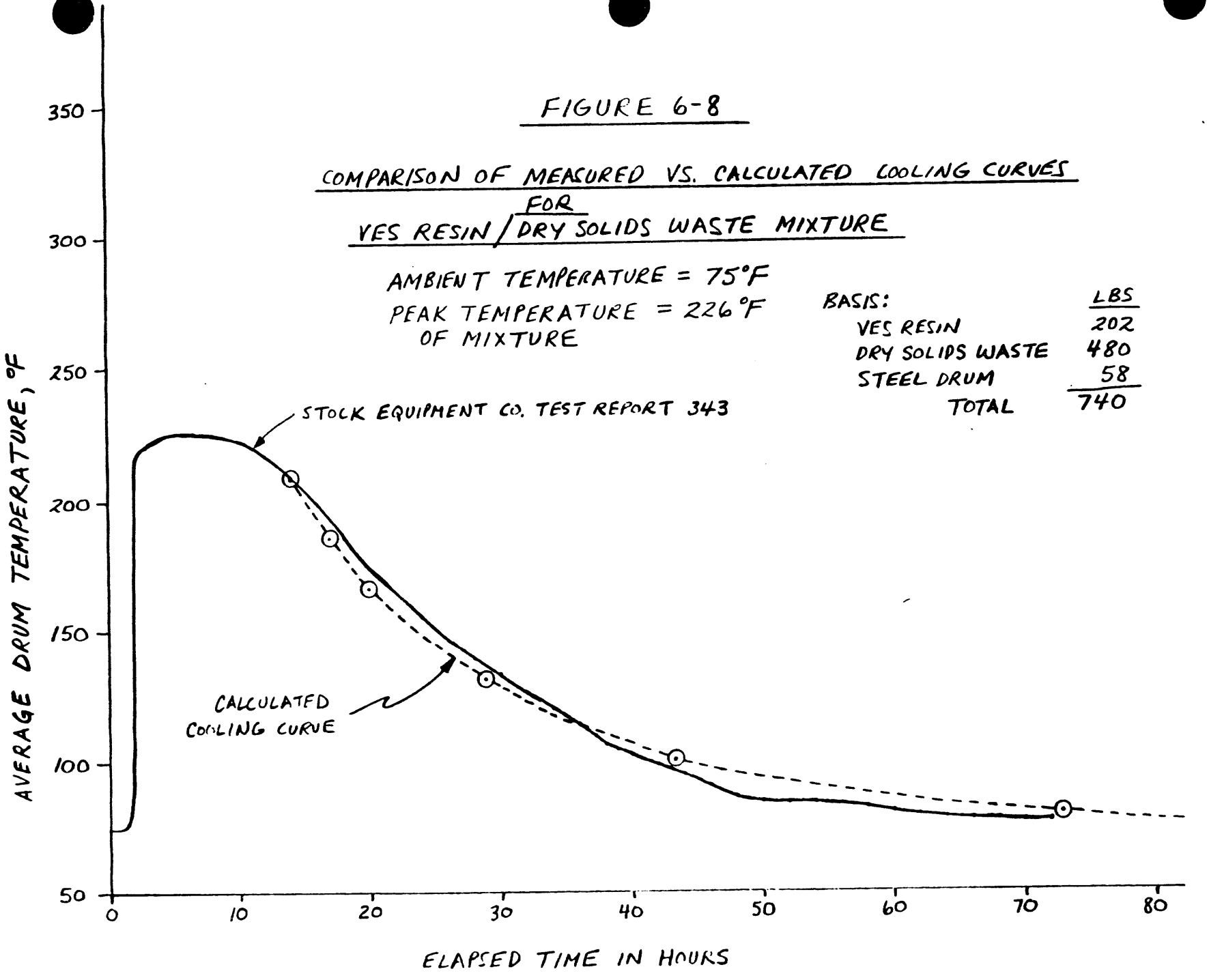
COMPARISON OF MEASURED VS. CALCULATED COOLING CURVES FOR VES RESIN / DRY SOLIDS WASTE MIXTURE

AMBIENT TEMPERATURE = 75°F

PEAK TEMPERATURE = 226°F OF MIXTURE

BASIS:

	LBS
VES RESIN	202
DRY SOLIDS WASTE	480
STEEL DRUM	58
TOTAL	740



e. For Streams 3 and 5A1, weighted average K, Cp and ρ valves were used based on K, Cp and ρ values of VES polymer and the waste. For Stream 5C1, which involves macroencapsulation of bulk lead, the lead comprises only about 12% of the net drum volume of 6.66 ft^3 and thus the K, Cp and ρ values of VES resin were used rather than the weighted average. This will give a much more conservative cooling curve than would a curve calculated using the weighted averages.

f. The cooling curves for VES resin/waste mixtures for Streams 3, 5A1 and 5C1 are shown in **Figure 6-6**. While Streams 3 and 5A1 cool to about 100°F in 48 hours, Stream 5C1 waste takes about 4 days (96 hours) to cool from 389° to less than 110°F. One reason why Stream 5A1 cooled so rapidly is that the thermal conductivity of the waste (amalgamated mercury) is relatively high (1.0 BTU/hr ft^2 (°F/ft) and the heat capacity is very low (0.05 BTU/lb °F). For Stream 5C1 where the thermal properties of the drum were assumed to be 100 percent VES resin, the bulk temperature after 48 hours is estimated to be 175°F and the surface temperature of the drum is estimated to be 95°F. After 72 hours of cooling the bulk temperature of the drum is estimated to be 137°F and the drum surface temperature is estimated to be 81°F.

g. Based on the peak exotherm temperatures shown in **Table 6-11**, about eight of the waste streams show peak exotherms above 300°F. These streams will probably have cooling curves that predict about three days (72 hours) are needed to cooi the drums to temperatures below 130°F, or a total heat loss greater than 75 percent.

h. For those waste streams whose peak exotherm temperatures were below 300°F, a cooling period of 48 hours is probably sufficient to remove about 75 percent of the drum heat content. Those streams containing water can have a significant difference in the peak exotherm temperatures, depending on the assumption of whether or not water is vaporized.

i. If water is assumed to be vaporized, 8 of the 9 streams containing water have peak exotherm temperatures below 300°F. Thus if water vaporization is assumed, 14 of the 19 waste streams have peak exotherms below 300°F and five have exotherms greater than 300°F.

j. Conversely, if water vaporization is not assumed, 12 of the 19 waste streams would have peak temperatures below 300°F and 7 of the 19 waste streams would have peak temperatures greater than 300°F. Thus, a cure time of 48 hours will probably be sufficient for 9 to 13 of the waste streams and a cure time of 72 hours will probably be needed for 6 to 10 of the waste streams.

6.4.4.2 Polyethylene Polymer

A. Vibro Mixing Equilibrium Temperatures Without Drum Heating

1. Polyethylene binder can be mixed with waste and extruded at 300°F or the molten polyethylene can be added to waste in a drum and vibrated to promote mixing. Nine waste streams would use vibro mixing of polyethylene and waste. Calculations were performed to determine the mixture temperature when hot (450°F) molten polyethylene is added to cold (60°F) waste. Polyethylene would probably be added in portions and then vibrated to assure the polyethylene completely filling in the void spaces in the waste. The equilibrium temperatures were calculated when one-third, two-thirds and all of the polyethylene was added to eight of the waste streams. For Stream 5C1, where bulk lead bricks are macroencapsulated with polyethylene, all of the polyethylene was assumed to be added in one continuous pour. Results of these calculations are shown in **Table 6-12.** The table shows that except for Stream 5C1, the mixture temperature (assuming all of the waste is heated to the equilibrium temperature when the polyethylene flows down through the waste to the bottom of the drum) is below the solidification temperature of polyethylene (approximately 250°F[12]) for eight of the wastes when one-third of the polyethylene is added and is still below the solidification temperature for six of the waste streams when two-thirds of the polyethylene is added. When all of the polyethylene is added, three of the waste streams are still below the solidification point. This means that there is a good possibility that air could be trapped in the mixture since the polyethylene may be solidifying before the air rises to the top of the mixture. Encapsulated waste with air pockets would not pass FDC criteria for uniform mixing or TCLP leaching criteria. External heating of the waste is required for two reasons: 1) to raise the temperature of the waste sufficiently so that mixtures that contain only one-third of the polyethylene would have mixture temperatures exceeding the 250°F solidification temperature and 2) to remove water (in two of the waste streams) by evaporation.

B. Drum Heater for Waste Vibro Mixed with Polyethylene

1. Preliminary specifications for a drum heater were determined based on the following assumptions:

   - Drum and waste heated from 60°F to 200°F.
   - Heating accomplished by an electrically heated air circulation heater.
   - Heater will have drums delivered to an inlet conveyor by an Automated Guided Vehicle (AGV) and picked up on an outlet conveyor by the same AGV.
   - Heater will have roll-up doors at the inlet and outlet.
   - Heater will be designed to hold up to four drums at a time on a queuing roller conveyor.

- For heat transfer purposes, the waste was assumed to be in 2" spherical chunks and heated by natural air convection inside the drum. An overall heat transfer coefficient of 2.1 BTU/hr ft^2 °F was assumed.

2. Based on the number of vibro drums per day and the heating duty required for each type of drum, the heating duty was calculated to be about 100,000 BTU/hr or about 36 KW. Drum residence time in the heater would vary from less than one hour to about 6 hours per day. It is conceivable that the heater could be filled with drums requiring a longer residence time and left on overnight to insure the heater dos not become a bottleneck to plant throughput. Air circulation has been estimated to be 300 CFM of fresh air and possibly 200 CFM of recirculation air for a total air circulation of 300 to 500 CFM.

C. Vibro Mixing Equilibrium Temperatures with Drum Heating

1. The mixture temperatures of vibro mixed polyethylene and waste heated to 200°F were checked to see if the temperatures at one-third and two-thirds filling with polyethylene would exceed the 250°F polyethylene solidification temperature. The two waste streams (1A and 2D) that originally contained water were assumed to be dry at 200°F. The calculations are summarized on **Table 6-13**. The table shows that in order to attain a final mix temperature arbitrarily set at 300°F minimum (to match the 300°F temperature of polyethylene/waste mixtures leaving the extruder), the mixture temperatures barely meet the 250°F level for four of the waste streams. This includes two streams where 450°F polyethylene (felt to be the maximum allowable temperature) is mixed with waste heated to 200°F. Generally, the polyethylene requires heating from 326°F to 392°F to attain a mixture temperature of 300°F.

2. In order to insure that the 250°F solidification threshold is exceeded, the waste could be preheated to a slightly higher temperature (say 215° to 225°F) in the drum heater by increasing the residence time in the heater. Polyethylene could be added at two or three temperature levels (say 350°F, 400°F or 450°F), especially if only one or two types of waste were processed in the plant per day. Only one waste (Stream 5C1) would not require drum heating in order to reach the 300°F final mixture temperature.

D. Cooling of Polyethylene/Waste Mixtures in Drums

1. All drums of waste encapsulated with polyethylene were assumed to have a final mixture temperature of 300°F. The calculation of heat loss was similar to that for VES polymer except the waste loadings and physical properties of polyethylene were used. Cooling curves were calculated for the following waste streams:

Stream No.

100% Polyethylene (for comparison with VES Resin)
3
5A1
5B
5C1
6

2. Based on thermal properties of the polyethylene/waste mixtures, Stream 6 was felt to have the slowest cooling rate. The calculated cooling curve for Stream 6 is shown in **Figure 6-9**. This curve indicates that the drum temperature would decrease to 132°F after 48 hours and to 105°F after 72 hours. The 132°F average drum temperature is felt to be a safe temperature to handle the drum, especially since the outside of the drum will be considerably cooler than the inside.

3. The cooling curves for polyethylene/waste mixtures for Streams 3, 5A1 and 5C1 are shown in **Figure 6-7**. All three streams mixed with polyethylene indicate bulk drum temperatures drop below 130°F after 48 hours of cooling. Surface temperatures of the drum would probably be below 100°F after 48 hours.

6.4.5 Recommendations

6.4.5.1 VES Polymer/Waste Cure Time

A. Although the outside surface of the VES polymer/waste drums is generally cooled below 110°F after 48 hours, the bulk or average temperature of the drums can be considerably higher, generally above 140°F for about one-third to one-half of the drums (maximum of 175°F). This leaves about 25 to 30 percent of the heat in the drums (assuming the ambient temperature is 75°F). This heat will have to be removed in another storage area if it is not removed in the cure area. It is recommended that the VES polymer cure area be sized to allow 72 hours of residence time uniformly for all VES polymer/waste drums. This allows for some uncertainty in the drum temperature calculations, and allows those drums whose bulk temperature is above 140°F to cool down to a more reasonable level around 100°F. If three days of cure storage are used, space for about 244 drums will be required for the VES polymer only case (not counting the campaigned special waste Streams 5A1, 5A2 and 5B). For the VES polymer and grout case, space for 207 drums would be needed in the polymer cure area.

6.4.5.2 Polyethylene/Waste Cure Time

A. After 48 hours of cooling, the polyethylene/waste drums are generally cooled to below 130°F, and in some cases below 100°F. This faster cooldown is primarily due to two factors: 1) the polyethylene/waste mixtures can begin cooling immediately once the drum is filled while the VES polymer/waste streams have a delay of about 10 hours after drum filling to allow for the VES polymerization exotherm to take place and stabilize and 2) peak temperatures for polyethylene/waste will be about 300°F while peak temperatures for VES polymer/waste can exceed 400°F. A side by side comparison of the cooling curves for 100% VES polymer and 100% polyethylene shows very little difference in cooling rates (**Figure 6-10**). It is recommended that the polyethylene cure area be sized to allow the FDC requirement of 48 hours of residence time. For the polyethylene only case, space for about 100 drums would be needed excluding the campaigned special waste Streams 5A1, 5A2 and 5B. For the polyethylene/grout case, space for about 74 drums would be required in the polymer cure area.

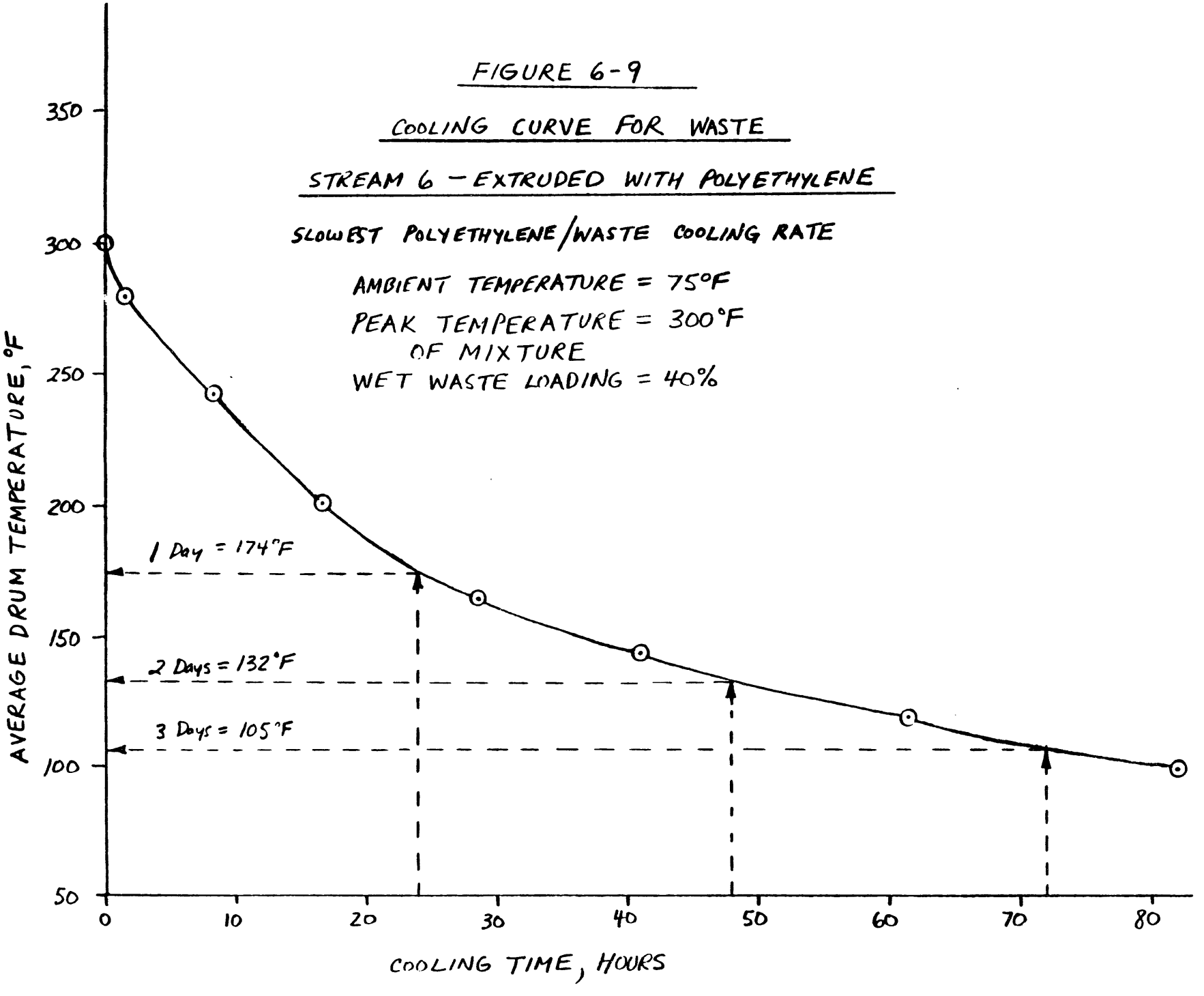
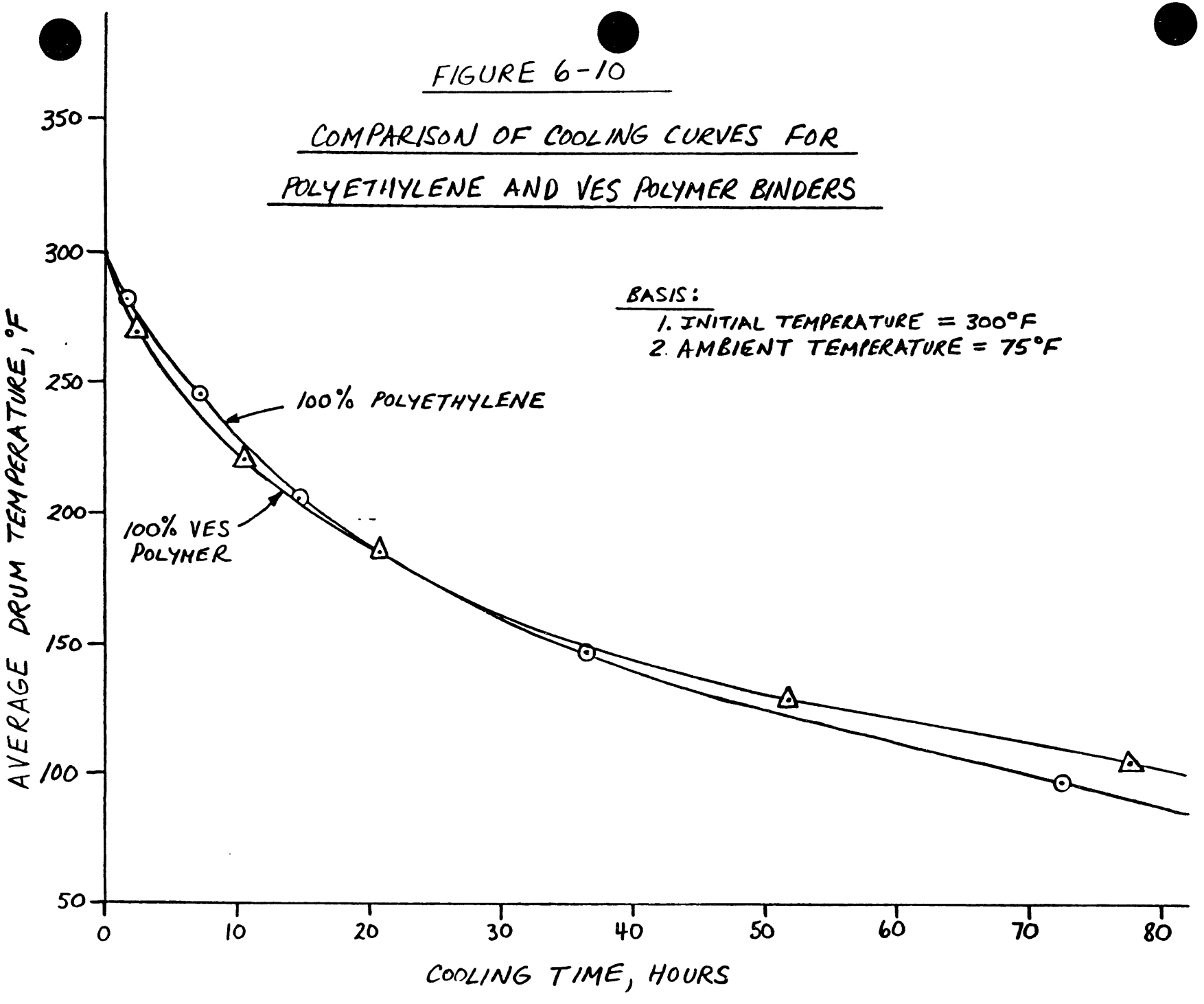


FIGURE 6-9
COOLING CURVE FOR WASTE
STREAM 6 – EXTRUDED WITH POLYETHYLENE
SLOWEST POLYETHYLENE/WASTE COOLING RATE
AMBIENT TEMPERATURE = 75°F
PEAK TEMPERATURE = 300°F
OF MIXTURE
WET WASTE LOADING = 40%
1 Day = 174°F
2 Days = 132°F
3 Days = 105°F
AVERAGE DRUM TEMPERATURE, °F
350
300
250
200
150
100
50
0
10
20
30
40
50
60
70
80
COOLING TIME, HOURS

FIGURE 6-10

COMPARISON OF COOLING CURVES FOR POLYETHYLENE AND VES POLYMER BINDERS



6.4.5.3 Configuration of Cure Area

A. Drums can be stored in a variety of ways: on a concrete floor, on a queuing type of roller conveyor or on shelves utilizing a stacker/retriever system. Since drums will be dropped off and picked up by AGV vehicles, the storage area should be such that drums can easily be retrieved and loaded onto an AGV. This would tend to eliminate floor storage, which would also be poor in terms of heat transfer since cooling air would only reach the drums in one horizontal plane. A single conveyor or more likely multiple queuing conveyors would interface well with an AGV, but the size of the drum storage required for either VES polymer or polyethylene would require many conveyors at a high total cost. Conveyors would also require a lot of floor space. A drum stacker/retriever would be recommended for the following reasons: 1) floor space would be minimized since drums could be stacked vertically in tiers 5-10 drums high, 2) a stacker/retrieval system would interface well with an AGV and 3) the vertical configuration of the stacker/retriever would promote a "chimney effect" caused by the natural convection of hot air. This natural convection would promote a higher heat transfer coefficient and thus higher exit air temperatures, reducing the amount of air circulation required.

6.4.5.4 Drum Temperature Monitoring

A. Drum temperature would need to be monitored, at least on a spot basis (if not for all drums), to assure that hot drums (above 140°F) are not removed from the polymer cure area prematurely. Drum temperature could be monitored by internal thermocouples (this could be quite expensive but would integrate well with a data acquisition system), external surface thermocouple or surface thermometers (again surface thermocouples would work well with a data acquisition system) or portable infrared pyrometers. The latter two alternatives would give surface temperatures but would not tell the internal or bulk temperature. Correlations could be developed however, that allow the internal temperature to be estimated based on a measurement of the external temperature. Since the temperature patterns of drums filled with the same type of polymer and same type of waste will tend to be somewhat uniform, monitoring of each drum is not considered absolutely necessary, and portable infrared pyrometers are recommended to scan the drums and locate hot drums. If each drum would need continuous monitoring, clamp-on or magnetic surface thermocouples would be recommended.

6.4.5.5 Drum Temperature Correlations

A. Full scale tests using 55 gallon drums are recommended in which internal and external thermocouples are used to measure drum temperatures from drum filling through peak exotherm or peak mixing temperature until cooldown is completed. Tests should be conducted using 100% of the polymer selected from the Single Immobilization Study[8] as well as polymer and surrogate waste mixtures which represent a range of thermal properties and waste loadings. This would give a range of peak temperatures and cooling rates from which to develop correlations. Thermocouples should be placed in the drum at the drum centerline, about one-third and two-thirds of the radial distance from the center line to the drum wall, about 1-2 inches from the drum wall and on the outside of the drum. Temperature data gathered from such tests would be used to develop correlations between the outside surface temperature of the drum and the inside or bulk temperatures of the polymer or polymer/waste matrix. This data will be useful in estimating the bulk drum temperature of a polymer/waste mixture from drum surface temperature measurements. If such tests are undertaken, accurate physical properties of the selected polymer and surrogate wastes (particle density, heat capacity and thermal conductivity) waste will also be required.

7.0 SENSITIVITY ANALYSES

7.1 VES Resin Heat Capacity

The maximum cure exotherm temperature of waste mixed with VES resin is a function of the physical properties of the waste and binder, waste loadings in binder, and water content of waste if vaporization of water is assumed to occur. The physical properties of binder which are critical for temperature rise and heat loss to the surroundings are specific density, thermal conductivity and specific heat. The study used the following values representing these properties for the solidified VES resin:

Density:	54 lb/ft^3
Thermal Conductivity:	0.08 BTU/hr ft^2 °F/ft
Heat Capacity:	0.29 BTU/lb°F

The above values were obtained from Dow Chemical product literature (Derakane Chemical Resistance and Engineering Guide) and represent Derakane 470 or 411 resins.

A sensitivity analyses was performed to determine the effect of VES resin assumed heat capacity on the peak monolith exotherm temperature. The same feedstreams as those identified for either agitated or vibro encapsulation in VES used previously were compared assuming heat capacities of 0.29 BTU/lb°F and 0.40 BTU/lb°F. The latter value was suggested by WHC as representing other literature sources for VES resin heat capacity.

The following table (Table 7-1) gives the maximum calculated cure temperature for each feedstream at either assumed heat capacity as well as the change in temperatures resulting from the higher assumed heat capacity.

TABLE 7-1

Waste Stream	Maximum Cure Temperature, °F		
	@Cp Pol = .29 BTU/lb °F	@Cp Pol = .40 BTU/lb °F	Temperature Decrease
5A1	418°F	331°F	87°F
5B	319°F	271°F	48°F
7	274°F	241°F	33°F
1_3D	263°F	234°F	29°F
3	187°F	176°F	11°F
4	222°F	203°F	19°F
5A2	302°F	260°F	42°F
5C1	406°F	324°F	82°F
5C2	187°F	176°F	11°F
5D	312°F	267°F	45°F

7.2 Drum Mass Effect Upon VES/Waste Exotherm

Initial exotherm calculations for mixed VES resin with waste were performed assuming that the effect of the steel drum upon the maximum temperature rise was neglegible. This assumption was made for the following reasons:

- Weight of steel drum (50 to 60 lbs) is low compared to the total mass of the treated waste monolith (5 to 10 percent)

- Specific heat of the steel drum is low (0.12 BTU/lb°F) compared to that of the VES polymer (0.29 to 0.40 BTU/lb°F).

- Drum temperature would probably never reach the peak exotherm temperatures of the VES resin since it is on the outside of the curing monolith, exposed to ambient air, and has a much higher thermal conductivity (30 BTU/hr ft^2 °F/ft) than VES resin (0.08 BTU/hr ft^2 °F/ft).

However, additional exotherm calculations were performed assuming that the drum weight was added to the mass of the VES and waste monolith and that the maximum temperature is equivalent throughout the drum and monolith. These maximum exotherms were calculated for all of the WRAP 2A feedstreams using the same waste loadings as used in the previous calculations. The exotherm, as before, were also calculated assuming either all water is vaporized or no water is vaporized for those feedstreams containing water. Revised cooling curves were produced for VES polymer/waste mixtures for feedstreams 3, 5A1 and 5C1.

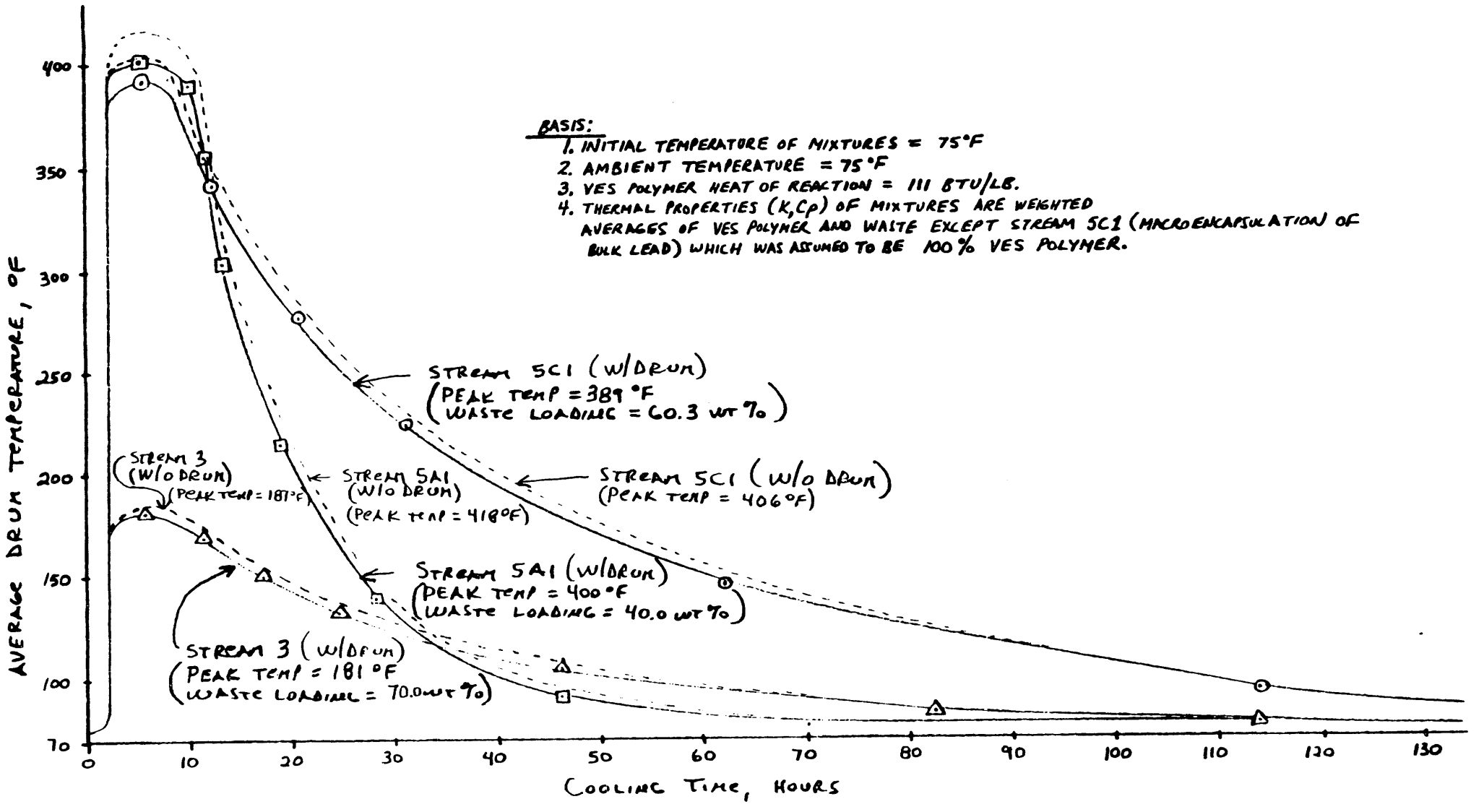
Table 7-2 shows a comparison between the initial calculations which ignored drum mass and the revised calculations which include a drum mass of 58 lb. As shown, the maximum temperature impact is for feedstream 5A1 which had the highest initial exotherm of 418°F. Including the drum mass drops the maximum exotherm to 400°F, which can be considered a minor change. However, the revised temperature could be considered a major change if the temperature drops below the water vaporization point. This does occur for Feedstream 2C, metal hydroxide sludges, which have a peak temperature reduction from 213°F to 209°F. This feedstream has a high inherent moisture content of 75 wt %. Therefore, the 4°F temperature drop could indicate considerably less water vaporization. However, this estimate must be confirmed via actual full scale testing due to the numerous assumptions involved in the calculation.

Figure 7-1 shows the sensitivity of VES resin/waste cooling curves to the mass of the drum and waste feedstreams 3, 5A1 and 5C1. The maximum peak exotherm temperature is reduced by 6°F, 18°F and 17°F for each feedstream, respectively. There is not an appreciable change in the cooling time required to reach average drum temperatures of 100°F or less.

TABLE 7-2
VES RESIN/POLYMER EXOTHERM SENSITIVITY COMPARISON

Agitated VES Polymer		Peak Exotherm Temperature, °F			
		All Water Vaporized		No Water Vaporized	
Stream No.	Assumed % Water	w/Drum	w/o Drum	w/Drum	w/o Drum
1B	4.0	333	347	362	377
1C	44.0	232	212	300	309
2A	10.0	264	273	336	348
2B	55.0	---	---	157	159
2C	75.0	---	212	209	213
5A1	0	---	---	400	418
5B	0	---	---	307	319
6	10.0	212	212	284	294
7	0	---	---	265	274
8	10.0	212	212	297	308
Vibro VES Polymer					
1A	10.0	276	286	351	364
1D	0	---	---	254	263
2D	50.0	---	---	160	163
3	0	---	---	181	187
4	0	---	---	214	222
5A2	0	---	---	289	302
5C1	0	---	---	389	406
5C2	0	---	---	183	187
D	0	---	---	302	312

FIGURE 7-1
VES RESIN/WASTE COOLING CURVE SENSITIVITY



8.0 REFERENCES

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3. Washington Administrative Codes 173-303. Dangerous Waste Regulations.

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16. Draft WRAP 2A Feedstream Specification Data, WHC, June 1, 1993.

APPENDIX A

WFQ TSD TELECONS

UNITED ENGINEERS & CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 4/12/93
Time: 9:00 a.m.

From:	R.L. HENKEL	**To:**	LOUISE TREMBLAY
Company:	UE&C	**Company:**	STABLEX CANADA
Phone:	(303) 843-3297	**Phone:**	(514) 430-9230
Project No.:	6237.008		
Subject:	WFQ TSDF SURVEY - STABLEX CANADA EXPERIENCE BASE		

Topics of Conversation:

1. Stablex Canada was contacted for their experience as a Treatment Storage and Disposal (TSD) Facility. Stablex Canada is owned by Concord Resources group, Inc. who also owns Highway 36 Land Development Co. Highway 36 is a TSD facility is eastern Colorado that was toured by WHC and BNFL in January of this year.

2. Stablex is located in Blainville, Quebec and is a full service facility capable of waste characterization confirmation, waste stabilization, solidification, and ultimate disposal. Stablex treats a diverse range of hazardous industrial wastes and uses specific BDAT when applicable to a waste type (see Attachment). The facility has been in operation for approximately 10 years at this site. Stablex treats waste to the province of Quebec regulatory requirements. However, even though they are not directly regulated by the EPA, Stablex performs leachability tests mandated by MENVIQ (Ministere de l'Environment du Quebec) which are similar to EP toxicity leachate tests.

3. Stablex is capable of treating a wide range of inorganic compounds such as heavy metals, cyanides, fluorides, nitrates, and sulfates. However, they will not accept wastes with elemental mercury or significant levels of organics (other than oils or greases). They limit ammonia content to 0.5% in solid wastes and 3.0% in liquid wastes.

4. Stablex does not treat reactive wastes defined as explosive, flammable, pyrophoric, radioactive, shock sensitive, or waste capable or releasing gas when reacted with water or alkalis. They also rule out wastes such as mercaptans or hydrogen sulfide which can produce odors at low concentrations. Stablex also will not treat waste particles if they are both non-soluble or non-dispersable as well as debris larger than 6" in size.

R. L. Henkel

R.L. Henkel

Attachment

Revision #14: 03/09/92

STABLEX CANADA INC.

APPLICABLE STANDARDS OF ACCEPTANCE
FOR TREATMENT AND DISPOSAL
OF DRUM AND BULK SHIPMENTS
OF INORGANIC INDUSTRIAL WASTE MATERIAL

I. BASE PRICE - Specific parameter limits

A) HEAVY METALS - total leachable*

HEAVY METALS	PPM	HEAVY METALS	PPM
Aluminum	420.0	Iron	420.0
Antimony	158.0	Lead	27.0
Arsenic	32.0	Manganese	53.0
Barium	840.0	Mercury	1.3
Beryllium	.53	Molybdenum	21.0
Bismuth	53.0	Nickel	840.0
Boron	3150.0	Selenium	6.3
Cadmium	4.2	Silver	21.0
Chromium	21.0	Tin	189.0
Cobalt	53.0	Vanadium	105.0
Copper	63.0	Zinc	420.0

B) ANIONS - maximum concentration in waste

ANIONS	PPM
Ammonia	300
Fluorides	1575

C) TOTAL ACIDITY - maximum concentration in waste

1% max.(expressed as grams of calcium hydroxide per 100 grams of waste)

I. <u>BASE PRICE</u> - Specific parameter limits (cont'd)

D) ORGANICS - maximum concentration in waste

ORGANICS	CONCENTRATION
Oil and grease (%)	5
PCB (ppm)	0
T.O.X (ppm)	15

E) ORGANICS - total leachable * (ppm)

	BULK		DRUM	
ORGANICS	SOLIDS	LIQUIDS	SOLIDS	LIQUIDS
Phenols	16	16	16	16
T.O.C.	1200	5000	1200	5000

F) ANIONS - total leachable

ANIONS	CONCENTRATION
Cyanide (ppm)	6

II. SPECIFICALLY PRICED MATERIAL - PARAMETER LIMITS

A) HEAVY METALS - total leachable * (ppm)

	BULK		DRUM	
HEAVY METALS	SOLIDS	LIQUIDS	SOLIDS	LIQUIDS
Arsenic	210	420	1050	2100
Boron	21000	42000	105000	210000
Beryllium	2.1	4.2	10.5	21
Bismuth	210	420	1050	2100
Antimony	630	1260	3150	6300
Selenium	42	84	210	420
Vanadium	420	840	2100	4200
Molybdenum	210	420	1050	2100
Others metals listed in I.A)	No limit	No limit	No limit	No limit

B) ANIONS - maximum concentration in waste

	BULK		DRUM	
ANIONS	SOLIDS	LIQUIDS	SOLIDS	LIQUIDS
Ammonia (%)	0.5	3.0	0.5	3.0
Cyanides (ppm) pH>8	No limit	No limit	No limit	No limit
Fluorides (ppm)	No limit	No limit	No limit	No limit

C) ACIDITY OR ALKALINITY

No limit

III. EXCLUSIONS

(Non compatible with the Stablex process or excluded from our permit)

REACTIVITY

- Explosive
- Flammable (flash point lower than 125° F)
- Pyrophoric
- Radioactive
- Reactivity with water and alkalis releasing gas
- Shock sensitive

ORGANICS

- Dioxins
- Furans
- No free organics - layer(s) or phase(s) floating on top
- Infectious or biological
- Pesticides, herbicides, insecticides
- Biodegradable

ODOR FREE

- Any other waste producing a strong odor at low concentrations
- Hydrogen Sulfide
- Mercaptans

OTHERS

- Metallic mercury, metallic aluminum
- Nodules non soluble in water or non dispersable, mechanically or chemically, non crushable, rubbery or monolithic plastic type that do not meet the MENVIQ (**) or E.P. toxicity leachate tests.
- Material must be free of debris (boulders larger than 6 inches, scrap wood, pipes, etc...)

LEACHATE PROCEDURE (STANDARDS BEFORE TREATMENT)

To one (1) part of waste material, add twenty (20) part of alkaline water so that pH >12, stir 30 minutes and filter. Testing to be carried out on filtrate

(*) Leachable means: amount of species that leach out of the waste material.

(**) Ministère de l'Environnement du Québec

N.B. All above listed parameters are subject to changes without notice.

JANUARY 1992

STABLEX CANADA INC.

GENERAL WASTE CATEGORIES ACCEPTED UNDER CURRENT PERMIT
(BASED ON SAMPLE REVIEW)

WASTE DESCRIPTION	WASTE CODE	REMARKS
Acids + Alkalis	D002	
Reactive	D003	Sulfide & cyanide only
Arsenic	D004	
Barium	D005	
Cadmium	D006	
Chromium	D007	
Lead	D008	
Mercury	D009	Except pure metal form
Selenium	D010	
Silver	D011	
Metal Hydroxide Sludge / Waste Water Sludge Electroplater	F006	Meet BDAT *
Spent cyanide plating bath solution	F007	Meet BDAT *
Plating bath residues with cyanides	F008	Meet BDAT *
Spent stripping and cleaning bath solution	F009	Meet BDAT *
Quenching bath residues with Cyanides	F010	
Spent cyanide solution from salt bath	F011	Meet BDAT *
Quenching waste water treatment	F012	Meet BDAT *
Wastewater treatment sludges from the chemical conversion coating of aluminum	F019	
Waste treatment sludge/pigments	K002	
" " " "	K003	
" " " "	K004	Treated & disposed according to Quebec regulations

(*) BDAT: Best Demonstrated Available Technology

STABLEX CANADA INC.

GENERAL WASTE CATEGORIES ACCEPTED UNDER CURRENT PERMIT (BASED ON SAMPLE REVIEW)

WASTE DESCRIPTION	WASTE CODE	REMARKS
Waste treatment sludge/pigments	K005	Treated & disposed according to Quebec regulations
Waste treatment sludge/pigments	K006	
Waste treatment sludge/pigments	K007	Treated & disposed according to Quebec regulations
Oven residue	K008	Treated & disposed according to Quebec regulations
Wastewater treatment sludges from the manufacturing, formulation and loading of leadbase initiating compound	K046	
Heat exchanger bundle cleaning sludge from petroleum refining ind.	K050	
API separator sludge from petroleum refining ind.	K051	
Tank bottoms (leaded)	K052	
Emission control dust/sludge from the primary production of steel in electric furnaces	K061	Meet BDAT *
Spent pickle liquor generated by steel finishing operations of facilities within the iron and steel industry	K062	Limited concentration
Emission control dust & sludge from secondary lead smelting	K069	Limited concentration
Brine purification muds (1)	K071	Currently under evaluation for BDAT requirements
Waste leaching solution from acid leaching of emission control dust/sludge	K100	

(*) BDAT: Best Demonstrated Available Technology

STABLEX CANADA INC.

GENERAL WASTE CATEGORIES ACCEPTED UNDER CURRENT PERMIT (BASED ON SAMPLE REVIEW)

WASTE DESCRIPTION	WASTE CODE	REMARKS
Wastewater treatment sludge from mercury cell process	K106	
Arsenic acid	P010	
Arsenic Pentoxide	P011	
Arsenic Trioxide	P012	
Barium Cyanide	P013	Meet BDAT *
Calcium Cyanide	P021	Meet BDAT *
Copper cyanide	P029	Meet BDAT *
Soluble cyanide salts not elsewhere specified	P030	Meet BDAT *
Nickel Cyanide	P074	Meet BDAT *
Osmium tetraoxide	P087	
Potassium Cyanide	P098	Meet BDAT *
Potassium silver cyanide	P099	Meet BDAT *
Silver Cyanide	P104	Meet BDAT *
Sodium cyanide	P106	Meet BDAT *
Strontium sulfide	P107	
Thallic oxide	P113	
Thallium selenide	P114	
Thallium sulfate	P115	
Vanadium Pentoxide	P120	
Zinc cyanide	P121	Meet BDAT *
Calcium chromate	U032	Meet BDAT *
Hydrofluoric acid	U134	
Lead phosphate	U145	Meet BDAT *

(*) BDAT: Best Demonstrated Available Technology

STABLEX CANADA INC.

GENERAL WASTE CATEGORIES ACCEPTED UNDER CURRENT PERMIT
(BASED ON SAMPLE REVIEW)

WASTE DESCRIPTION	WASTE CODE	REMARKS
Thallium carbonate	U215	
Thallium chloride	U216	
Thallium nitrate	U217	

(*) BDAT: Best Demonstrated Available Technology

STABLEX PROCESS

All above listed waste materials, in bulk or drums, liquid or solids, are desensitized, neutralized, stabilized, formulated to solidify after placement in controlled cells located at our treatment facility in Blainville, Québec, Canada.

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 4/12/93
Time: 10:00 a.m.

From:	R.L. HENKEL	To:	ALLEN CARVO
Company:	UE&C	Company:	APTUS
Phone:	(303) 843-3297	Phone:	(801) 882-8873
Project No.:	6237.008		
Subject:	WFQ TSDF SURVEY - APTUS EXPERIENCE BASE		

Topics of Conversation:

1. APTUS operates a thermal incinerator near Grantsville, Utah and is listed as a commercial TSD facility for treatment of hazardous wastes generated at DOE sites. The facility does not directly dispose of the treated waste. Incinerator ash is either transferred by APTUS to USPCI's ash stabilization and disposal facility (Grassy Mountain) near Clive Utah or it is transported to the Highway 36 TSD in Colorado.

2. The incinerator has a capacity of approximately 15 Lb/Hr maximum feed rate. The feed must have a given percentage of combustible organics and APTUS often blends waste feedstreams to attain the proper BTU content. As such, purely inorganic materials such as soils or metal salts can not be fed directly without adjusting the organic content.

3. APTUS will mail a more detailed listing of types of wastes they can and cannot accept. All EPA and RCRA regulatory requirements are applicable to APTUS.

R.L. Henkel

R.L. Henkel

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 4/09/93
Time: 1:30 p.m.

From:	R.L. HENKEL	To:	T. NELSON/C. MOSELEY
Company:	UE&C	Company:	UE&C
Phone:	(303) 843-3297	Phone:	(303) 843-2774
Project No.:	6237.008		
Subject:	WFQ TSDF SURVEY - USPCI EXPERIENCE BASE		

Topics of Conversation:

1. UE&C has been working closely with USPCI on the design, construction, and startup/operation planning for a thermal treatment facility near Clive, Utah. This facility (which will operate within a year) is comprised of two primary incinerators, a rotary kiln and a burner kiln, which share a common secondary combustion chamber. The rotary kiln is designed to handle up to 35,000 lb/hr (130,000 ton/yr) of bulk solids such contaminated soils with solvent or fuel. The burner kiln can handle liquid wastes such as aqueous or organic solvents with some level of PCB or dioxin contaminants. The production throughput of the incinerators is limited by BTU, chlorides, and heavy metals content of the waste. Wastes are blended to obtain the proper combustion heating valve with LPG or fuel oil used as supplemental fuel, if required.

2. Incinerator ash is stabilized and disposed at USPCI's Grassy Mountain Facility located in the Great Salt Lake Desert. This facility maintains a Part B permit to dispose of RCRA, CERCLA, TSCA, and industrial wastes. The APTUS incineration facility (see 4/12/93 telecon with A. Carvo of APTUS) also uses the Grassy Mountain facility for stabilization and disposal of a portion of their incinerator ash.

3. USPCI also operates additional hazardous waste TSD facilities. The Grayback Mountain Site in Tooele County, Utah is an EPA permitted PCB solids landfill and treatment facility. Treatment consists of USPCI's proprietary PCB dechlorination process for PCB oils. USPCI also operates the Lone Mountain Site in Oklahoma which is the only EPA, Part B, permitted facility to treat, store, and dispose of RCRA regulated wastes in the state. This facility offers waste stabilization capabilities including cyanide/sulfide oxidation, chrome reduction, neutralization, and waste water treatment.

R. L. Henkel

R.L. Henkel

	Analytical Services	Remedial Services	Hydrocarbon Recovery Services	Solvent Services	PCB Services	Graybacks Mountain TSCA Facility	Lone Mountain TSD Facility	Grassy Mountain TSD Facility	Ash Management Services
Hazardous Waste Landfill								✓	
Industrial Waste Landfill								✓	
Tank & Container Storage				✓		✓		✓	
Stabilization								✓	
Neutralization				✓				✓	
Waste Reduction				✓				✓	
Cyanide/Sulfide Oxidation								✓	
Deactivation								✓	
Wastewater Treatment		✓		✓				✓	
Full-service Laboratory								✓	
Waste Analysis		✓		✓				✓	
Acid/Base Neutralization				✓				✓	
Chrome Reduction				✓				✓	
PCB Disposal						✓			
PCB-Contaminated Debris Acceptance						✓			
Transformer Reclamation & Disposal						✓			
Fuels Blending				✓					
Waste Oil & Solvent Recycling				✓					
Bio Treatment				✓					
LabPack Services		✓		✓				✓	
Incineration Services				✓					
Precipitation				✓					
Heavy Metals Recovery				✓					
PCB Oil Detoxification									
PCB Screens									
Energy Recovery				✓					
Waste Repackaging				✓					
Product Sales									
SOG Services				✓					
Gas Chromatography/Mass Spectrometry									
Metals Analysis				✓					
TOC/TOX									
General Chemistry				✓					
Field Services		✓							
Environmental Site Assessment		✓							
Excavation & Source Removal		✓							
Groundwater Remediation		✓							
On-Site Services		✓		✓					
Transportation Services		✓		✓		✓		✓	
Landfill Design & Permitting		✓							
Toll Processing									
By-Product FGD Handling Systems									
Research & Development		✓							
UST Programs		✓							

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 4/12/93
Time: 11:30 a.m.

From:	R.L. HENKEL	**To:**	JOHN MARSHALL
Company:	UE&C	**Company:**	YENTER ENVIRONMENTAL SERVICES
Phone:	(303) 843-3297	**Phone:**	(303) 278-1858
Project No.:	6237.008		
Subject:	WFO TSDF SURVEY - YENTER ENVIRONMENTAL SERVICES EXPERIENCE BASE		

Topics of Conversation:

1. Yenter Environmental Services was listed as a commercial TSD facility involved with treating DOE site generated waste from 1984 through 1991. According to Mr. Marshall, Yenter is not an actual TSD facility, but a company which acts as a "broker" to identify potential TSD facilities for waste generators. Yenter also arranges for sampling of waste to certify characterization as well as provide transportation from the generator to the ultimate TSD facilities.

2. Yenter works with many TSD facilities around the USA that deal with any type of waste other than medical or radioactive waste. They currently work extensively with Treatment TX-1 near Houston Texas for treatment of drummed or bulk shipped wastes. Transportation to the TSDF using bulk truck shipments is subcontracted to Vacuum - Jet. Yenter has also worked with a TSDF in Latham, N.Y. for elemental mercury recovery using BDAT.

3. Mr. Marshall will mail a brochure giving further qualifications of his company and additional TSD facilities they have accessed.

R.L. Henkel

R.L. Henkel

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/21/93
Time: 3:05 p.m.

From:	DAN VERONICA	**To:**	BILL DENNISON
Company:	UE&C	**Company:**	CLEAN HARBORS CINCINNATI, OH
Phone:	303-843-3508	**Phone:**	(513) 874-5888
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - CLEAN HARBORS**		

Topics of Conversation:

1. Upon calling the listing CECOS International at Spring Grove Ave., Cincinnati, OH; I was told the facility was now owned by "Clean Harbors, Inc." and directed to a central sales office at another location.

2. Clean Harbors has multiple facilities, is based in Boston, MA, and has been in existence 13 years.

3. Heavy metal inorganic sludges would be accomodated at a facility in Connecticut which is fully Part B permitted.

4. Waste is generally received at Clean Harbors in either waste water, drums or roll-off (20 yd^3) boxes. Product is delisted per 40CFR268 (i.e., TCLP passed). Cementing is the immobilization technology.

D. Veronica

D. Veronica

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/18/93
Time: 1:25 p.m.

From:	DAN VERONICA	**To:**	ANN HOBLAND
Company:	UE&C	**Company:**	HERITAGE ENVIR. SVCS. INDIANAPOLIS
Phone:	303-843-3508	**Phone:**	317-243-0811
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - HERITAGE ENVIRONMENTAL SERVICES**		

Topics of Conversation:

Heritage has been in operation since 1978 and offers consulting services. Heritage describes themselves as a "full-service" TSD facility (refer to the 1988 "hazardous waste consultant index" for services available). I specifically asked about the "EP toxic metals" capability listed in the index and whether their product satisfied 40CFR268 TCLP criteria (which replaced EP TOX criteria). Heritage is familiar with TCLP and stated they satisfy the requirements using a cement-based solidification process which they were very reluctant to further describe. Ms. Hobland only would say that the solidification involved an "aqueous" pretreatment where the metals are "precipitated out" of the sludge.

D. Veronica

D. Veronica

UNITED ENGINEERS & CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 06/21/93
Time: 2:10 p.m.

From:	DAN VERONICA	**To:**	SUE THOMAN
Company:	UE&C	**Company:**	NORTHWEST ENVIRO SERVICE SEATTLE, WA
Phone:	303-843-3508	**Phone:**	206-622-1090
Project No.:	6237.008		
Subject:	WFQ TSD SURVEY - NORTHWEST ENVIRO SERVICE		

Topics of Conversation:

1. NES is listed in Hazardous Waste consultant as treatment and storage vendor.

2. When asked how "EP Tox" heavy metal sludges are processed at NES, Ms. Thoman said the metals are precipitated from the aqueous component of the sludge. Metals are stabilized chemical by a conversion process (probably involving formation of less soluble forms such as hydroxides). NES obtains a discharge permit for disposal of the water. Solids are stabilized with a cement kiln dust mixture in "roll-offs" (20 cu. yd. boxes).

3. Contaminated soils are stabilized in a similar manner.

4. Mercury comes to the facility principally in the form of mercury halides from spent lighting units.

5. NES stores Hg wastes for processing in commercial retorting operations at other facilities.

6. NES will send a brochure describing their facility.

D. Veronica

D. Veronica

UNITED ENGINEERS & CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/24/93
Time: 8:00 a.m.

From:	DAN VERONICA	**To:**	BOB TETTER
Company:	UE&C	**Company:**	ENVIRITE CORP/CANTON, OH
Phone:	303-843-3508	**Phone:**	216-456-6238
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - ENVIRITE CORP**		

Topics of Conversation:

1. Envirite, a hazardous waste TSD for 18 years, has three treatment facilities and four non-hazardous landfills. Envirite says all their wasteform products qualify as delisted under the provisions in the CFR. Their landfill sites, although only required to comply with nonhazardous waste criteria, actually are constructed with double lined sheeting as practiced for hazardous landfills.

2. Envirite principally serves steel industry clients in the northeast. However, they were selected by the U.S. Department of Interior to treat portion of a 5,000 drum cache of hazardous waste found on land that the department had acquired near Denver, CO.

3. Envirite normally conducts a "treatability survey" prior to quoting rates to a prospective client based on samples provided by the prospect.

4. There is no charge if a quote is not given (i.e., the treatment is outside their scope) and a $300 charge if they do quote a price. Minimum treatment rates are generally $140 - 200/ton including treatment and disposal.

5. Mr. Tetter was conversant about the TCLP requirement and stated EPA toxicity characteristics are derived from the Safe Drinking Water Act limits for LDRs times a factor of 100, whereas Envirite is able to achieve levels only 10x the SDWA limits in their products.

6. Envirite binds LDR metals into a matrix composed mainly of lime, "ferrosulfate" and water; the product is not so much a solid block but rather a sludge or a cake. Its leachability resistance permits the product to be delisted under 40 CFR.

7. Mr. Tetter was not specific about Envirite's capabilities with mercury contaminated wastes, except to say that they would have to evaluate the waste on a case basis and that they routinely handle only very small quantities of Hg-contaminated waste.

8. Envirite is providing a brochure and video tape describing their capability.

D. Veronica

D. Veronica

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/17/93
Time: 1:30

From:	DAN VERONICA	To:	ANDREA FAUCETTE
Company:	UE&C	Company:	EG&G/RFP
Phone:	303-843-3508	Phone:	303-966-6420
Project No.:	6237.008		
Subject:	WFQ TSD SURVEY - RFP PROGRESS RELATED TO POLYMER WASTE SOLIDIFICATION		

Topics of Conversation:

Background: EG&G/RFP has been conducting development work in solidification of mixed waste sludges in polyethylene. Primary focus has been in getting LDR-laden PE wasteforms to pass the TCLP test of 40CFR268 by a technique of converting the metals to a less soluble hydroxide form. This work was documented by EG&G/RFP in a 30 Sept. 92 interim report.

1. UE&C Has any progress been achieved since September?

   EG&G/RFP Yes, quite a lot. We presented the results in a paper at "Waste Tech 93" and it will be released in their proceedings. I can send a copy next week. However, something that is a significant factor is that Colo. Dept. of Health is saying grinding (size reduction) of TCLP samples is not required, and they cite a March 1990 federal register release as documentation. (It appears that someone at Colo. Dept. of Health has made this interpretation of the EPA requirements.) EG&G/RFP is researching the situation, i.e. looking for a way that this interpretation could be legitimately drawn from how the EPA document is written. It is possible that the Colo. Dept. of Health has the TCLP confused with the earlier EP toxicity characteristic test protocol.

2. UE&C Have you done any work with Hg concentrations in your waste samples?

   EG&G/RFP No, I would expect that Hg would be mixed with sulfides to form insoluble mercury sulfides. However, we have not yet done any work on this, we don't have a lot of mercury contamination.

D. Veronica

D. Veronica

UNITED ENGINEERS & CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/23/93
Time: 8:45 a.m.

From:	DAN VERONICA	To:	ANDREA FAUCETTE
Company:	UE&C	Company:	EG&G/RFP
Phone:	303-843-3508	Phone:	303-966-6420
Project No.:	6237.008		
Subject:	WFQ TSD SURVEY - RFP EXPERIENCE RELATED TO PE WASTES IMMOBILIZATION		

Topics of Conversation:

The purpose of this call was to obtain information on three topics:

1. EG&G/RFP experience with polyethylene extrusion of Hg-contaminated waste;
2. Plans for a commercial extrusion equipment vendor to run a demonstration of PE extrusion;
3. Status of a proposed trip by Earl McDaniel, waste immobilization consultant.

a. Ms. Faucette stated that EG&G/RFP had never passed Hg-contaminated wastes through a PE extruder, thus had no data on whether Hg vapor is evolved in such a process. She said EG&G had no intention of ever attempting immobilization of Hg-contaminated solids by such means, that instead, the process they favor would involve chemically stabilizing Hg in the form of a sulfide compound and then macroencapsulating in cement or thermoset polymer. Ms. Faucette said the "federal register" (meaning 40CFR268) recognizes that although amalgamation (mixture with zinc) is the BDAT for Hg, the amalgamation is not feasible when only small quantities of Hg are present, so that encapsulation (subject to TCLP) is appropriate. The sulfide reaction reverts the Hg to its insoluble ore state (cinnabar).

b. A contract is under negotiation where a commercial vendor of extrusion equipment will demonstrate for EG&G a pilot of a production-size PE extrusion process using surrogate waste provided by EG&G. Performance is expected "this summer", however Ms. Faucette could not disclose further details, except that the demonstration will utilize off-the-shelf components.

c. A trip had been organized by DOE where Earl McDaniel would tour various facilities in Japan to survey the state of immobilization technology (particularly with PE) there. The trip was cancelled 18 hours prior to departure by DOE-HQ for unknown reasons. Ms. Faucette said a rescheduling of anything like this again appears very unlikely since apparently the DOE action has irritated the Japanese greatly.

D. Veronica

D. Veronica

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 06/03/93
Time: 11:00 p.m.

From:	R.L. HENKEL	To:	BARBARA SAUER
Company:	RAYTHEON ENGIN. & CONST.	Company:	MERCURY REFINING, INC.
Phone:	(303) 843-3297	Phone:	(518) 459-0820
Project No.:	6237.008		
Subject:	WFQ TSD SURVEY - MERCURY REFINING, INC.		

Topics of Conversation:

Mercury Refining, Inc. is listed as a commercial hazardous waste TSD Facility by the 1992 Kirkpatrick survey. However, discussions with Barbara Sauer indicate that Mercury Refining, Inc. operates as a pretreatment facility to principally recover mercury from bulk wastes. Any chemical fixation or solidification required for disposal is contracted out to other firms such as Chemical Waste Management.

Mercury Refining, Inc. is capable of handling large waste volumes and has current on-site storage capacity of 880 drums. Mercury is removed and recovered using retorting process techniques that comply to BDAT.

Additional information will be sent which details the specific types of waste which can be handled by this process.

R.L. Henkel

R.L. Henkel

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 06/03/93
Time: 12:00 p.m.

From:	JOHN BOYLE	To:	R.L. HENKEL
Company:	BETHLEHEM APPARATUS, INC.	Company:	RAYTHEON ENGIN. & CONST.
Phone:	(215) 838-7034	Phone:	(303) 843-3297
Project No.:	6237.008		
Subject:	WFQ TSD SURVEY - BETHLEHEM APPARATUS, INC.		

Topics of Conversation:

Bethlehem Apparatus, Inc. was contacted due to their experience with mercury recovery from hazardous wastes. They are not a TSD facility since they specialize only in heavy metal recovery and would contract out any remaining treatment and disposal to another facility. However, they did provide a good deal of useful information about their process which may be of use in designing the WRAP 2A mercury evaporator.

Bethlehem is capable of recovering mercury from many types of solid waste including bulk contaminated waste such as soils or organic material with absorbed mercury. The mercury is recovered by retorting of the waste in a "bell jar" dome reactor that is all stainless steel construction. The reactor is heated using convective and radiant heaters and is capable of accepting and processing a full 55 gallon drum of preloaded waste if the waste is not densely packed. In the case of densely packed soils or sludges, approximately 2/3 drum of waste is loaded onto a tray to allow additional surface area for heat transfer and vaporization.

Currently, the reactor operates in batch mode with a 18 to 42 hour heat soak followed by cooling. The retorting temperature is as high as 1250°F. The retort is maintained under almost a complete vacuum of 25" to 27" Hg to accelerate mercury vaporization and to prevent combustion of any organic material in the waste. After initial pyrolysis of the organic material at retorting temperature, air is pulsed into the retort to lower the mercury vapor pressure and enhance almost total mercury recovery.

Bethlehem currently has more than a dozen of the bell jar retorts in operation and is working on a design to allow a more automated batch or semi-continuous operation. The new design makes use of feed and discharge chambers that optimize preheat and cool down time intervals and maximize mercury vapor recovery. Currently, they can not remove treated waste material from the reactor until it has cooled to at least 150°F.

Although Bethlehem did not express any concern about organic content of the waste, there are inorganics which can cause problems with the retorting operation. Chlorides or nitrates are highly corrosive to the stainless steel construction of the retort at high temperature. Sulfides and sulfates are not considered to be a problem. Also, other heavy metals such as cadmium in the waste tend to combine with mercury and form an amalgam which can foul the mercury condensing equipment.

Mr. Boyle will send additional information which describes what types of waste they can or can not process. Currently, they are not retorting contaminated soils since this type of waste is lower in priority than other bulk wastes which are in larger supply.

R.L. Henkel

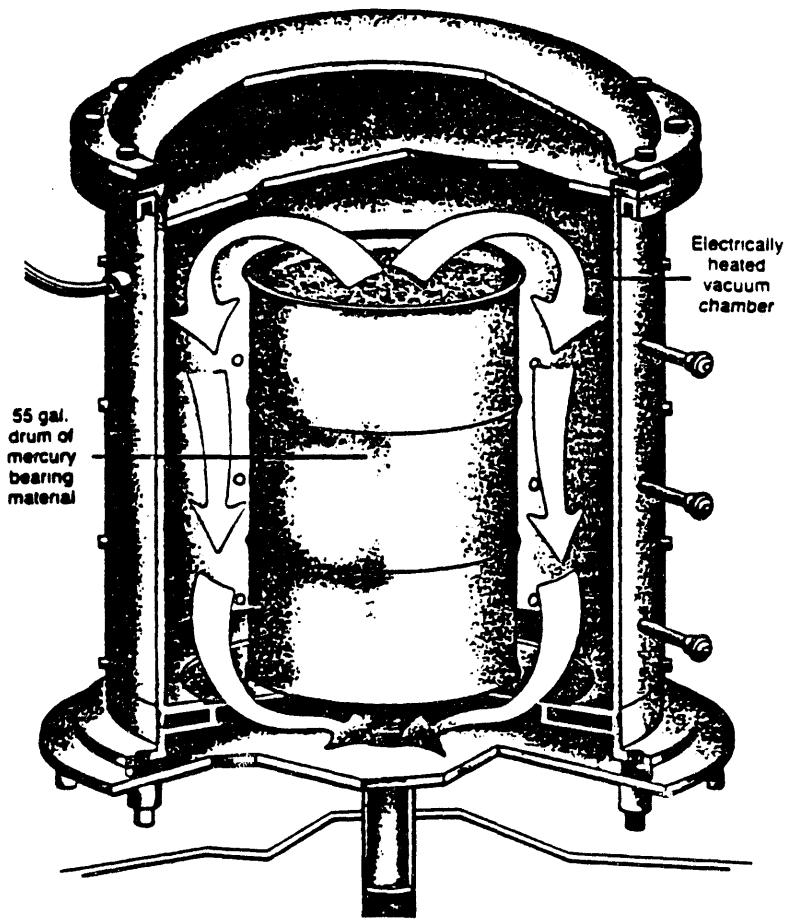
R.L. Henkel

BETHLEHEM
MERCURY RECOVERY/RECYCLING SERVICE

Bethlehem has developed a high vacuum mercury retort recovery still for processing EPA D009 hazardous waste. The recovery system heats mercury bearing materials up to 1,350 degrees F. Mercury vapor is condensed in a water cooled condenser for transfer to our vacuum triple distillation units. Since the recovery system operates under high vacuum the exhaust from the vacuum pumps is easily scrubbed and passed through treated activated charcoal for mercury vapor removal. No exhaust stack or Air Quality Permits are required for the system. Residue from the process must pass TCLP analysis for mercury before it is sent to an industrial non hazardous waste landfill.

Each mercury recovery high vacuum retort system is controlled with a microprocessor temperature controller capable of running 16 different programmed temperature cycles for the wide variety of materials to be processed. To date we have processed the following types of materials:

- fever and industrial thermometers
- metal switches
- quartz lamps
- dental amalgams
- ignitron tubes
- mercury in soil
- telephone switches
- porisimitry samples
- sphygmomonometers
- barometers
- glass switches
- mercury batteries
- thermocouples
- mercury sludges
- mercury rectifiers
- mercury relays
- manometers
- mercuric oxide
- pc board relays



FOR MORE INFORMATION ASK FOR A MERCURY RECOVERY PACKET!

All shipments must have prior approval before they are accepted for processing. All materials that are processed in our recovery retort distillation units are considered HAZARDOUS WASTE, and must be sent using a Pennsylvania Hazardous Waste Manifest.

To receive authorization for shipments you must obtain a **work authorization number** from our office. Authorization numbers will be issued for each shipment provided there is a signed Recovery/Recycling Agreement on file and your waste is on our Material Acceptance List. For new materials to be approved there must be samples and material analysis sent for evaluation.

Bethlehem Apparatus Company, Inc.

890 Front St., P.O. Box Y, Hellertown, PA 18055 • 215-838-7034 • FAX 215-838-6333 • TELEX 494-9195

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 06/03/93
Time: 11:30 p.m.

From:	R.L. HENKEL	**To:**	BOB ROBERTS
Company:	RAYTHEON ENGIN. & CONST.	**Company:**	QUICKSILVER PRODUCTS
Phone:	(303) 843-3297	**Phone:**	(415) 468-2000
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - QUICKSILVER PRODUCTS**		

Topics of Conversation:

Quicksilver is listed as a commercial hazardous waste TSD in the Kirkpatrick survey. Their principal line of work is to recover mercury from mercury containing devices such as thermometers, arc lamps, and switches. They do not process mercury contaminated bulk wastes such as soils, water, or organic waste with absorbed mercury.

Quicksilver referred me to anther firm in the Los Angeles area (Mercury Recovery Services, 818-303-2053) which also processes the above listed mercury containing devices in addition to fluorescent light bulbs. However, any further waste treatment or recovery is contracted to other firms such as Mercury Refining, Inc. or Bethlehem Apparatus, Inc.

R.L. Henkel

R.L. Henkel

From:	R.L. HENKEL	To:	JIM WILSON
Company:	UE&C	Company:	ROHM & HAAS
Phone:	303-843-3297	Phone:	215-592-6712
Project No.:	6237.008		
Subject:	WFQ TSD SURVEY - MERCURY REMOVAL FROM WASTEWATER VIA ION EXCHANGE RESIN		

Topics of Conversation:

1. A recent publication by Westinghouse Savannah River Co. ("Treatment of Radioactive Laboratory Waste for Mercury Removal", A.B. Osteen & J.P. Bibler) describes the use of ion exchange resin for removal of mercury from low activity liquid waste. The use of Duolite GT-73 resin was recommended for effective removal of mercury from not only laboratory waste but also basin groundwater liquid. It was therefore considered that the GT-73 resin could be used as a media for mercury removal in the polyethylene extruder offgas condensate process being evaluated in the Single Immobilization Study.

2. Duolite FT-73 resin is one of the few, if not the only, product on the market capable of selectively removing mercury in any of its common ionic states. Elemental mercury must be converted to the ionic state by chlorination at a pH of about 3. Two ion exchange beds in series are recommended for water treatment. The first bed acts as the primary removal unit while the second acts as a polishing unit. Typical bed depths range from 1 1/2' to 6'. The bed volumetric flow rate recommendation for the waste water is from 2 to 8 gal/min - ft^2. The maximum mercury loading is given as 31 K grain of mercury (as Ca CO_3) per ft^3 of resin. This is equivalent to about 2.2 lb of mercury per ft^3 of resin.

3. The cost of the GT-73 resin is relatively high at about \$850/ft^3 delivered in bulk, bags, or drums. The resin can be regenerated using 35% HCl and will produce between 8 and 10 bed volumes of waste concentrate containing the mercury. Based upon the resin rate of consumption, regeneration can be economical if the resins can be reused from 3 to 4 times. Jim Wilson will send additional information on regeneration requirements.

R. L. Henkel

R. Henkel

UNITED ENGINEERS & CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/17/93
Time: 10:30 A.M.

From:	DAN VERONICA	**To:**	
Company:	UE&C	**Company:**	US EPA - DENVER
Phone:	303-843-3508	**Phone:**	303-236-5122
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - HAZARDOUS WASTE REFERENCES**		

Topics of Conversation:

1. Background: The "EI Environmental Services Directory" was identified by the WHC White Paper title "Commercial Hazardous Waste Management Facilities" as being the best and most comprehensive reference to commercial environmental business. The directory is not available locally to WHC.

2. A copy of the EI directory is available for public access (not checkout) at the EPA Library, Denver...

D. Veronica

D. Veronica

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/18/93
Time: 10:30 A.M.

From:	DAN VERONICA	**To:**	JANICE PERROE
Company:	UE&C	**Company:**	HAZARDOUS NAT'L BRACH
Phone:	303-843-3508	**Phone:**	
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - TCLP PROTOCOL**		

Topics of Conversation:

1. Background: Based on the information that Colo. Dept. of Health is telling RFP that grinding of TCLP is not required, I called Denver office of U.S. EPA to verify.

2. The Denver office is responsible only for enforcement (e.g. inspections of hazardous waste sites and records). Ms. Perroe was familiar with TCLP but said she had not heard of any recent or pending change to the test procedure. She provided two contacts:

   a. Gale Hansen, U.S. EPA HQ Laboratories Staff (202) 260-6722

   b. EPA Test Methods Hotline (703) 821-4789.

D. Veronica

D. Veronica

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company

Western Operations

Date: 6/17/93
Time: 10:30 A.M.

From:	DAN VERONICA	**To:**	
Company:	UE&C	**Company:**	DENVER PUBLIC LIBRARY
Phone:	303-843-3508	**Phone:**	
Project No.:	**6237.008**		
Subject:	**WFQ TSD SURVEY - LOCAL ENVIRONMENTAL BUSINESS REFERENCES**		

Topics of Conversation:

DPL searched their database for locally held copies of the following documents referred to in the WHC White Paper Titled "Commercial Hazardous Waste Management Facilities" (May 1993)...

1. "Hazardous Waste Consultant" (March/April Index Issue).

2. "EI Environmental Services Directory" Environmental Information, Ltd.; Minneapolis.

Neither is held by local public libraries or universities.

D. Veronica

D. Veronica

APPENDIX B

CALCULATION OF VES POLYMER/WASTE EXOTHERMS

CALCULATION OF VES POLYMER/WASTE COOLING CURVES

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2AP CALC. SET NO. 001	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-30-93	DATE 9/2/93
VOID			
SHEET 1 OF 19		DATE	DATE
J.O 6237008			

CALCULATION DISCLOSURE SHEET

ITEM #	CALC. SHEET #	ITEM DESCRIPTION	CALC. SET REV. # (Item Resolved)	REMARKS
1	18	Verify waste and binder physical property data.		

TOTAL NUMBER OF CALCULATION SET SHEETS 19 CALC. SET REV. 1

CALCULATION DONE BY K. D. Van Zanten/R. HENKEL DATE 9-2-93

CALCULATION CHECKED BY K.D. Van Zanten DATE 9-28-93

CONCURRED BY _____ DATE _____
LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE: United Engineers & Constructors

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

WRAP CALC. SET NO. 001	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-30-93	DATE 9/21
VOID			
SHEET 2 OF 19		DATE	DATE
J.O. 6227002			

CALCULATION CONTROL SHEET

PROBLEM STATEMENT

Calculate exotherms for VES Polymer/Waste mixtures in drums.

DESIGN BASIS

1. VES Polymer Only System Mass Balance, Rev. 2, 6/1/93
2. Stock Equipment Company, Dry Salt Mixing and Solidification Test Reports 343 and 350, 1983
3. Waste and Binder Physical Property Data (p. 18)
4. VES Resin Heat of Reaction = 111 BTU/lb (calculated by R. Henkel).
5. VES Polymer and Waste mixed at 75°F.
6. No heat loss during exotherm.

TOTAL NUMBER OF CALCULATION SET SHEETS 19 CALC. SET REV. 1

CALCULATION DONE BY K.D. Van Zanten / R. HENKEL DATE 9-2-93

CALCULATION CHECKED BY K.D. Van Zanten DATE 9-28-93

CONCURRED BY _____ DATE _____

LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE: **United Engineers & Constructors** A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-30-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 3 OF 19		1	RLH DATE 9/2/93	KDV DATE 9-23-93
J.O 6237002				

CALCULATION SUMMARY SHEET

AGITATED VES POLYMER

STREAM NO.	% WATER	PEAK EXOTHERM TEMPERATURE, °F * ⚠
1B	4.0	~~347/377~~ 333/362
1C	44.0	212/~~309~~ 300
2A	10.0	~~273/348~~ 264/336
2B	55.0	157 ~~159~~ (No water vaporized)
2C	75.0	~~212/213~~ 209 (No water vaporized)
5A1	0	~~418~~ 400
5B	0	~~319~~ 307
6	10.0	212/~~294~~ 284
7	0	~~274~~ 265
8	10.0	212/~~308~~ 297

VIBRO VES POLYMER

1A	10.0	~~286/364~~ 276/35[illegible]
1D	0	~~263~~ 254
2D	50.0	160 ~~163~~ (No water vaporized)
3	0	~~187~~ 181
4	0	~~222~~ 214
5A2	0	~~302~~ 289
5C1	0	~~406~~ 389
5C2	0	~~187~~ 183
5D	0	~~212~~ 200

* FOR WASTE STREAMS CONTAINING WATER, THE LOWER TEMPERATURE WAS CALCULATED ASSUMING WATER IS VAPORIZED AT 212°F WHILE THE HIGHER TEMPERATURE WAS CALCULATED ASSUMING NO VAPORIZATION (SENSIBLE HEAT ONLY).

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Stone & Webster Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2AP CALC. SET NO. 001	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-30-93	DATE 7/12/93
VOID			
SHEET 4 OF 19		DATE	DATE
J.O 6237008			

CALCULATION REFERENCE SHEET

1. Perry's Chemical Engineering Handbook, 6TH Edition, 1984
2. Stock Equipment Company, Dry Salt Mixing and Solidification Test Reports 343 and 350, 1983
3. Principles of Unit Operations, Foust et al, 1960

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-10-93	DATE 9/12/93
VOID				
SHEET 5 OF 19			DATE	DATE
J.O 6237008				

NAME OF COMPANY: DOE/WHC-WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

Calculate VES polymer/waste exotherms (min and max) based on Stock Equipment Co. data. Check R. Henkel's calculated value of 111 BTU/lb VES Resin against Stock Equipment Co. Test Reports 343 and 350.

Test 343 (Ref. 2)

Basis:

202	lbs	VES Resin → Cp = 0.29 BTU/lb°F (per R. Henkel)
480	lbs	Dry Solids Waste (Fly Ash and Salts)
58	lbs	Drum (steel)
740	lbs	Total

Ignore drum due to high heat loss (outside of drum) and low Cp of 0.12 BTU/lb°F

Onset of Exotherm = 82°F
Exotherm Peak = 226°F
} ΔT = 144°F

use 0.19 {Clinker 0.186, Sand 0.191} Ref. 3

$$(202\ lb)(0.29\ BTU/lb°F)(144°) + (480)(0.19)(144) = 8436 + 13{,}133$$
$$= 21{,}569\ BTU$$

$$\text{Calculated } \Delta H_{RXN} = \frac{21{,}569\ BTU}{202\ lb\ VES} = \underline{107\ BTU/lb\ VES\ Resin}$$

Test 350 (Ref. 2) (Used anhydrous sodium sulfate – Na_2SO_4)

Basis:

202	lb	VES Resin
500	lb	Sodium Sulfate
58	lb	Steel Drum
760	lb	Total

Perry, 6TH Edition, p. 3-134 (Ref. 1)

$$\text{Sodium Sulfate } Cp = \frac{32.8\ cal/°C\ mole}{142.05\ g/mole} = 0.231\ cal/g°C = 0.231\ \frac{BTU}{lb°F}$$

For exotherm calculation, ignore steel drum due to high heat loss (outside of drum) and low Cp of 0.12 BTU/lb°F.

40 min Onset of Exotherm 126°F
7 hours Exotherm Peak 263°F
} ΔT = 137°F

$$(202\ lb)(0.29\ BTU/lb°F)(137°) + (500\ lb)(0.231\ BTU/lb°F)(137°) =$$
$$8025 + 15{,}824 = 23{,}849\ BTU$$

$$\Delta H_{RXN} = \frac{23{,}849}{202} = \underline{118\ BTU/lb\ VES\ Resin}$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WRAP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-10-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 6 OF 19		1	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE EXOTHERMS

Average of 2 Tests = $\frac{107 + 118}{2}$ = 112.5 BTU/lb VES Resin (Dow Binder 101)

This compares very well with R. Henkel's value of 111 BTU/lb VES Resin.

∴ Use ΔH_{RXN} = 111 BTU/lb VES Resin.

Initially, calculate peak exotherms for dry waste. Assume initial temp of mixture = 75°F.

Streams $\underbrace{5A1, 5B, 7}_{\text{Agitated}}$, $\underbrace{1D, 3, 4, 5A2, 5C1, 5C2, 5D}_{\text{Vibro}}$

AGITATED

⚠ with steel drum (58 lb)(.12 BTU/lb °F)(ΔT) = 6.96 ΔT

Stream 5A1

	Lbs
VES	388.2
Waste	258.8
	647.0

$(388.2)(0.29)(\Delta T) + (258.8)(0.05)(\Delta T) = (388.2)(111)$

$(112.58 + 12.94)(\Delta T) = 43{,}090$

$125.52 + 6.96$ ⚠ $= 132.48$ ⚠

$\Delta T = \cancel{343}°$ 325 ⚠

$T = 75 + 343 = \cancel{418}°F$ 400 ⚠

Stream 5B

	Lbs
VES	305.9
Waste	458.8
	764.7

$(305.9)(0.29)(\Delta T) + (458.8)(0.11)(\Delta T) = (305.9)(111)$

$(88.71 + 50.47)(\Delta T) = 33{,}955$

$139.18 + 6.96$ ⚠ $= 146.14$ ⚠

$\Delta T = \cancel{244}°$ 232 ⚠

$T = 75 + 244 = \cancel{319}°F$ 307 ⚠

Stream 7

	Lbs
VES	262.2
Waste	233.1
	495.3

$(262.2)(0.29)(\Delta T) + (233.1)(0.30)(\Delta T) = (262.2)(111)$

$(76.04 + 69.93)(\Delta T) = 29{,}104$

$145.97 + 6.96$ ⚠ $= 152.93$

$\Delta T = \cancel{199}°$ 190 ⚠

$T = 75 + 199 = \cancel{274}°F$ 265 ⚠

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2 AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-10-93	DATE 9/2/93
VOID				
SHEET 7 OF 19		1	RLH	KDV
J.O 6237008			DATE 9/2/93	DATE 9-28-93

VIBRO (Dry)

Stream 1D

	Lbs
VES	223.4
Waste	335.2
	558.6

$(223.4)(0.29)(\Delta T) + (335.2)(0.20)(\Delta T) = (223.4)(111)$

$(64.79 + 67.04)(\Delta T) = 24{,}797$

$131.83 + 6.96$ △ $= 138.79$ △

$\Delta T = \cancel{188}^\circ$ 179 △

$T = 75 + 188 = \cancel{263}^\circ F$ 254 △

Stream 3

	Lbs
VES	119.5
Waste	278.7
	398.2

$(119.5)(0.29)(\Delta T) + (278.7)(0.30)(\Delta T) = (119.5)(111)$

$(34.66 + 83.61)(\Delta T) = 13{,}265$

$118.27 + 6.96$ △ $= 125.23$ △

$\Delta T = \cancel{112}^\circ$ 106 △

$T = 75 + 112 = \cancel{187}^\circ F$ 181 △

Stream 4

	Lbs
VES	171.4
Waste	399.9
	571.3

$(171.4)(0.29)(\Delta T) + (399.9)(0.20)(\Delta T) = (171.4)(111)$

$(49.71 + 79.98)(\Delta T) = 19{,}025$

$129.69 + 6.96$ △ $= 136.65$ △

$\Delta T = \cancel{147}^\circ$ 139 △

$T = 75 + 147 = \cancel{222}^\circ F$ 214 △

Stream 5A2

	Lbs
VES	246.5
Waste	164.3
	410.8

$(246.5)(0.29)(\Delta T) + (164.3)(0.30)(\Delta T) = (246.5)(111)$

$(71.49 + 49.29)(\Delta T) = 27{,}362$

$120.78 + 6.96$ △ $= 127.74$ △

$\Delta T = \cancel{227}^\circ$ 214 △

$T = 75 + 227 = \cancel{302}^\circ F$ 289 △

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 001	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL			
VOID			
SHEET 8 OF 9	1	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 637008			

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

Vibro (cont)

Stream 5C1

		lbs
	VES	377.1
60.3%	Waste	572.7
		949.8

$(377.1)(0.29)(\Delta T) + (572.7)(0.03)(\Delta T) = (377.1)(111)$

$(109.36 + 17.18)(\Delta T) = 41,858$

$126.54 + 6.96$ ⚠ $= 133.5$ ⚠

$\Delta T = \cancel{331}\,°F$ 314 ⚠

$T = 75 + 331 = \cancel{406}\,°F$ 389 ⚠

Stream 5C2

		lbs
	VES	176.5
70%	Waste	411.7
		588.2

$(176.5)(0.29)(\Delta T) + (411.7)(0.30)(\Delta T) = (176.5)(111)$

$(51.19 + 123.51)(\Delta T) = 19,592$

$174.70 + 6.96$ ⚠ $= 181.66$ ⚠

$\Delta T = \cancel{112}°$ 108 ⚠

$T = 75 + 112 = \cancel{187}\,°F$ 183 ⚠

Stream 5D

		lbs
	VES	342.0
64%	Waste	608.0
		950.0

$(342.0)(0.29)(\Delta T) + (608.0)(0.10)(\Delta T) = (342.0)(111)$

$(99.18 + 60.80)\Delta T = 37,962$

$159.98 + 6.96$ ⚠ $= 166.94$

$\Delta T = \cancel{237}$ 227 ⚠

$T = 75 + 237 = \cancel{312}\,°F$ 302 ⚠

Calculate peak exotherms for wet waste streams two ways.

(1) Calculate peak exotherm assuming <u>part or all</u> water is free water and can be vaporized.

(2) Calculate peak exotherms assuming <u>no</u> free water (or all bound water) and no water is vaporized. Assume only sensible heat $C_p = 1.0 \frac{BTU}{lb°F}$.

AGITATED

STREAM NO.	% H_2O
1B	4.0
1C	44.0
2A	10.0
2B	55.0
2C	75.0
6	10.0
8	10.0

VIBRO

STREAM NO.	% H_2O
1A	10.0
2D	50.0

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 9 OF 19		1	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237008				

Stream 1B 4% water

		lbs	
	VES	372.0	
	Dry Waste	119.0	124.0
4%	Water	5.0	
		496.0	

Calculate peak exotherm assuming all water is vaporized at 212°F

1 WITH STEEL DRUM (58.16)(.12 BTU/lb °F)(ΔT) = 6.96 ΔT

$$(372.0)(0.29)(\Delta T) + (119.0)(.20)(\Delta T) + (5.0)(\overset{1107.5}{1150.5-43}) = (372.0)(111)$$

$$(107.88 + 23.80)\Delta T + 5538 = 41{,}292$$

$$131.68\ \Delta T = 35{,}754$$

$+6.96 = 138.64\ \Delta T$ 1

$\Delta T = \cancel{272}$ °F 258 1

$T = 75 + 272 = \cancel{347}$ °F OK 333 1

Calculate peak exotherm assuming no water is vaporized.

$$(372.0)(0.29)(\Delta T) + (119.0)(0.20)(\Delta T) + (5.0)(1)(\Delta T) = (372.0)(111)$$

$$(107.88 + 23.80 + 5.0)(\Delta T) = 41{,}292$$

$$136.68\ \Delta T = 41{,}292$$

$+6.96 = 143.64\ \Delta T =$ 1

$\Delta T = \cancel{302}$ 287 1

$T = 75 + 302 = \cancel{377}$ °F 362 1

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 10 OF 19		△	ELH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237008				

NAME OF COMPANY: DOE/WHC - 300KAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

Stream 1C 44.0% Water

Calculate peak exotherm assuming no water is vaporized

	lbs	
VES	353.2	
Dry Waste	65.9	117.7
44% Water	51.8	
	470.9	

$$(353.2)(0.29)(\Delta T) + (65.9)(0.20)(\Delta T) + (51.8)(1.0)(\Delta T) = (353.2)(111)$$

$$(102.43 + 13.18 + 51.80)\,\Delta T = 39{,}205$$

$$167.41\ \Delta T = 39{,}205$$

$+6.96 = 174.37\ \Delta T$ △

$\Delta T = \cancel{234^\circ}$ 225 △

$T = 75 + 234 = 309^\circ F$ 300 △

Calculate peak exotherm assuming some water is vaporized at 212°F

X = fraction of water vaporized

$$(353.2)(0.29)(137) + (65.9)(0.20)(137) - (51.8)(1.0)(137) - (X)(51.8)(970.3) = (353.2)(111)$$

$$14033 + 1806 + 7097 + X(50{,}262) = 39{,}205$$

$+953$ △

$$(X)(50{,}262) + \cancel{22{,}934} = 39{,}205$$

23890 △

$$(X)(50{,}262) = \cancel{16{,}269}$$ 15310 △

$X = \cancel{0.324}$ ∴ $T = 212^\circ F$

0.305 △

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S: CALCULATION OF VES POLYMER/WASTE

SUBJECT: EXOTHERMS

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 11 OF 19		1	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237008				

Stream 2A 10% Water

Calculate peak exotherm assuming all water is vaporized at 212°F.

Assume materials are mixed at 75°F

	Lbs	
VES	359.5	
Dry Waste	107.8	119.8
10% Water	12.0	
	479.3	

$$(359.5)(0.29)(\Delta T) + (107.8)(0.25)(\Delta T) + (12.0)(\overset{1107.5}{1150.5 - 43}) = (359.5)(111)$$

$$(104.26 + 29.95)(\Delta T) + 13{,}290 = 39{,}905$$

$$134.21\ \Delta T = 26{,}615$$

$+6.96 = 141.17\ \Delta T$ ⚠

189 ⚠ 264 ⚠

$\Delta T = \cancel{198}^{\circ}$ 189 ⚠ $T = 75 + \cancel{198} = \cancel{273}^{\circ}F$ OK

Calculate peak exotherm assuming no water is vaporized

	lbs
VES	359.5
Dry Wast.	107.8
10% Water	12.0
	479.3

$$(359.5)(0.29)(\Delta T) + (107.8)(0.25)(\Delta T) + (12.0)(1.0)(\Delta T) = (359.5)(111)$$

$$(104.26 + 29.95 + 12.0)(\Delta T) = 39{,}905$$

$$146.21\ \Delta T = 39{,}905$$

$+6.96\ \Delta T = 153.17$

$\Delta T = \cancel{273}^{\circ}F$ 261 ⚠

$T = 75 + 273 = \cancel{342}^{\circ}F$ 336 ⚠

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 12 OF 19		Δ	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237008				

Stream 2B 55% Water

Calculate peak exotherm assuming some water is vaporized

	lbs	
VES	190.3	
Dry Waste	128.4	285.4
Water	157.0	
	475.7	

$\Delta T = 212 - 75 = 137°$

$$(190.3)(0.29)(137) + (128.4)(0.3)(137) + (157.0)(1)(137) + (x)(157.0)(970.3) = (190.3)(111)$$

$$7561 + 5277 + 21{,}509 + (x)\,152{,}337 = 21{,}123$$

+953 Δ

$$\cancel{34{,}347} + (x)(152{,}377) = 21{,}123$$

35300 Δ

$x = [\text{negative}]$ ∴ No water is vaporized

$$(190.3)(0.29)(\Delta T) + (128.4)(0.3)(\Delta T) + (157.0)(1.0)(\Delta T) = (190.3)(111)$$

$$(55.19 + 38.52 + 157.0)(\Delta T) = 21{,}123$$

$$250.71\ \Delta T = 21{,}123$$

$-1.30 = 277.27\ \Delta T$ Δ

$\Delta T = \cancel{84}$ 82

$T = 75 + 84 = \cancel{159}°F$ 157 °F Δ

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2A P CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.		0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 13 OF 19		Δ	RLH DATE 9/2/93	KDV DATE 9-23-93
J.O. 6237008				

Stream 2C 75% Water

Calculate peak exotherm assuming some of the water is vaporized

	lbs	
VES	328.3	
Dry Waste	54.7	218.9
75% Water	164.2	
	547.2	
	383.0 w/o water	

Assume peak temp = 212°F (assume 1 atm)

$\Delta T = 212 - 75 = 137\,°F$

X = fraction of water vaporized

$$(328.3)(0.29)(137) + (54.7)(0.1)(137) + (164.2)(1)(137) + (X)(164.2)(970.3) = (328.3)(111)$$

$$13{,}043 + 749 + 22{,}495 + (X)(159{,}323) = 36441$$

36,287 +953 Δ -799 Δ

$$X = \frac{154}{159{,}323} = \cancel{0.000967}$$ negative Δ

$(.000967)(164.2) = 0.216\ H_2O$

No water vaporized Δ

∴ ~~At 212°F, peak exotherm reached~~ Δ No water vaporized

Calculate peak exotherm assuming no water is vaporized.

$$328.3(0.29)(\Delta T) + (547)(0.1)(\Delta T) + (164.2)(1.0)(\Delta T) = (328.3)(111)$$

$$(95.21 + 5.47 + 164.2)(\Delta T) = 36{,}441$$

$$264.88\ \Delta T = 36{,}441$$

Δ +1.96 =

$$\Delta T = \cancel{138}\,°F$$ 34 Δ

$$T = 75 + 138 = \cancel{213}\,°F$$ 209 Δ

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - INRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 5-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 14 OF 17		1	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237-09				

Stream 6 10% Water

Calculate peak exotherm assuming some water is vaporized at 212°F

Assume materials are mixed at 75°F

	lbs
VES	290.5
Dry Waste	174.2 } 193.6
10% Water	19.4 }
	484.1

X = fraction of water vaporized

$\Delta T = 212 - 75 = 137°$

$$(290.5)(0.29)(137) + (174.2)(0.25)(137) + (19.4)(1)(137) + (X)(19.4)(970.3) = (290.5)(111)$$

$$11{,}542 + 5966 + 2658 + (X)(18{,}824) = 32{,}246$$

+953 ⚠

$$(X)(18{,}824) + \cancel{20{,}166} = 32{,}246$$

21,119 ⚠

$$(X)(18{,}824) = \cancel{12{,}080}$$ 11127 ⚠

$$X = \cancel{0.642}$$ .591 ⚠

$$\therefore T = 212°F$$

Calculate peak exotherm assuming no water is vaporized, sensible heat only.

$$(290.5)(0.29)(\Delta T) + (174.2)(0.25)(\Delta T) + (19.4)(1.0)(\Delta T) = (290.5)(111)$$

$$(84.25 + 43.55 + 19.40)(\Delta T) = 32{,}246$$

$$147.2\ \Delta T = 32{,}246$$

−6.96 − 154.16 ΔT ⚠

$$\Delta T = \cancel{219}°$$ 209 ⚠

$$T = 75 + 219 = \cancel{294}°F$$

284 ⚠

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WJAP CALC. SET NO. 00	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL			
VOID			
SHEET 15 OF 19	1	RLH DATE 9/2/93	KDV DATE 9-28-93
J.O 6237008			

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

Stream 8 10% Water

Calculate peak exotherm assuming some water is vaporized at 212°F

	lbs	
VES	290.5	
Dry Waste	174.2	193.6
Water	19.4	
	484.1	

Assume materials are mixed at 75°F

$\Delta T = 212° - 75 = 137°F$

X = fraction of water vaporized

$$(290.5)(0.29)(137) + (174.2)(0.20)(137) + (19.4)(1)(137) + (X)(19.4)(970.3) = (290.5)(111)$$

$$11{,}542 + 4773 + 2658 + (X)(18{,}824) = 32{,}246$$

$$(X)(18{,}824) + \cancel{18{,}973}\ 19{,}926 = 32{,}246 \quad (+953)$$

$$(X)(18{,}824) = \cancel{13{,}273}\ 12320$$

$$X = \cancel{0.705}\ .654 \quad \therefore T = 212°F$$

Calculate peak exotherm assuming no water is vaporized

$$290.5(0.29)\Delta T + (174.2)(0.20)(\Delta T) + (19.4)(1)(\Delta T) = (290.5)(111)$$

$$(84.25 + 34.84 + 19.4)(\Delta T) = 32{,}246$$

$$138.49\ \Delta T = 32{,}246$$

$$+6.96 = 145.45$$

$$\Delta T = \cancel{233°F}\ 222$$

$$T = 75 + 233 = \cancel{308°F}\ 297$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNITS

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

W2A PCALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-11-93	RLH DATE 9/2/93
FINAL				
VOID				
SHEET 16 OF 19		1	RLH DATE 9/2/93	KDV DATE 9-22-93
J.O 6237002				

Stream 1A 10% Water

Calculate peak exotherm assuming all water is vaporized at 212°F

Assume materials are mixed at 75°F

	lbs	
VES	368.2	
Dry Waste	110.5	122.8
10% Water	12.3	
	491.0	

$$(368.2)(0.29)(\Delta T) + (110.5)(0.20)(\Delta T) + (12.3)(\overset{1107.5}{1150.5-43}) = (368.2)(111)$$

$$(106.78 + 22.10)(\Delta T) + 13,622 = 40,870$$

$$128.88\ \Delta T = 27,248$$

$$+6.96 = 135.84\ \Delta T \quad \Delta$$

$$\Delta T = \cancel{211^\circ}\ 201 \quad \Delta$$

$$T = 75 + 211 = \cancel{286}\ 276\ ^\circ F \quad \Delta$$

Calculate peak exotherm assuming no water is vaporized, sensible heat only.

$$368.2(0.29)(\Delta T) + (110.5)(0.20)(\Delta T) + 12.3(1)(\Delta T) = 368.2(111)$$

$$(106.78 + 22.10 + 12.30)(\Delta T) = 40,870$$

$$+6.96$$

$$141.18\ \Delta T = 40,870$$

$$+6.96 = 148.14\ \Delta T \quad \Delta$$

$$\Delta T = \cancel{289^\circ}\ 256 \quad \Delta$$

$$T = 75 + 289 = \cancel{364} = 331 \quad \Delta$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - UNRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE EXOTHERMS

UNRAP CALC. SET NO. 101		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-11-93	DATE 9-2-93
VOID				
SHEET 17 OF 19		1	CLH	KDV
J.O. 6237008			DATE 9/2/93	DATE 9-22-93

Stream 2D 50% water

Calculate peak exotherm assuming no water is vaporized.

	lbs	
VES	146.3	
Dry wast.	109.75	219.5
Water	109.75	
	365.8	

$$(146.3)(0.29)(\Delta T) + (109.75)(0.30)(\Delta T) + (109.75)(1.0)(\Delta T) = (146.3)(111)$$

$$(42.43 + 32.93 + 109.75)(\Delta T) = 16,239$$

$$185.11\ \Delta T = 16,239$$

$$+6.96 = 192.07\ \Delta T \quad 1$$

$$\Delta T = \cancel{88^\circ}\ 85 \quad 1$$

$$T = 75 + 88 = \cancel{163^\circ F}\ 160 \quad 1$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 001		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-11-93	DATE 9/2/93
VOID				
SHEET 18 OF 17			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE EXOTHERMS

WASTE AND BINDERS PHYSICAL PROPERTY DATA

Waste Feedstreams	Treated Bulk Density (lb/ft³)	Treated Particle Density (lb/ft³)	Heat Capacity (BTU/lb°F)	Thermal Conductivity (BTU/hr ft²(°F/ft))	Moisture Content (Wt%)
1A	100	130	0.2	0.3	10
1B	60	140	0.2	0.2	4
1C	69	100	0.2	0.2	44
1D	75	105	0.2	0.2	–
2A	88	111	0.25	0.3	10
2B	55	77	0.3	0.1	65
2C	75	140	0.1	0.2	75
2D	40	50	0.3	0.1	50
3	45	58	0.3	0.12	–
4	60	100	0.2	0.3	–
5A1 (amalgamated mercury)	408	408	0.05	1.0	–
5A2 (bulk mercury)	40	58	0.3	0.1	–
5B	200	240	0.11	8	--
5C1 (elemental lead)	710	710	0.03	20	–
5C2 (bulk lead)	80	105	0.3	0.1	--
5D	450	450	0.1	30	--
6	90	90	0.25	0.1	10
7	35	90	0.3	0.3	--
8	90	90	0.2	0.2	10
Binders					
VES Resin (Derakane 470-36)	65	65	0.29	0.08	--
Polyethylene	57	57	0.55	0.19	–

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: UHC / DOE - NRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER WASTE EXOTHERMS

NRAP CALC. SET NO. 201		REV	COMP. BY	CHK'D. BY
PRELIM.	—	0	RLH	KDV
FINAL			DATE 7/12/93	DATE 7/22/93
VOID				
SHEET 19 OF 19			DATE	DATE
J.O. 6237008				

CALC BASIS - SENSITIVITY TO Cp

- PROVIDE COMPARISON TABLE SHOWING SENSITIVITY OF MAX VES/WASTE EXOTHERM TEMP TO SPECIFIC HEAT ASSUMPTION FOR VES RESIN
- VES SPECIFIC HEAT USED IN KDV 6/10/93 CALC "CALC OF VES POLYMER/WASTE EXOTHERMS"

  = .29 BTU/lb °F

  REFERENCE: DOW PLASTICS CHEMICAL RESISTANCE & ENGINEERING GUIDE, PAGE 6, TABLE 12, "HEAT CAPACITY OF SOLID RESINS"

  FOR DERAKANE 470-36

  @ 60-80°C C_p = 1.2 JOULE/g K
  = .29 BTU/lb °F

- FOR SENSITIVITY CALC, SUBSTITUTE $C_{p\,POL}$ = .40 BTU/lb °F INTO FOLLOWING FORMULA IN KDV 6/10/93 CALC.

$$(M_{POL})(C_{p\,POL})(\Delta T) + (M_{WASTE})(C_{p\,WASTE})(\Delta T) = (M_{POL})(\text{HEAT OF RXN})$$

WHERE $H_{T\,RXN}$ = 111 BTU/lb

COMPARISON TABLE

WASTE STREAM	MAX CURE TEMP °F @ $C_{p\,POL}$ = .29	MAX CURE TEMP °F @ $C_{p\,POL}$ = .40	TEMP DELTA
5A1	418 °F	331 °F	87 °F
5B	319 °F	271 °F	48 °F
7	274 °F	241 °F	33 °F
1D	263 °F	234 °F	29 °F
3	187 °F	176 °F	11 °F
4	222 °F	203 °F	19 °F
5A2	302 °F	260 °F	42 °F
5C1	406 °F	324 °F	82 °F
5C2	187 °F	176 °F	11 °F
5D	312 °F	267 °F	45 °F

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FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 9/2/93
VOID				
SHEET 1 OF 23			DATE	DATE
J.O 6237008				

CALCULATION DISCLOSURE SHEET

ITEM #	CALC. SHEET #	ITEM DESCRIPTION	CALC. SET REV. # (Item Resolved)	REMARKS
1	18	Verify waste and binder physical property data		

TOTAL NUMBER OF CALCULATION SET SHEETS 23 CALC. SET REV. 1

CALCULATION DONE BY K.D. Van Zanten/R. Henkel DATE 9/8/93

CALCULATION CHECKED BY K. D. VAN ZANTEN DATE 9/28/93

CONCURRED BY _____ DATE _____

LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 9/3/93
VOID				
SHEET 2 OF 23			DATE	DATE
J.O 6237008				

CALCULATION CONTROL SHEET

PROBLEM STATEMENT

Calculate VES Polymer/Waste Cooling Curves for selected waste streams.

DESIGN BASIS

1. VES Polymer Only System Mass Balance, Rev. 2, 6/1/93
2. Stock Equipment Company, Dry Salt Mixing and Solidification Test Report 343, 1983
3. Waste and Binder Physical Property Data (p. 18)
4. Calculation of VES Polymer/Waste Exotherms, 6/30/93
5. Ambient Air Temperature = 75°F.

TOTAL NUMBER OF CALCULATION SET SHEETS 23 CALC. SET REV. 1

CALCULATION DONE BY K.D. Van Zanten DATE 9/8/93

CALCULATION CHECKED BY _____ DATE _____

CONCURRED BY _____ DATE _____
LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 9/3/93
VOID				
SHEET 3 OF 23			DATE	DATE
J.O 6237002				

CALCULATION SUMMARY SHEET

See Sheets 19-23 for Cooling Curve Graphs.

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2A PCALC. SET NO. 002	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-30-93	DATE 9/3/93
VOID			
SHEET 4 OF 23		DATE	DATE
J.O 6237008			

CALCULATION REFERENCE SHEET

1. Stock Equipment Company, Dry Salt Mixing and Solidification Test Report 343, 1983
2. Fundamentals of Heat Transfer, Kutateladze, 1963, p. 104 ~~114~~
3. Tranter Product Data Manual (Catalog No. 5-63), p. ~~70~~
4. Principles of Unit Operations, Foust et al, 1960
5. Figure 21 from Reference 2.

114 *VIII. Unsteady Heat Conduction in Solids*

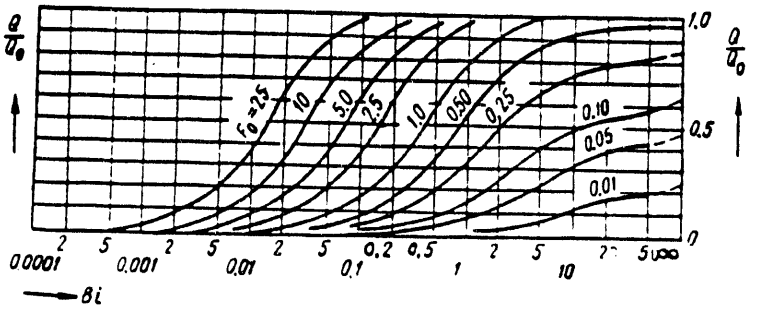

Fig. 21. Heat loss for an infinite cylinder with t_0 = const.

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
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W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-14-92	DATE 9/3/92
VOID				
SHEET 5 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC-WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

Calculate thermoset polymer/waste cooldown rate

Check calculation against Stock Equipment Co. Test Report 343

Calculate weighted average physical properties from test data.

Basis:

202 lbs	VES Resin
480 lbs	Dry Solids Waste (Fly Ash and Salts)
58 lbs	Steel Drum
740 lbs	Total

Using book "Fundamentals of Heat Transfer", Kutateladze, p.104-114

Heat loss for an infinite cylinder with T_o = constant (boundary condition) is given in Fig. 21., p. 114.

$$Q_o = (m)(C_p)(T_{START} - T_o)$$

$$Q = (m)(C_p)(T - T_o)$$

$$\therefore \text{A ratio of } Q/Q_o = \frac{T - T_o}{T_{START} - T_o}$$

m = lbs
C_p = BTU/lb °F
T_o = boundary condition, °F
T_{START} = temp of drum at start of cooling, °F
T = bulk (average) temperature of drum, °F

Need to determine Q/Q_o as function of Bi and Fo (both dimensionless)

$$Bi = \frac{hR}{k}$$

h = heat transfer coefficient, BTU/hr ft² °F
R = radius of cylinder, ft
k = thermal conductivity, BTU/hr ft² (°F/ft)

$$Fo = \frac{\alpha \theta}{R^2}$$

θ = time, hours

$$\alpha = \frac{k}{C_p \rho}$$

C_p = specific heat, BTU/lb °F
ρ = density, lb/ft³

Calculate weighted avg values of k, C_p, ρ (don't include steel drum)

k

$$\frac{\overset{\text{VES Resin}}{(202.0)(0.08)} + \overset{\text{Waste}}{(480)(0.30)}}{682} = \frac{16.16 + 144}{682} = \frac{160.16}{682} = 0.23$$

Use ash, salt k values

Say 0.23 BTU/hr ft² (°F/ft)

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 002	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-14-93	DATE 9/3/93
VOID			
SHEET 6 OF 23		DATE	DATE
J.O 6237008			

NAME OF COMPANY DOE/WHC-WRAP IA UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

C_p

$$\frac{(202)(0.29) + (480)(0.19)}{682} = \frac{58.58 + 91.2}{682} = \frac{149.78}{682} = 0.22 \frac{BTU}{lb\,°F}$$

(VES resin, Waste)

ρ

$$\frac{202 + 480}{\frac{202}{65} + \frac{480}{69.4}} = \frac{682}{3.11 + 6.92} = \frac{682}{10.03} = 68.0\ lb/ft^3$$

Waste Density = 1.112 x 62.4 = 69.4 lb/ft^3

$$\alpha = \frac{K}{C_p \rho} = \frac{0.23}{(0.22)(68.0)} = 0.015$$

Drum diameter = 22.5 inches.

$$F_o = \frac{\alpha \theta}{R^2} \qquad R = \frac{22.5''}{(2)(12)} = 0.9375\ ft.$$

$$F_o = \frac{(0.015)(\theta)}{(0.9375)^2} = 0.017\ \theta \qquad \theta \text{ in hours}$$

Determine h Per Tranter, p.70 h is a function of ΔT, air velocity and Product in Tank for Heat Loss from storage tanks.

For Uninsulated Tanks in Still Air

U	ΔT, °F	Product Correction Factor for Asphalt, Tar (lowest given)
1.8	60	= 0.50 @ 75°F } Product Temperature
2.1	100	0.55 @ 150°F
2.7	200	0.60 @ 250°F

For Test, use 75°F ambient temp

For start of cooling, use T = 209°F @ 14 hours ΔT = 209 − 75 = 134°

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-14-93	DATE 7/13
VOID			
SHEET 7 OF 23		DATE	DATE
J.O 6237008			

$$U = 2.1 + 0.6\left(\frac{34}{100}\right) = 2.30 \text{ Uncorrected}$$

0.20

Solid

Try correction factor = 0.40 $h = 2.30 \times 0.40 = 0.92$ BTU/hr-ft²-°F

$$Bi = \frac{hR}{K} = \frac{(0.92)(0.9375)}{0.23} = 3.8$$

Using Fig. 21 $\theta = 0.59$ hrs

At $Bi = 3.8$ and $F_o = 0.017(0.59) = 0.01$

$Q/Q_o = 0.03$

$\Delta T = 134 \times 0.03 = 4°$ $T = 209 - 4 = 205°F$ 14.59 hrs

$\theta = 2.94$ hrs $F_o = 0.017(2.94) = 0.05$

$Q/Q_o = 0.17$

$134 \times 0.17 = 23°$ $T = 209 - 23 = 186°F$ 16.94 hrs

$\theta = 5.88$ hrs $F_o = 0.017(5.88) = 0.10$

$Q/Q_o = 0.31$

$134 \times 0.31 = 42°$ $T = 209 - 42 = 167°F$ 19.88 hrs

$\theta = 14.7$ hrs $F_o = 0.017(14.7) = 0.25$

$Q/Q_o = 0.58$

$134 \times 0.58 = 78°$ $T = 209 - 78 = 131°F$ 28.7 hrs

$\theta = 29.4$ hrs $F_o = 0.017(29.4) = 0.50$

$Q/Q_o = 0.81$

$134 \times 0.81 = 109°$ $T = 209 - 109 = 100°F$ 43.4 hrs

$\theta = 58.8$ hrs $F_o = 0.017(58.8) = 1.00$

$Q/Q_o = 0.97$

$134 \times 0.97 = 130°$ $T = 209 - 130 = 79°F$ 72.8 hrs

A plot of measured vs. calculated temperatures (next page) shows fairly good agreement.

∴ Use h values with 0.40 product correction factor.

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

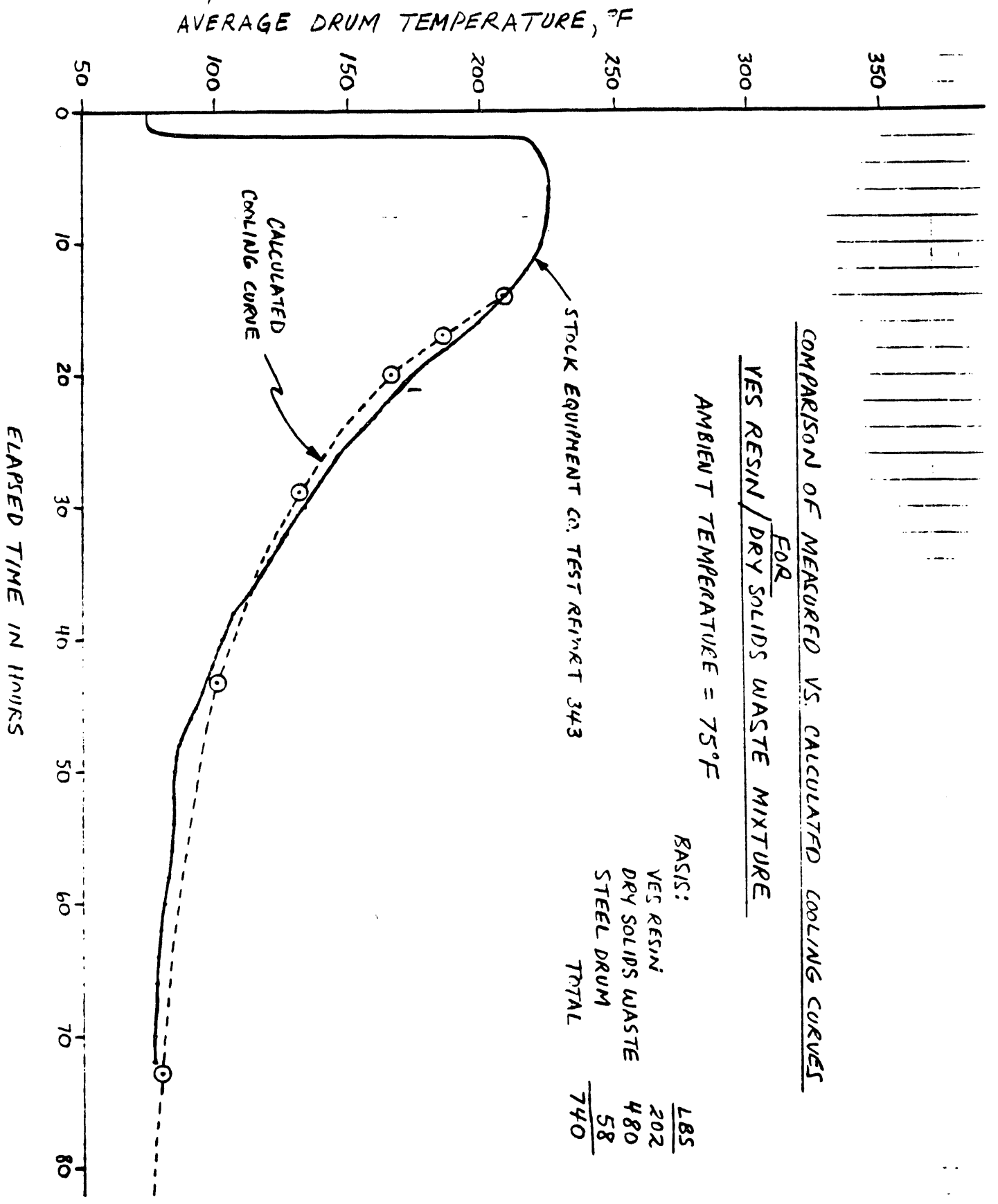
(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 002	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-14-93	DATE 7-12-93
VOID			
SHEET 8 OF 23		DATE	DATE
J.O 6237008			

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES



COMPARISON OF MEASURED VS. CALCULATED COOLING CURVES FOR VES RESIN/DRY SOLIDS WASTE MIXTURE

AMBIENT TEMPERATURE = 75°F

BASIS:

	LBS
VES RESIN	202
DRY SOLIDS WASTE	480
STEEL DRUM	58
TOTAL	740

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC-WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2A P CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-15-93	RLH DATE 9-13-93
FINAL				
VOID				
SHEET 9 OF 23		1	RLH DATE 9-18-93	KDV DATE 9-27-93
J.O 6237008				

Calculate some cooling curves for 100% VES Polymer and VES Polymer/Waste mixtures using peak exotherms calculated in Calc. Set No.

Calculate fastest and slowest cooling rates, as well as hottest and coldest peak exotherms. Use dry waste streams since it is not clear what the peak exotherm temperature is with waste containing water.

STREAM NO.	PEAK TEMP. °F	
100% VES POLYMER	300°F	(For comparison with polyethylene)
5A1	400 ~~418~~°F	
3	181 ~~187~~°F	
5C1	389 ~~406~~°F	

Assume cooling begins 10 hours after mixing of VES polymer and waste. Stock Equipment Co. data indicates that it takes about this long for the temperature in the drum to stabilize before cooling begins.

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
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W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 7/2/93
VOID				
SHEET 10 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

Calculate Cooling Curve for 100% VES Resin, Assume $T_0 = 300°F$

$6.66\ ft^3 \times 65\ lb/ft^3 = 432.9\ lbs$ (For comparison with polyethylene)

$$\alpha = \frac{k}{C_p \rho} = \frac{0.08}{(0.29)(65)} = 0.00424$$

$$F_0 = \frac{\alpha \theta}{R^2} = \frac{0.00424\ \theta}{(.9375)^2} = 0.00483\ \theta$$

$$Bi = \frac{hR}{K} \quad \frac{(1.14)(.9375)}{0.08} = 13.36$$

@ $\theta = 24$ hrs. $Q/Q_0 = 0.54$

$F_0 = 0.116$

@ $\theta = 20.7$ hrs, $F_0 = 0.10$ $Q/Q = 0.51$

$225 \times 0.51 = 115°$ $T = 300 - 115° = 185°F$

$\theta = 2.07$ hrs $F_0 = 0.01$ $Q/Q_0 = 0.14$

$225 \times 0.14 = 31°$ $T = 300 - 31° = 269°F$

$\theta = 10.35$ hrs $F_0 = 0.05$ $Q/Q_0 = 0.35$

$225 \times 0.35 = 79°$ $T = 300 - 79 = 221°F$

$\theta = 51.76$ hrs $F_0 = 0.25$ $Q/Q_0 = 0.76$

$225 \times .76 = 171$ $T = 300 - 171 = 129°F$

$\theta = 77.64$ hrs $F_0 = 0.375$ $Q/Q_0 = 0.87$

$225 \times .87 = 196°F$ $T = 300 - 196 = 104°F$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-15-93	RLH DATE 7/21
FINAL				
VOID				
SHEET 11 OF 23		1	RLH DATE 7/21/93	KDV DATE 9-28-93
J.O. 6237008				

Stream 5A1

	Lbs
VES	388.2
Waste	258.8
Total	647.0

Calculate average K, Cp, ρ

$$K = \frac{(388.2)(0.08) + (258.8)(1.0)}{647.0} = \frac{31.06 + 258.8}{647.0} = 0.45$$

$$Cp = \frac{(388.2)(0.29) + (258.8)(0.05)}{647.0} = \frac{112.58 + 12.94}{647.0} = 0.19$$

$\rho = 97.14\ lb/ft^3$ from R. Heaked Table.

$$\alpha = \frac{K}{Cp\,\rho} = \frac{0.45}{(0.19)(97.14)} = 0.0244$$

Peak Temp = ~~418~~ 400 Δ °F

Ambient Temp = 75°F (assumed)

$\Delta T = \cancel{418} - 75 = \cancel{343}$ 400 Δ 325 Δ °F

$$h = 2.7 + 0.6\left(\frac{\cancel{143}}{100}\right) = \cancel{3.558}\ 3.45 \times 0.40 = \cancel{1.42}\ 1.32\ \Delta\ BTU/hr\text{-}ft^2\text{-}°F$$

Product Correction Factor

$\Delta T = 200°F$

$$Bi = \frac{hR}{K} = \frac{(\cancel{1.42}\ 1.38\ \Delta)(0.9375)}{0.45} = \cancel{3.0}\ 2.92\ \Delta$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV DATE 6-15-93	RLH DATE 9/3/93
FINAL			
VOID			
SHEET 12 OF 23	1	RLH DATE 9/9/93	KDV DATE 9-23-93
J.O 6237078			

Stream 5A1 (cont.) $F_o = \frac{\alpha \theta}{R^2}$ θ in hours

$\alpha = 0.0244$ $F_o = \frac{(0.0244)(\theta)}{(1.9375)^2} = 0.0278\,\theta$

$\Delta T = \cancel{343}\ 325$ △ $Bi = \cancel{3.0}\ 2.92$ △

$\theta = 0.36$ hrs $F_o = 0.01$ $Q/Q_o = 0.04$

$\frac{10}{10.36}$ $T = \cancel{418}\ 400$ △ $- 0.04(\cancel{343}\ 325) = \cancel{404}\ 387$ °F △

$\theta = 1.80$ hrs $F_o = 0.05$ $Q/Q_o = 0.15$

$\frac{10}{11.8}$ $T = \cancel{418}\ 400$ △ $- 0.15(\cancel{343}\ 325) = \cancel{367}\ 351$ °F △

$\theta = 3.6$ hrs $F_o = 0.10$ $Q/Q_o = 0.30$

$\frac{10}{13.6}$ $T = \cancel{418}\ 400$ △ $- 0.30(\cancel{343}\ 325) = \cancel{315}\ 303$ °F △

$\theta = 9$ hrs $F_o = 0.25$ $Q/Q_o = 0.56$

$\frac{10}{19}$ $T = \cancel{418}\ 400$ △ $- 0.56(\cancel{343}\ 325) = \cancel{226}\ 218$ °F △

$\theta = 18$ hrs $F_o = 0.50$ $Q/Q_o = 0.79$

$\frac{10}{28}$ $T = \cancel{418}\ 400$ △ $- 0.79(\cancel{343}\ 325) = \cancel{147}\ 143$ °F △

$\theta = 36$ hrs $F_o = 1.0$ $Q/Q_o = 0.94$

$\frac{10}{46}$ $T = \cancel{418}\ 400$ △ $- 0.94(\cancel{343}\ 325) = \cancel{96}\ 95$ °F △

Calculate temperature at center of drum and at surface of drum for $\theta = 13$ and $\theta = 36$ hours. 2.92 △

$\theta = 18$ $F_o = 0.5$ $Bi = \cancel{3.0}$ Use Fig. 19 and 20, Kutateladze

$\frac{+10}{28}$ $\vartheta_c = \frac{T_c - T_o}{T_i - T_o} = \frac{T_c - 75}{\cancel{418}\ 400 - 75}$ △ $= 0.28$ $T_c = \cancel{171}\ 166$ °F △ (center)

$\vartheta_s = \frac{T_s - T_o}{T_i - T_o} = \frac{T_s - 75}{\cancel{418}\ 400 - 75}$ △ $= 0.10$ $T_s = \cancel{109}\ 108$ °F △ (surface)

$\theta = 36$ $F_o = 1.0$

$\frac{+10}{46}$ $\vartheta_c = \frac{T_c - 75}{\cancel{418}\ 400 - 75}$ △ $= 0.06$ $T_c = \cancel{96}\ 95$ °F △ (center)

$\vartheta_s = \frac{T_s - 75}{} = 0.02$ $T_s = 82$ °F (surface)

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-15-93	RLH DATE 9/3/92
FINAL				
VOID				
SHEET 13 OF 23		1	RLH DATE 9/9/93	KDV DATE 9-28-93
J.O 6237008				

Stream 3

	Lbs
VES	119.5
Waste	278.7
	398.2

$$K = \frac{(119.5)(0.08) + (278.7)(0.12)}{398.2} = \frac{9.56 + 33.44}{398.2} = 0.108$$

$$C_p = \frac{(119.5)(0.29) + (278.7)(0.30)}{398.2} = \frac{34.66 + 83.61}{398.2} = 0.297$$

$$\rho = 59.79 \text{ lb/ft}^3$$

$$\alpha = \frac{0.108}{(0.297)(59.79)} = 0.00608 \qquad F_o = \frac{(.00608)(\theta)}{(.9375)^2} = 0.00692\,\theta$$

$$\Delta T = \cancel{112}\ 106\ ^\circ F \triangle \qquad h = 2.1 + 0.6\left(\frac{\cancel{12}\ 6}{100}\right) = \cancel{2.172}\ 2.136 \triangle \times 0.40 = \cancel{0.869}\ 0.854 \triangle$$

$$Bi = \frac{hR}{K} = \frac{(\cancel{0.869}\ 0.854)(.9375)}{0.108} = \cancel{7.5}\ 7.42 \triangle$$

$\theta = 1.45$ hrs, $F_o = 0.01$, $Q/Q_o = 0.09$
+10
11.45
$T = \cancel{187}\ 181 - 0.09(\cancel{112}\ 10) = \cancel{177}\ 171\ ^\circ F$

$\theta = 7.2$ hrs, $F_o = 0.05$, $Q/Q_o = 0.27$
+10
17.2
$T = \cancel{187}\ 181 - 0.27(\cancel{112}\ 30) = \cancel{157}\ 152\ ^\circ F$

$\theta = 14.5$ hrs, $F_o = 0.10$, $Q/Q_o = 0.45$
+10
24.5
$T = \cancel{187}\ 181 - 0.45(\cancel{112}\ 50) = \cancel{137}\ 133\ ^\circ F$

$\theta = 36.1$ hrs, $F_o = 0.25$, $Q/Q_o = 0.70$
+10
46.1
$T = \cancel{187}\ 181 - 0.70(\cancel{112}\ 78) = \cancel{109}\ 103\ ^\circ F$

$\theta = 72.2$, $F_o = 0.50$, $Q/Q_o = 0.90$
+10
82.2
$T = \cancel{187}\ 181 - 0.90(\cancel{112}\ 101) = 86\ ^\circ F$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Stone & Webster Company

W2AP CALC. SET NO. 002	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV DATE 6-15-93	RLH DATE 9/28/93
FINAL			
VOID			
SHEET 14 OF 23	1	RLH DATE 9/28/93	KDV DATE 9-28-93
J.O 6237008			

NAME OF COMPANY: DOE/WHC - WRAP 2A

UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE COOLING CURVES

Stream SC1 (Macroencapsulation of Lead bricks)

	Lbs	ft^3
VES	377.1	5.85
Waste	572.7	0.81
	949.8	6.66

12.1% of volume

Due to low volume of lead, assume for heat loss calculations, that the bulk properties are those of VES Resin.

From p. 6 VES
$$\begin{cases} k = 0.08 \text{ BTU/hr ft}^2(°F/ft) \\ C_p = 0.29 \text{ BTU/lb °F} \\ \rho = 65 \text{ lb/ft}^3 \end{cases}$$

$$\alpha = \frac{.08}{(0.29)(65)} = 0.00424$$

$\Delta T = \cancel{406}\ 389 - 75 = \cancel{331}\ 314$ △

Product Correction Factor

$$h = 2.7 + 0.6\left(\frac{\cancel{131}\ 114}{100}\right) = \cancel{3.486}\ 3.384 \times 0.40 = \cancel{1.394}\ 1.354 \text{ BTU/hr ft}^2\,°F$$ △

$$Bi = \frac{hR}{k} = \frac{(\cancel{1.394}\ 1.354)(0.9375)}{0.08} = \cancel{16.3}\ 15.9$$ △

$$F_o = \frac{\alpha\theta}{R^2} = \quad F_o = \frac{(0.00424)(\theta)}{(.9375)^2} = 0.00482\,\theta \qquad \theta \text{ in hours}$$

$\Delta T = \cancel{331}\ 314°$ △ $\quad Bi = \cancel{16.3}\ 15.9$ △

$\theta = 2.1$ hrs. $\quad F_o = 0.01 \quad Q/Q_o = 0.15$

$+ 10$

12.1 hrs $\quad T = \cancel{406}\ 389 - 0.15(\cancel{331}\ 314) = \cancel{356}\ 342°F$ △

$\theta = 10.4$ hrs $\quad F_o = 0.05 \quad Q/Q_o = 0.37$

$+ 10$

20.4 hrs $\quad T = \cancel{406}\ 389 - 0.37(\cancel{331}\ 314) = \cancel{284}\ 273°F$ △

$\theta = 20.8$ hrs. $\quad F_o = 0.10 \quad Q/Q_o = 0.53$

$+ 10$

30.8 hrs $\quad T = \cancel{406}\ 389 - 0.53(\cancel{331}\ 314) = \cancel{231}\ 223°F$ △

$\theta = 51.9$ hrs $\quad F_o = 0.25 \quad Q/Q_o = 0.77$

$+ 10$

$61.9 \quad T = \cancel{406}\ 389 - 0.77(\cancel{331}\ 314) = \cancel{151}\ 147°F$ △

$\theta = 103.7$ hrs. $\quad F_o = 0.50 \quad Q/Q_o = 0.94$

$+ 10$

$113.7 \quad T = \cancel{406}\ 389 - 0.94(\cancel{331}\ 314) = \cancel{95}\ 94°F$ △

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 9/13/93
VOID				
SHEET 15 OF 23		1	RLH	KDV
0 6237008			DATE 9/13/93	DATE 9-23-93

Stream 5C1 (cont)

Calculate temperature at center of drum and at surface of drum at 24, 48, 72 and 96 hours

$Fo = .00482\,\theta$

$Bi = \cancel{16.3}\ 15.9$ △

$\theta = 14 + 10 = 24$ $\quad Fo = 0.0675$

Use Fig. 19 (T_c) and Fig. 20 (T_s) in Kutateladze

$\vartheta_c = \dfrac{T_c - T_o}{T_i - T_o}$ (No curve in this region)

$\vartheta_s = \dfrac{T_s - T_o}{T_i - T_o} = \dfrac{T_s - 75}{\cancel{406}\ 389 - 75} = 0.11$ △ $\quad T_s = \cancel{111}\ 110\,°F$ △ vs. $T_{AVG} = \cancel{263}\ 257\,°F$ △ (24 hours)

$\theta = 38 + 10 = 48$ $\quad Fo = 0.183$

$\vartheta_c = \dfrac{T_c - 75}{\cancel{406}\ 389 - 75} = 0.60$ △ $\quad T_c = \cancel{274}\ 263\,°F$ △

$\vartheta_s = \dfrac{T_s - 75}{\cancel{406}\ 389 - 75} = 0.06$ △ $\quad T_s = \cancel{95}\ 94\,°F$ △

vs. $T_{AVG} = \cancel{175}\ 170\,°F$ △ (48 hours)

$\theta = 62 + 10 = 72$ $\quad Fo = 0.30$

$\vartheta_c = \dfrac{T_c - 75}{\cancel{406}\ 389 - 75} = 0.34$ △ $\quad T_c = \cancel{188}\ 122\,°F$ △

$\vartheta_s = \dfrac{T_s - 75}{\cancel{406}\ 389 - 75} = 0.028$ △ $\quad T_s = \cancel{81}\ 84\,°F$ △

vs. $T_{avg} = \cancel{137}\ 133\,°F$ △ (72 hours)

$\theta = 86 + 10 = 96$ $\quad Fo = 0.415$

$\vartheta_c = \dfrac{T_c - 75}{\cancel{406}\ 389 - 75} = 0.20$ △ $\quad T_c = \cancel{141}\ 138\,°F$ △

$\vartheta_s = \dfrac{T_s - 75}{\cancel{406}\ 389 - 75} = 0.014$ △ $\quad T_s = \cancel{80}\ 79\,°F$ △

vs. $T_{avg} = \cancel{111}\ 109\,°F$ △ (96 hours)

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S:

SUBJECT: CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 7-13-93
VOID				
SHEET 16 OF 23		1	PLH	KDV
J.O. 6237008			DATE 9/9/93	DATE 9-23-93

Stream 8 Assume no water is vaporized, Peak temp = ~~308~~ 297 °F

	165
VES	290.5
Dry Waste	174.2
Water	19.4
	484.1

$K_{water} = 0.39$ (Ref. 4)

$\bar{T} = \frac{\cancel{308}\,297 + 75}{2} = \cancel{192}\,186\,°F$

$\Delta T = \cancel{308}\,297 - 75 = \cancel{233}\,222\,°F$

$$K = \frac{(290.5)(0.08) + (174.2)(0.20) + (19.4)(0.39)}{484.1} = \frac{23.24 + 34.84 + 7.57}{484.1} = 0.136$$

65.65

$$C_p = \frac{(290.5)(0.29) + (174.2)(0.20) + (19.4)(1.0)}{484.1} = \frac{84.25 + 34.84 + 19.4}{484.1} = 0.286$$

138.49

$\rho = 72.68\ lb/ft^3$ (from Mass Balance Table)

$$\alpha = \frac{K}{C_p \rho} = \frac{0.136}{(0.286)(72.68)} = 0.00654$$

Product Correction Factor

$$h = 2.7 + 0.6\left(\frac{\cancel{33}\,22}{100}\right) = \cancel{2.898}\,2.832 \times 0.40 = \cancel{1.16}\,1.13\ BTU/hr\,ft^2\,°F$$

$$Bi = \frac{hR}{K} = \cancel{8.0}\,7.8$$

$$F_o = \frac{\alpha\theta}{R^2} = \frac{(0.00654)(\theta)}{(.9375)^2} = 0.00744\,\theta \quad \theta \text{ in hours}$$

$\theta = 1.34$
$+10$
11.34 hrs.

$F_o = 0.01$ $Q/Q_o = 0.10$

$T = \cancel{308}\,297 - 0.10(\cancel{233}\,222) = \cancel{285}\,275\,°F$

$\theta = 6.72$
$+10$
16.72 hrs.

$F_o = 0.05$ $Q/Q_o = 0.28$

$T = \cancel{308}\,297 - 0.28(\cancel{233}\,65\ 222) = \cancel{243}\,235\,°F$

$\theta = 13.5$
$+10$
23.5 hrs.

$F_o = 0.10$ $Q/Q_o = 0.46$

$T = \cancel{308}\,297 - 0.46(\cancel{233}\,107\ 222) = \cancel{201}\,195\,°F$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 9/13
VOID				
SHEET 17 OF 23		1	RLH	KDV
J.O 6237008			DATE 11-9-93	DATE 9-23-93

Stream 8 (cont)

$\theta = 33.6 + 10 = 43.6$ $\quad F_0 = 0.25 \quad Q/Q_0 = 0.71$

$T = \cancel{308}^{297\,\Delta} - 0.71(\cancel{233}^{165\ 222}) = \cancel{143}^{139\,\Delta}\,°F$

$\theta = 67.2 + 10 = 77.2$ $\quad F_0 = 0.50 \quad Q/Q_0 = 0.91$

$T = \cancel{308}^{297\,\Delta} - 0.91(\cancel{233}^{212\ 222}) = \cancel{96}^{95\,\Delta}\,°F$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY UOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF VES POLYMER/WASTE COOLING CURVES

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 9/13/93
VOID				
SHEET 18 OF 23			DATE	DATE
J.O 6237002				

WASTE AND BINDERS PHYSICAL PROPERTY DATA

Waste Feedstreams	Treated Bulk Density (lb/ft^3)	Treated Particle Density (lb/ft^3)	Heat Capacity (BTU/lb°F)	Thermal Conductivity (BTU/hr ft^2(°F/ft)	Moisture Content (Wt%)
1A	100	130	0.2	0.3	10
1B	60	140	0.2	0.2	4
1C	69	100	0.2	0.2	44
1D	75	105	0.2	0.2	–
2A	88	111	0.25	0.3	10
2B	55	77	0.3	0.1	55
2C	75	140	0.1	0.2	75
2D	40	50	0.3	0.1	50
3	45	58	0.3	0.12	–
4	60	100	0.2	0.3	–
5A1 (amalgamated mercury)	408	408	0.05	1.0	–
5A2 (bulk mercury)	40	58	0.3	0.1	–
5B	200	240	0.11	8	–
5C1 (elemental lead)	710	710	0.03	20	–
5C2 (bulk lead)	80	105	0.3	0.1	–
5D	450	450	0.1	30	–
6	90	90	0.25	0.1	10
7	35	90	0.3	0.3	--
8	90	90	0.2	0.2	10
Binders					
VES Resin (Derakane 470-36)	65	65	0.29	0.08	–
Polyethylene	57	57	0.55	0.19	–

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

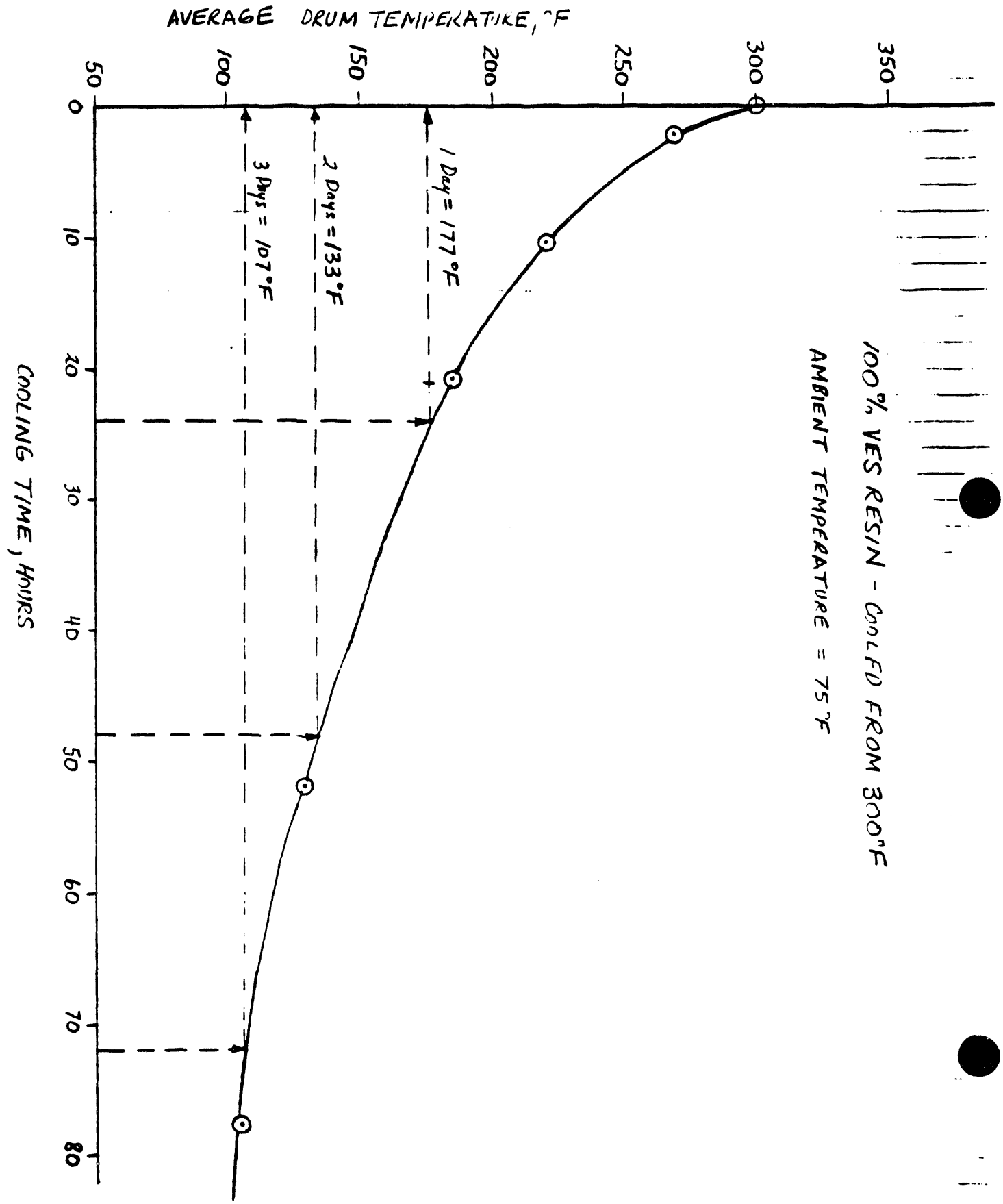
(DISCIPLINE)

United Engineers & Constructors
A Stone & Webster Company

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 2/3/92
VOID				
SHEET 19 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC-URAP 2A UNIT/S

SUBJECT COOLING CURVE FOR 100% VES RESIN FROM 300°F



FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

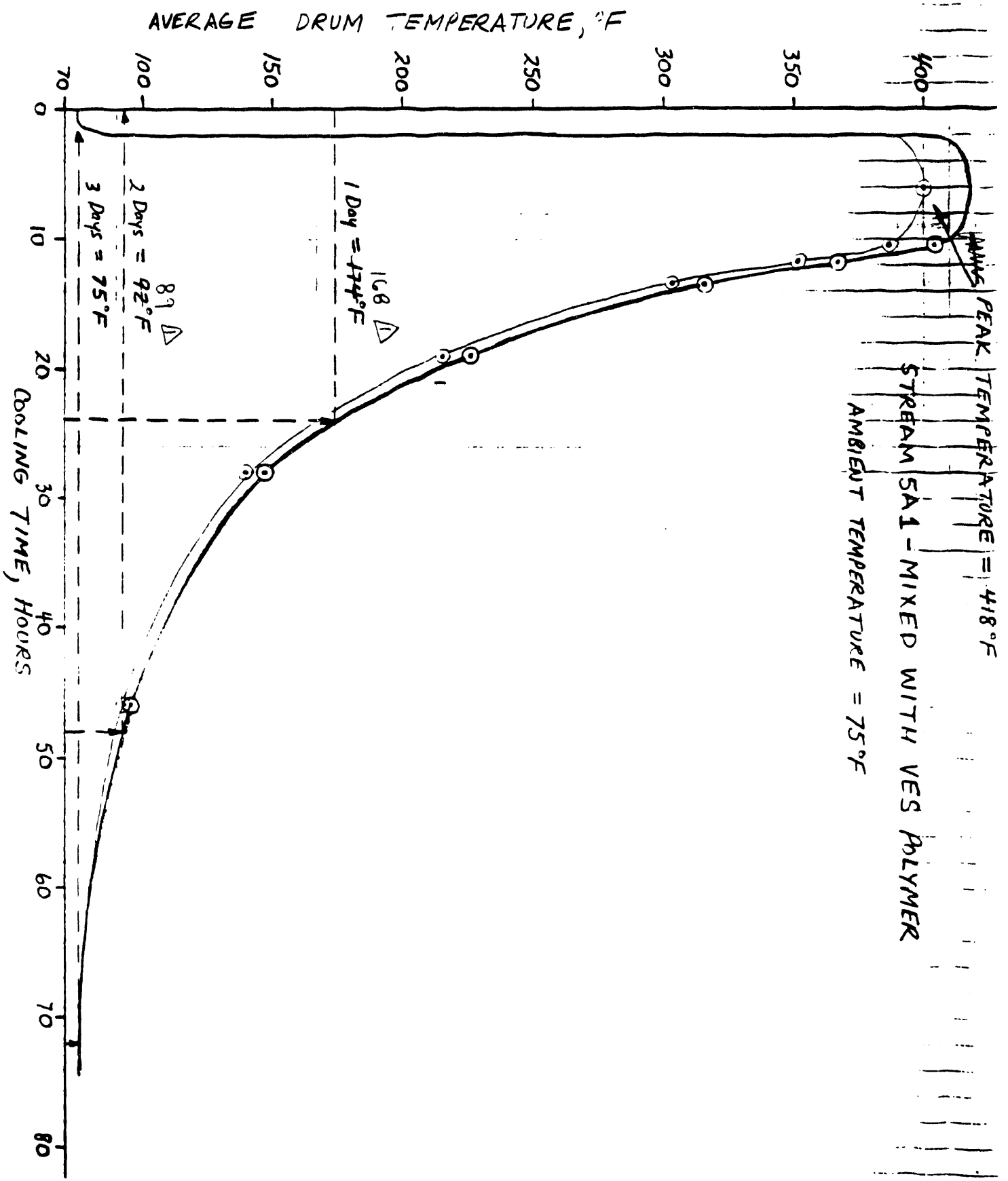
(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WRAP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-15-93	RLH DATE 9/13/93
FINAL				
VOID				
SHEET 20 OF 23		1	RLH DATE 9/8/93	KDV DATE 9-22-93
J.O 6237008				

NAME OF COMPANY: DOE/WHC - WRAP 2A UNITS

SUBJECT: COOLING CURVE FOR MIXTURE OF STREAM 5A1 AND VES POLYMER



FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

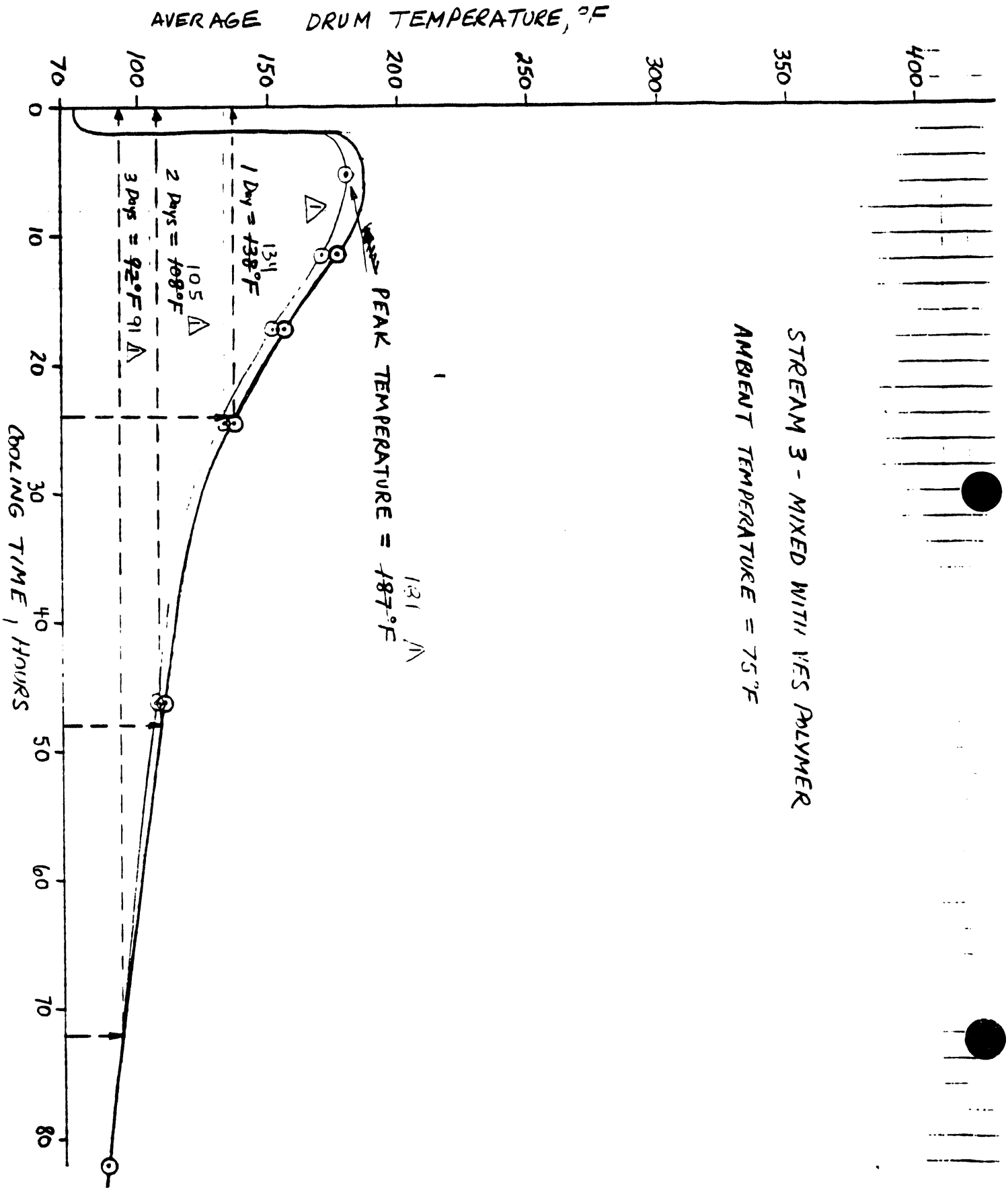
(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV DATE 6-15-93	RLH DATE 9/7/93
FINAL				
VOID				
SHEET 21 OF 23		1	CLH DATE 9/8/93	KDV DATE 9-22-93
J.O 6237002				

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: COOLING CURVE FOR MIXTURE OF STREAM 3 AND VES POLYMER



FORM 5007 REV 1/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors

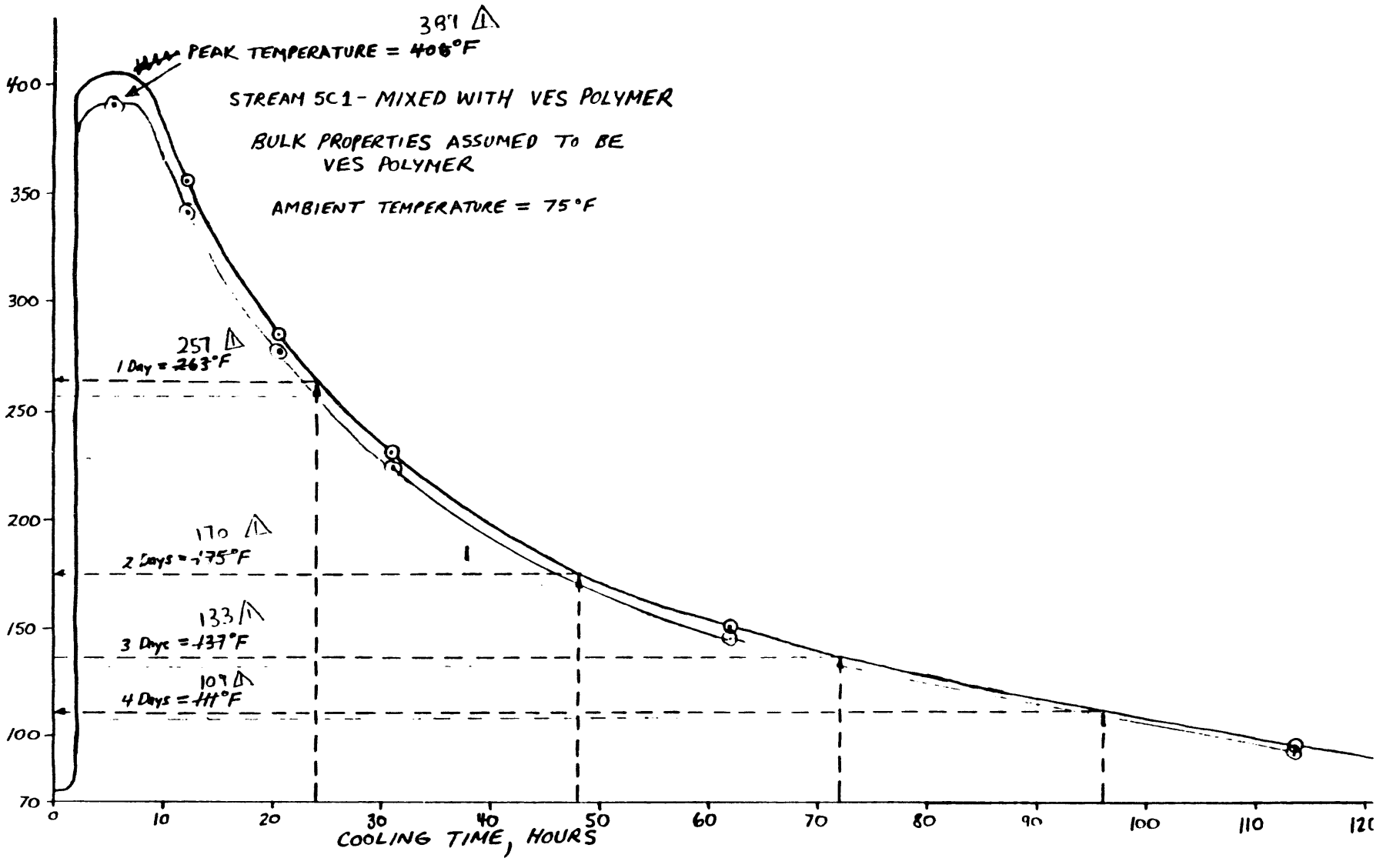
NAME OF COMPANY DOE/WHC - WRAP 2A UNITS

SUBJECT COOLING CURVE FOR MIXTURE OF STREAM SC1 AND VES POLYMER

W2A P CALC. SET NO 002	REV	COMP BY	CHK'D BY
PRELIM. ✓	0	KDV DATE 6-25-92	RLH DATE 9/13/93
FINAL			
VOID		RLH DATE 9/16/92	KDV DATE 9-20-93

SHEET 22 OF 23

J.O. 6237003



FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

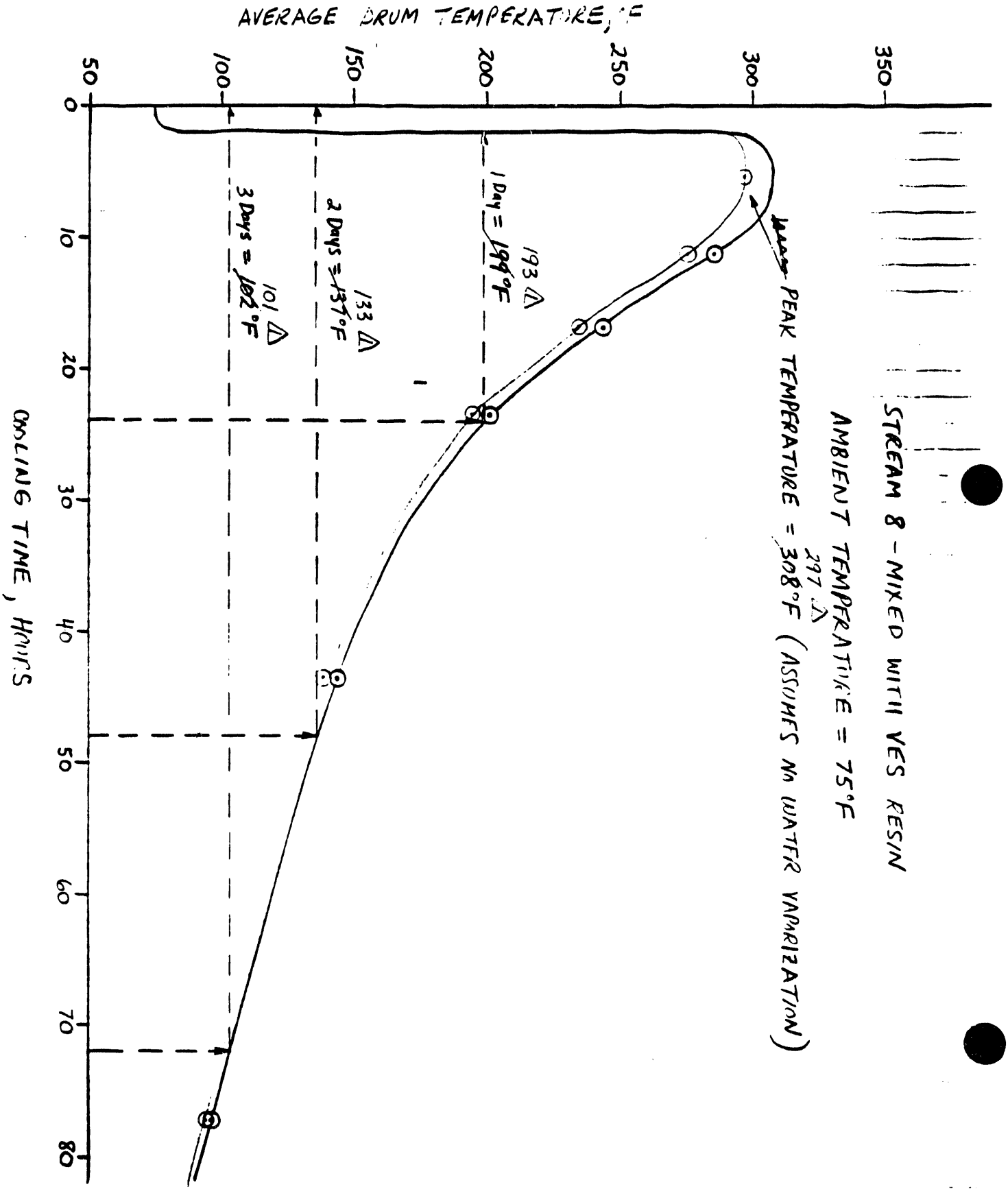
United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY: DOE/WHC - WRAP 2A

UNIT/S

SUBJECT: COOLING CURVE FOR MIXTURE OF STREAM 8 AND VES POLYMER

W2AP CALC. SET NO. 002		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-15-93	DATE 9 3
VOID				
SHEET 23 OF 23		1	RLH	KDV
J.O. 6237008			DATE 9/1/93	DATE 9-28-93



FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

DISCIPLINE

United Engineers & Constructors

W2AP CALC. SET NO 003	REV	COMP BY	CHK'D BY
PRELIM ✓	0	KDV	
FINAL		DATE 6-30-93	DATE
VOID			
SHEET 1 OF 23		DATE	DATE
J.O 6237008			

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

CALCULATION DISCLOSURE SHEET

ITEM #	CALC. SHEET #	ITEM DESCRIPTION	CALC. SET REV. # (Item Resolved)	REMARKS
1	23	Verify waste and binder physical property data		

TOTAL NUMBER OF CALCULATION SET SHEETS 23 CALC. SET REV. 0

CALCULATION DONE BY K.D. Van Zanten DATE 6-30-93

CALCULATION CHECKED BY R. L. HENKEL DATE 7/1/93

CONCURRED BY _____ DATE _____

LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

DISCIPLINE: Unified Engineers & Constructors

NAME OF COMPANY: DOE/WHC - WRAP 2A UNITS:

SUBJECT: CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

WRAP CALC SET NO 003	REV	COMP BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-30-93	DATE 7/1/
VOID			
SHEET 2 OF 23		DATE	DATE
J.O 6237008			

CALCULATION CONTROL SHEET

PROBLEM STATEMENT

Calculate the final equilibrium temperatures after mixing hot molten polyethylene and size reduced vibro waste.

DESIGN BASIS

1. Polyethylene Only System Mass Balance, Rev. 2, 6/1/93
2. Waste and Binder Physical Property Data (p.23)
3. Polyethylene temperature between 250°F and 450°F
4. Waste temperatures 60°F and/or 200°F.
5. No heat loss during mixing.

TOTAL NUMBER OF CALCULATION SET SHEETS 23 CALC. SET REV. 0

CALCULATION DONE BY K.D. Van Zanten DATE 6-30-93

CALCULATION CHECKED BY R. L. HENKEL DATE 7/1/93

CONCURRED BY _____ DATE _____

LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 7/1/93
VOID				
SHEET 3 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

CALCULATION OF: POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT: EQUILIBRIUM TEMPERATURES

CALCULATION SUMMARY SHEET

① No Waste Preheat

STREAM NO.	1/3 Polyethylene Added*	2/3 Polyethylene Added**	All Polyethylene Added**
1D (0% Water)	200°F ✓	266°F ✓	304°F ✓
3 (0% Water)	136°F ✓	188°F ✓	225°F ✓
4 (0% Water)	164°F ✓	224°F ✓	264°F ✓
5A2 (0% Water)	166°F ✓	227°F ✓	266°F ✓
5C1 (0% Water)	(Macroencapsulation - all polyethylene added at one time)		403°F ✓
5C2 (0% Water)	138°F ✓	190°F ✓	227°F ✓
5D (0% Water)	229°F ✓	296°F ✓	332°F ✓
1A (10% Water)	212°F ✓	220°F ✓	277°F
2D (50% Water)	120°F ✓	163°F ✓	197°F ✓

* Basis: Polyethylene @ 450°F, Waste and Drum @ 60°F

② With Waste Preheat

STREAM NO.	POLYETHYLENE TEMP, °F	PREHEATED WASTE AND DRUM, °F	1/3 POLYETHYLENE ADDED	2/3 POLYETHYLENE ADDED	ALL POLYETHYLENE ADDED
1D	360°F ✓	200°F ✓	257°F ✓	284°F ✓	300°F ✓
3	450°F ✓	200°F ✓	249°F ✓	282°F ✓	306°F ✓
4	392°F ✓	200°F ✓	251°F ✓	281°F ✓	300°F ✓
5A2	389°F ✓	200°F ✓	252°F ✓	281°F ✓	300°F ✓
5C1	333°F ✓	60°F ✓	(Macroencapsulation - all polyethylene added at one time)		300°F ✓
5C2	450°F ✓	200°F ✓	250°F ✓	283°F ✓	307°F ✓
5D	344°F ✓	200°F ✓	262°F ✓	287°F ✓	300°F ✓
1A	326°F ✓	200°F ✓	271°F ✓	291°F ✓	300°F ✓
2D	349°F ✓	200°F ✓	261°F ✓	287°F ✓	300°F ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WIRAP 2A UNITS

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

SUBJECT

W2A-P CALC. SET NO 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 7/1/93
VOID				
SHEET 4 OF 23			DATE	DATE
J.O 6237008				

CALCULATION REFERENCE SHEET

1. Perry's Chemical Engineering Handbook, 6TH Edition, 1984
2. Principles of Unit Operations, Foust et al, 1960

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6/7/93	DATE 7/1/93
VOID				
SHEET 5 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC-WRAP 2A UNIT/S

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

Calculate the final equilibrium temperatures of mixing hot (450°F*) molten polyethylene (PE) and size reduced vibro mixed waste. Assume waste at room temperature (60°F) and heat capacities per R. Henkel (6/4/93) and waste loadings per R. Henkel (Rev. 2 6/1/93). Assume no heat loss.

Calculate temperatures for wastes w/o water. (Streams 1D, 3, 4, 5A2, 5C1, 5C2, 5D

Assume steel drum weighing 50#. Steel Cp = 0.12 BTU/lb°F

* 450°F BASED UPON MAXIMUM RECOMMENDED EXTRUDER TEMP FOR LOW DENSITY POLYETHYLENE FROM BNL DATA

STREAM 1D

Cp = 0.2 BTU/lb°F PE Cp = 0.55 BTU/lb°F

Waste	313.9 lbs
PE	209.2 lbs
Drum	50.0 lbs
Total	573.1 lbs

① Add 1/3 PE to full drum of waste. Assume all waste, drum and PE reach final equilibrium temperature.

$$\underset{m}{(313.9)}\underset{Cp}{(0.2)}\underset{\Delta T}{(T-60)} + \underset{m}{(50)}\underset{Cp}{(0.12)}\underset{\Delta T}{(T-60)} = \underset{m}{\left(\frac{209.2}{3}\right)}\underset{Cp}{(0.55)}\underset{\Delta T}{(450-T)}$$

$$(62.78 + 6)(T-60) = (38.35)(450-T)$$

$$68.78\,T - 4126.8 = 17257.5 - 38.35\,T$$

$$107.13\,T = 21{,}324.3 \qquad T = 199.6\,°F$$ too low

② Try 1/2 PE to full drum of waste

$$(313.9)(0.2)(T-60) + (50)(0.12)(T-60) = (1/2)(209.2)(0.55)(450-T)$$

$$68.78\,T - 4126.8 = 57.53(450-T)$$

$$126.31\,T = 25{,}888.5 + 4126.8 = 30{,}015.3$$

$$T = 237.6\,°F$$ too low

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6/7/93	DATE 7/1/93
VOID				
SHEET 6 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC-WRAP 2A UNIT/S

CALCULATION OF POLYETHYLENE/WASTE VIBRS MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

(Stream 1D cont)

③ Try 2/3 PE to full drum of waste

$$(313.9)(0.2)(T-60)+(50)(0.12)(T-60) = (2/3)(209.2)(0.55)(450-T)$$

$$68.78\,T - 4126.8 = 76.71(450-T) \qquad 34519.5$$

$$68.78T + 76.71T = 145.49\,T = 34519.5 + 4126.8 = 38{,}646.3$$

$$T = 265.6\ °F \quad ✓\ OK$$

④ Try all PE to full drum of waste

$$(313.9)(0.2)(T-60)+(50)(0.12)(T-60) = (209.2)(0.55)(450-T)$$

$$68.78\,T - 4126.8 = 115.06(450-T) \qquad 51777$$

$$68.78T + 115.06T = 183.84\,T = 51{,}777 + 4126.8 = 55{,}903.8$$

$$T = 304.1\ °F \quad ✓\ OK$$

∴ For Stream 1D, Need external heating if 1/3 – 1/2 PE is added to full drum of waste

Stream 3

$C_p = 0.3$ BTU/lb °F

Waste	269.0
PE	115.3
Drum	50.0
Total	434.3 lbs

① Add 1/3 PE to full drum of waste.

$$(269.0)(0.3)(T-60)+(50)(0.12)(T-60) = (\tfrac{1}{3})(115.3)(0.55)(450-T)$$

$$(80.7+6)(T-60) = 21.14(450-T)$$

$$86.7\,T - 5202 = 9513 - 21.14\,T$$

$$86.7T + 21.14T = 107.84\,T = 9513 + 5202 = 14{,}715$$

$$T = 136.5\ °F \quad ✓\ \text{too low}$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WRAP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	EL
FINAL			DATE 6/7/93	DATE
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SHEET 7 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNITS

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

(Stream 3 cont.)

(2) Try 2/3 PE to full drum of waste

$$(269.0)(0.3)(T-60) + (50)(0.12)(T-60) = (2/3)(115.3)(0.55)(450-T)$$

$$86.7T - 5202 = 42.28(450-T) \quad 19024.5$$

$$128.98\,T = 24{,}226.5$$

$$T = 187.8\,°F$$ too low

(3) Try all PE to full drum of waste

$$(269.0)(0.3)(T-60) + (50)(0.12)(T-60) = (115.3)(0.55)(450-T)$$

$$86.7T - 5202 = 63.42(450-T) \quad 28536.8$$

$$150.12T = 33738.8$$

$$T = 224.7\,°F$$ ✓

∴ Need external heating to raise final temp above 250°F.

Stream 4

Waste	380.2
PE	162.9
Drum	50.0
Total	593.1 lbs

$C_p = 0.2$ BTU/lb °F

(1) Add 1/3 PE to full drum of waste

$$(380.2)(0.2)(T-60) + (50)(0.12)(T-60) = (\tfrac{1}{3})(162.9)(0.55)(450-T)$$

$$(76.04 + 6)(T-60) = 29.87(450-T) \quad 13439.3$$

$$82.04T + 29.87T = 111.91T = 13439.3 + 4922.4 = 18361.7$$

$$T = 164.1\,°F$$ ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6/7/93	DATE
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J.O 6237002			

NAME OF COMPANY DOE/WHC - WRAP 2A UNITS

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

(Stream 4 cont.)

② Add 2/3 PE to full drum of waste

$$(380.2)(0.2)(T-60) + (50)(0.12)(T-60) = (2/3)(162.9)(0.55)(450-T)$$

$$82.04T - 4922.4 = 59.73(450-T) \quad 26878.5$$

$$82.04T + 59.73T = 141.77T = 26878.5 + 4922.4 = 31800.9$$

$$T = 224.3°F \checkmark \text{ too low}$$

③ Add all PE to full drum of waste

$$(380.2)(0.2)(T-60) + (50)(0.12)(T-60) = (162.9)(0.55)(450-T)$$

$$82.04T - 4922.4 = 89.60(450-T) = 40317.8 - 89.60T$$

$$171.64T = 45,240.2$$

$$T = 263.6°F \checkmark \text{ OK}$$

∴ Need external heating to add partial amounts of PE (1/3 - 2/3)

<u>Stream 5A2</u>

Waste	230.2	Cp = 0.3 BTU/lb °F
PE	153.4	
Drum	50.0	
Total	433.6 lbs	

① Add 1/3 PE to full drum of waste

$$(230.2)(0.3)(T-60) + (50)(0.12)(T-60) = (1/3)(153.4)(0.55)(450-T)$$

$$75.06T \quad (69.06 + 6)(T-60) = 28.12(450-T) = 12655.5 - 28.12T$$

4503.6

$$103.18T = 12655.5 + 4503.6 = 17159.1$$

$$T = 166.3°F \checkmark \text{ too low}$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLL
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J.O 6237008			

NAME OF COMPANY DOE/WHC - WRAP 2A UNITS

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

(Stream 5A cont)

(2) Add 2/3 PE to full drum of waste

$$(230.2)(0.3)(T-60)+(50)(0.12)(T-60) = (2/3)(153.4)(0.55)(450-T)$$

$$75.06T - 4503.6 = 56.25(450-T) = 25{,}311 - 56.25T$$

$$131.31\,T = 29{,}814.6$$

$$T = 227.1\ °F \quad \text{too low}$$

(3) Add all PE to full drum of waste

$$75.06T - 4503.6 = (153.44)(0.55)(45$$

$$75.06T - 4503.6 = 84.37(450-T)$$

$$= 37966.5 - 84.37$$

$$159.43T = 42470.1$$

$$T = 266.4\ °F$$

∴ Need external heating for 1/3 and 2/3 PE to fill drum of waste

Stream 5C1

Waste	620.6	Cp = 0.03 BTU/lb °F
PE	329.8	
Drum	50	
Total	1000.4 lbs	

Since this is macroencapsulation of lead, add all PE to drum.

(1) Add all PE to full drum of waste

$$(620.6)(0.03)(T-60)+(50)(0.12)(T-60) = (329.8)(0.55)(450-T)$$

$$24.62T\ (18.62+6)(T-60) = 181.39(450-T) = 81625.5 - 181.39T$$

1477.2

$$24.62T - 1477.1 = 81625.5 - 181.39T$$

$$206.01\,T = 83{,}102.7$$

$$T = 403.4\ °F$$

∴ No external heating needed.

Stream 5C2

Waste	390.8	Cp = 0.3 BTU/lb °F
PE	167.5	
Drum	50.0	
	608.3 lbs	

(1) Add 1/3 PE to full drum of waste

$$(390.8)(0.3)(T-60)+(50)(0.12)(T-60) = (1/3)(167.5)(0.55)(450-T)$$

$$123.2T\ (117.2+6)(T-60) = 30.71(450-T) = 13818.8 - 30.71T$$

7392

$$153.91T = 21210.8 \qquad T = 137.8\ °F \quad \text{too low}$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

(Stream 5C2 cont.)

② Try 2/3 PE to full drum of waste

$$(390.8)(0.3)(T-60)+(50)(0.12)(T-60)=(2/3)(167.5)(0.55)(450-T)$$

$$123.2T-7392 = 61.42(450-T) = 27637.5-61.42T$$

$$184.62T = 35029.5$$

$$T = 189.7\,°F$$ ✓ too low

③ Try All PE to full drum of waste

$$(390.8)(0.3)(T-60)+(50)(0.12)(T-60)=(167.5)(0.55)(450-T)$$

$$123.2T-7392 = 92.13(450-T) = 41456.3-92.13T$$

$$215.33T = 48848.3$$

$$T = 226.9\,°F$$ ✓ too low

∴ Need external heating to add all PE

Stream 5D

Waste	652.0	$C_p = 0.1$ BTU/lb °F
PE	297.0	
Drum	50.0	
Total	999.0 lbs	

① Try 1/3 PE to full drum of waste

$$(652.0)(0.1)(T-60)+(50)(0.12)(T-60)=(1/3)(297.0)(0.55)(450-T)$$

$$(65.2+6)(T-60) = 54.45(450-T) = 24502.5-54.45T$$

$$71.2T-4272 = 24502.5-54.45T \qquad 125.65T = 28774.5$$

$$T = 229.0\,°F$$ ✓ too low

② Try 2/3 PE to full drum of waste

$$71.2T-4272 = 2/3(297.0)(0.55)(450-T) = 108.9(450-T)$$

$$49005-108.9T$$

$$180.1T = 53277 \qquad T = 295.8\,°F$$ OK ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY	DOE/WHC - WRAP 2A	UNITS	
CALCULATION OF	POLYETHYLENE/WASTE VIBRO MIXING		
SUBJECT	EQUILIBRIUM TEMPERATURES		

WRAP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
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(Stream 5D cont.)

③ Try all PE to full drum of waste

$$71.2T - 4272 = (297.0)(0.55)(450-T) = 163.35(450-T)$$

$$73507.5 - 163.35T$$

$$234.55T = 77779.5$$

$$T = 331.6°F \quad OK ✓$$

∴ Need external heating if 1/3 PE is add to full drum of waste

<u>Calculate streams with Water</u> (Streams 1A, 2D)

<u>Stream 1A</u> 10% Water

Dry Waste	176.2
Water	19.6
PE	293.8
Drum	50.0

① Try 1/3 PE to full drum of waste

Trial 1 Try 212°F X = fraction water vaporized

$$(176.2)(0.2)(\overset{152}{212-60}) = 1410$$
$$(50)(0.12)(212-60) = 912 \quad \Big\} 5301$$
$$(19.6)(1)(212-60) = 2979$$
$$(X)(19.6)(9703) = 7518$$
$$12{,}819$$

$$(1/3)(293.8)(0.55)(\overset{238}{450-212}) = 12{,}819$$

$X = 0.395$ ∴ $T = 212°F$ ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W&P CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

Stream 1A

(2) Try 2/3 PE to full drum of waste

Trial 1 Try 212°F X = fraction water vaporized

$(176.2)(0.2)(\overset{152}{212-60}) = 1410$
$(50)(0.12)(212-60) = 912$ } 5301
$(19.6)(1.0)(212-60) = 2979$
$(X)(19.6)(970.3) = 20,338$
$25,639$

$(2/3)(293.8)(0.55)(\overset{238}{450-212}) = 25,639$

$X = 1.069 \quad \therefore T > 212°F$

Trial 2 Try 220°F

$5301\left(\frac{160}{152}\right) = 5580$
$(19.6)(970.3) = 19,018$
$24,598$

$25,639\left(\frac{230}{238}\right) = 24,777$

Trial 3 Try 221°F

$5301\left(\frac{161}{152}\right) = 5614$, $19,018$ } $24,632$

$25,639\left(\frac{229}{238}\right) = 24,669$ OK $T = 220°F$ ✓

(3) Add All PE to full drum of waste

$$(176.2)(0.2)(T-60) + (50)(0.12)(T-60) + (19.6)(970.3) = (293.8)(0.55)(450-T)$$

$$35.24 + 6 = 41.24(T-60) + 19,018 = 161.59(450-T)$$

$$41.24T - 2474 + 19018 = 72,716 - 161.59T$$

$$202.83T = 56,172$$

$$T = 277°F$$ ✓

Stream 2D

Dry Waste	105.0
Water	105.1
PE	140.1
Drum	50.0
Total	400.2

(1) Try 1/3 PE to full drum of waste

Trial 1 Assume $T < 212$ (No vaporization)

$T = 120°F$

$$(105)(0.30)(T-60) + (50)(0.12)(T-60) + (105.1)(1.0)(T-60) = (1/3)(140.1)(0.55)(450-T)$$

$$(31.5 + 6 + 105.1)(T-60) = 25.69(450-T) = 11,558 - 25.69T$$

$$142.6T - 8556 \quad 168.29T = 20,114 \quad T = 120°F$$ ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY	DAE/WHC - WRAP 2A	UNIT/S	
CALCULATION OF	POLYETHYLENE/WASTE VIBRO MIXING		
SUBJECT	EQUILIBRIUM TEMPERATURES		

W2A² CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
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J.O 6237.008				

Stream 2D

(2) Try 2/3 PE to full drum of waste

Assume $T < 212°F$ (No water vaporized)

$$(105)(0.30)(T-60) + (50)(0.12)(T-60) + (105.1)(1.0)(T-60) = (2/3)(140.1)(0.55)(450-T)$$

$$142.6T - 8556 = 51.37(450-T)$$

$$= 23,117 - 51.37T$$

$$193.97T = 31,673$$

$$T = 163°F \quad \text{OK} \checkmark$$

(3) Add all PE to full drum of waste

Assume $T < 212°F$ (No water vaporized)

$$(105)(0.30)(T-60) + (50)(0.12)(T-60) + (105.1)(1.0)(T-60) = (140.1)(0.55)(450-T)$$

$$142.6T - 8556 = 77.06(450-T) = 34,675 - 77.06T$$

$$219.66T = 43,231$$

$$T = 197°F \quad \text{OK} \checkmark$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KOV	RLH
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SHEET 14 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING

SUBJECT EQUILIBRIUM TEMPERATURES

Stream 1D

	lbs
PE	209.2
Waste	313.9
Drum	50.0
	573.1

Calculate PE temp required to reach final mix temp of 300°F, if waste and drum preheated to 200°F

$$(313.9)(0.2)(300-200) + (50)(0.12)(300-200) = (209.2)(0.55)(T-300)$$

$$6278 + 600 = 115.06(T-300) = 115.06T - 34{,}518$$

$$115.06T = 41{,}396 \qquad T = 360°F \checkmark \text{ Polyethylene}$$

① Add 1/3 PE @ 360°F

$$(313.9)(0.2)(T-200) + (50)(0.12)(T-200) = (1/3)(209.2)(0.55)(360-T)$$

$$(62.78+6)(T-200) = 38.35(360-T)$$

$$68.78T - 13{,}756 = 13{,}806 - 38.35T$$

$$107.13T = 27{,}562 \qquad T = 257°F \checkmark \text{ OK (above 250°F)}$$

② Add 2/3 PE @ 360°F

$$(313.9)(0.2)(T-200) + (50)(0.12)(T-200) = (2/3)(209.2)(0.55)(360-T)$$

$$68.78T - 13{,}756 = 76.71(360-T) = 27{,}614 - 76.71T$$

$$145.49T = 41{,}370$$

$$T = 284°F \checkmark \text{ OK}$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Waste 269.0
PE 115.3
Drum 50.0
Total 434.3 lbs

Stream 3

Assume waste and drum @ 200°F, PE @ 450°F

① Add 1/3 PE to full drum of waste

$$(269.0)(0.3)(T-200)+(50)(0.12)(T-200)=(1/3)(115.3)(0.55)(450-T)$$

$$(80.7+6)(T-200) = 21.14(450-T)$$

$$86.7T - 17340 = 9513 - 21.14T$$

$$107.84T = 26{,}853 \qquad T = 249°F$$ ✓ OK

(Solidification Temp ≈ 250°F)

② Add 2/3 PE to full drum of waste

$$(269.0)(0.3)(T-200)+(50)(0.12)(T-200) = (2/3)(115.3)(0.55)(450-T)$$

$$86.7T - 17340 = 42.28(450-T) = 19{,}024.5 - 42.28T$$

$$128.98T = 36{,}364.5 \qquad T = 282°F$$ ✓ OK

③ Add all PE to full drum

$$86.7T - 17340 = (115.3)(0.55)(450-T) = 28{,}536.8 - 63.42T$$

$$150.12T = 45{,}876.8 \qquad T = 306°F$$ ✓ OK

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2A-P CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
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NAME OF COMPANY DAE/WHC - WRAP 2A UNITS

CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

SUBJECT

Stream 4

	lbs
PE	162.9
Waste	380.2
Drum	50.0
	593.1

Calc PE temp required to reach final mix temp of 300°F, if waste and drum preheated to 200°F.

$$(380.2)(0.20)(300-200)+(50)(0.12)(300-200)=(162.9)(0.55)(T-300)$$

$$7604+600 = 89.60(T-300) = 89.60T-26{,}879$$

$$89.60T = 35{,}082 \qquad T = 392°F \text{ Polyethylene}$$

① Add 1/3 PE @ 392°F

$$(380.2)(0.20)(T-200)+(50)(0.12)(T-200)=(1/3)(162.9)(0.55)(392-T)$$

$$(76.04+6)(T-200) = 29.87(392-T) = 11707-29.87T$$

$$82.04T - 16{,}408 = 11{,}707 - 29.87T$$

$$111.91T = 28{,}115 \qquad T = 251°F \text{ OK (above 250°F)}$$

② Add 2/3 PE @ 392°F

$$82.04T - 16{,}408 = (2/3)(162.9)(0.55)(392-T) =$$

$$= 59.73(392-T) = 23{,}414 - 59.73T$$

$$141.77T = 39{,}822$$

$$T = 281°F \text{ OK}$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Bechtel Company

WZAP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
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NAME OF COMPANY: DOE/WHC - WIRAP 2A UNIT/S

SUBJECT: CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Stream 5A2

	lbs
PE	153.4
Waste	230.2
Drum	50.0
	433.6

Calculate PE temp required to reach final mix temp of 300°F, if waste and drum preheated to 200°F.

$$(230.2)(0.3)(300-200) + (50)(0.12)(300-200) = (153.4)(0.55)(T-300)$$

$$6906 + 600 = 84.37(T-300) = 84.37T - 25{,}311$$

$$84.37T = 32{,}817 \qquad T = 389°F$$ ✓ Polyethylene

① Add 1/3 PE @ 389°F

$$(230.2)(0.3)(T-200) + (50)(0.12)(T-200) = (1/3)(153.4)(0.55)(389-T)$$

$$(69.06+6)(T-200) = 28.12(389-T) = 10{,}940 - 28.12T$$

$$75.06T - 15{,}012 = 10{,}940 - 28.12T$$

$$103.18T = 25{,}952 \qquad T = 252°F$$ ✓ OK (above 250°F)

② Add 2/3 PE @ 389°F

$$75.06T - 15{,}012 = (2/3)(153.4)(0.55)(389-T)$$

$$= 56.25(389-T) = 21{,}880 - 56.25T$$

$$131.31T = 36{,}892$$

$$T = 281°F$$ ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WRAP CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KOV	RLH
FINAL		DATE 6-9-93	DATE 7/1/93
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J.O 6237008			

NAME OF COMPANY DOE/WHC-WRAP 2A UNITS

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Stream 5C1

	lbs
PE	329.8
Waste	620.6
Drum	50.0
	1000.4

All PE added at once (microencapsulation of lead bricks)

Calculate PE temp required to reach final mix temp of 300°F, if waste and drum at 60°F (no preheating)

$$(620.6)(0.03)(\overset{240}{300-60}) + (50)(0.12)(300-60) = (329.8)(0.55)(T-300)$$

$$4468 + 1440 = 181.39(T-300) = 181.39T - 54{,}417$$

$$181.39T = 60{,}325$$

$$T = 333°F$$ ✓ Polyethylene

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WRAP CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-9-93	DATE 7/1/93
VOID				
SHEET 19 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY: DOE/WHC - WRAP 2A UNIT/S

SUBJECT: CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Stream 5C2

Assume waste and drum @ 200°F
PE @ 450°F

	Lbs
PE	167.5
Waste	390.8
Drum	50
	608.3

① Add 1/3 PE to full drum of waste

$$(390.8)(0.3)(T-200) + (50)(0.12)(T-200) = (1/3)(167.5)(0.55)(450-T)$$

$$(117.24 + 6)(T-200) = 30.71(450-T)$$

123.24

$$123.24T - 24{,}648 = 13{,}820 - 30.71T$$

$$153.95T = 38{,}468 \qquad T = 250°F \checkmark \text{ OK}$$

② Add 2/3 PE to full drum of waste

$$(390.8)(0.3)(T-200) + (50)(0.12)(T-200) = (2/3)(167.5)(0.55)(450-T)$$

$$123.24T - 24{,}648 = 61.42(450-T)$$

$$= 27{,}639 - 61.42T$$

$$184.66T = 52{,}287 \qquad T = 283°F \checkmark$$

③ Add all PE to full drum of waste

$$123.24T - 24{,}648 = (167.5)(0.55)(450-T)$$

$$= 92.13(450-T)$$

$$41{,}456 - 92.13T$$

$$215.37T = 66{,}104$$

$$T = 307°F \checkmark$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
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W2A1 CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	ELH
FINAL			DATE 6-9-93	DATE 7/1/93
VOID				
SHEET 20 OF 23			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Stream 5D

	lbs
PE	297.0
Waste	652.0
Drum	50.0
	999.0

Calculate PE temp required if final mix temp = 300°F and waste and drum are preheated to 200°F.

$$(652.0)(0.1)(300-200) + (50)(0.12)(300-200) = (297.0)(0.55)(T-300)$$

$$6520 + 600 = 163.35(T-300) = 163.35T - 49{,}005$$

$$163.35T = 56{,}125$$

$$T = 344°F \quad \text{Polyethylene}$$

① Add 1/3 PE @ 344°F

$$(652.0)(0.1)(T-200) + (50)(0.12)(T-200) = (1/3)(297.0)(0.55)(344-T)$$

$$(65.2+6)(T-200) = 54.45(344-T)$$

$$71.2T - 14{,}240 = 18{,}731 - 54.45T$$

$$125.65T = 32{,}971$$

$$T = 262°F \quad \text{OK (above 250°F)}$$

② Add 2/3 PE @ 344°F

$$(652.0)(0.1)(T-200) + (50)(0.12)(T-200) = (2/3)(297.0)(0.55)(344-T)$$

$$71.2T - 14{,}240 = 108.90(344-T) = 37{,}462 - 108.90T$$

$$180.1T = 51{,}702$$

$$T = 287°F$$

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

(DISCIPLINE)

United Engineers & Constructors
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W2 A P CALC. SET NO. 003		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-9-93	DATE 6-11-93
VOID				
SHEET 21 OF 23			DATE	DATE
J.O 6237002				

NAME OF COMPANY DOE/WHC-WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Stream 1A

	lbs
PE	293.8
Dry Waste	176.2
Drum	50.0
	520.0

All water evaporated (10%)

Calculate PE temp required if final mix temp = 300°F and waste and drum are preheated to 200°F

$$(176.2)(0.2)(300-200) + (50)(0.12)(300-200) = (293.8)(0.55)(T-300)$$

$$3524 + 600 = 161.59(T-300) = 161.59\,T - 48{,}477$$

$$161.59T = 52601 \qquad T = 326°F$$ ✓ Polyethylene

① Add 1/3 PE @ 326°F

$$(176.2)(0.2)(T-200) + (50)(0.12)(T-200) = (1/3)(293.8)(0.55)(326-T)$$

$$(35.24+6)(T-200) = 53.86(326-T)$$

$$41.24T - 8248 = 17{,}558 - 53.86T$$

$$95.1\,T = 25{,}806 \qquad T = 271°F$$ ✓ OK (above 250°F)

② Add 2/3 PE @ 326°F

$$(176.2)(0.2)(T-200) + (50)(0.12)(T-200) = (2/3)(293.8)(0.55)(326-T)$$

$$41.24\,T - 8248 = 107.73(326-T) = 35{,}119 - 107.73\,T$$

$$148.97\,T = 43{,}367$$

$$T = 291°F$$ ✓

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-9-93	DATE 7/1/93
VOID			
SHEET 22 OF 23		DATE	DATE
J.O 6237008			

NAME OF COMPANY DOE/WHC-WRAP 2A UNITS

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

Stream 2D

	Lbs
PE	140.1
Dry Waste	105.0
Drum	50.0
	295.1

Assume waste and drum @ 200°F (all water evaporated)
PE @ ? °F
Calculate for final mixture temp of 300°F
Calc ③ first, then do ① and ②

① Add 1/3 PE to full drum of waste, PE = 349°F

$$(105)(0.30)(T-200)+(50)(0.12)(T-200) = (1/3)(140.1)(0.55)(349-T)$$

$$(31.5+6)(T-200) = 25.69(349-T)$$

$$37.5T - 7500 = 8{,}966 - 25.69T$$

$$63.19T = 16{,}466 \qquad T = 261°F \checkmark \text{ OK (above 250°F)}$$

② Add 2/3 PE @ 349°F

$$(105)(0.30)(T-200)+(50)(0.12)(T-200) = (2/3)(140.1)(0.55)(349-T)$$

$$37.5T - 7500 = 51.37(349-T) = 17{,}928 - 51.37T$$

$$88.87T = 25{,}517$$

$$T = 287°F \text{ OK} \checkmark$$

③ Use all PE @ ? °F for T_{mix} = 300°F

$$(105)(0.30)(300-200)+(50)(0.12)(300-200) = (140.1)(0.55)(T-300)$$

$$(31.5+6)(100) = 3750 = 77.06(T-300) = 77.06T - 23{,}117$$

$$77.06T = 26{,}867$$

$$T = 349°F \checkmark \text{ Polyethylene}$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

WRAP CALC. SET NO. 003	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-9-93	DATE 7/1/93
VOID			
SHEET 23 OF 23		DATE	DATE
J.O 6237008			

NAME OF COMPANY DOE/WHC -WRAP 2A UNITS

SUBJECT CALCULATION OF POLYETHYLENE/WASTE VIBRO MIXING EQUILIBRIUM TEMPERATURES

WASTE AND BINDERS PHYSICAL PROPERTY DATA

Waste Feedstreams	Treated Bulk Density (lb/ft^3)	Treated Particle Density (lb/ft^3)	Heat Capacity (BTU/lb°F)	Thermal Conductivity (BTU/hr ft^2(°F/ft)	Moisture Content (Wt%)
1A	100	130	0.2	0.3	10
1B	60	140	0.2	0.2	4
1C	69	100	0.2	0.2	44
1D	75	105	0.2	0.2	–
2A	88	111	0.25	0.3	10
2B	55	77	0.3	0.1	55
2C	75	140	0.1	0.2	75
2D	40	50	0.3	0.1	50
3	45	58	0.3	0.12	–
4	60	100	0.2	0.3	–
5A1 (amalgamated mercury)	408	408	0.05	1.0	–
5A2 (bulk mercury)	40	58	0.3	0.1	–
5B	200	240	0.11	8	–
5C1 (elemental lead)	710	710	0.03	20	–
5C2 (bulk lead)	80	105	0.3	0.1	–
5D	450	450	0.1	30	–
6	90	90	0.25	0.1	10
7	35	90	0.3	0.3	--
8	90	90	0.2	0.2	10
Binders					
VES Resin (Derakane 470-36)	66	66	0.29	0.08	--
Polyethylene	57	57	0.55	0.19	–

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

DISCIPLINE

United Engineers & Constructors

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

W2AP CALC. SET NO. 004		REV	COMP BY	CHK'D. BY
PRELIM	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 7/1/93
VOID				
SHEET 1 OF 21			DATE	DATE
J.O 6237008				

CALCULATION DISCLOSURE SHEET

ITEM #	CALC. SHEET #	ITEM DESCRIPTION	CALC. SET REV. # (Item Resolved)	REMARKS
1	17	Verify waste and binder physical property data		

TOTAL NUMBER OF CALCULATION SET SHEETS 21 CALC. SET REV. 0

CALCULATION DONE BY K. D. Van Zanten DATE 6-30-93

CALCULATION CHECKED BY R. L. HENKEL DATE 7/1/93

CONCURRED BY _____ DATE _____

LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

DISCIPLINE(

Universal Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

CALCULATION OF POLYETHYLENE/WASTE
SUBJECT COOLING CURVES

W2AP CALC. SET NO 004		REV	COMP BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 7/1/93
VOID				
SHEET 2 OF 21			DATE	DATE
J.O 6237008				

CALCULATION CONTROL SHEET

PROBLEM STATEMENT

Calculate Polyethylene/Waste Cooling Curves for selected waste streams

DESIGN BASIS

1. Polyethylene Only System Mass Balance, Rev. 2, 6/1/93
2. Waste and Cinder Physical Property Data (p. 17)
3. Calculation of VES Polymer/Waste Cooling Curves, 6/30/93
4. Calculation of Polyethylene/Waste Vibro Mixing Equilibrium Temperatures, 6/30/93
5. Initial temperature of polyethylene/waste mixtures = 300°F
6. Ambient Air Temperature = 75°F

TOTAL NUMBER OF CALCULATION SET SHEETS 21 CALC. SET REV. 0

CALCULATION DONE BY K.D. Van Zanten DATE 6-30-93

CALCULATION CHECKED BY R. L. HENKEL DATE 7/1/93

CONCURRED BY _____ DATE _____
LEAD DISCIPLINE ENGINEER

FORM 5007 REV. 7.79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNITS

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

W2A-P CALC. SET NO 004		REV	COMP BY	CHK'D. BY
PRELIM	✓	0	KDV	RLH
FINAL			DATE 6-30-93	DATE 7/1/93
VOID				
SHEET 3 OF 21			DATE	DATE
JO 6237008				

CALCULATION SUMMARY SHEET

See Sheets 18-21 for Cooling Curve Graphs

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Stone & Webster Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

W2A-P CALC. SET NO 004	REV	COMP BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-30-93	DATE 7/1/93
VOID			
SHEET 4 OF 21		DATE	DATE
J.O 6237002			

CALCULATION REFERENCE SHEET

1. Fundamentals of Heat Transfer, Kutateladze, 1963, p. 104-114
2. Tranter Product Data Manual (Catalog No. 5-63), p. 70
3. Principles of Unit Operations, Foust et al, 1960

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Stone & Webster Company

NAME OF COMPANY	DOE/WHC - WRAP 2A	UNITS	
SUBJECT	CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES		

WRAP CALC. SET NO. 024		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-16-93	DATE
VOID				
SHEET 5 OF 21			DATE	DATE
J.O. 6237008				

Calculate cooldown curves for Max and Min extruded polyethylene/waste

Pick Streams based on F_o and Bi numbers

Assume extrusion temp = 300°F for all streams and ambient temperature = 75°F

$\Delta T = 300 - 75° = 225°F$

$h = \underset{\Delta T = 200°F}{2.7} + 0.6\left(\frac{25}{100}\right) = 2.85 \times \underset{\text{Correction Factor}}{0.40} = 1.14 \text{ BTU/hr ft}^2\,°F$

Stream 1B

Dry Waste 191.1
PE 298.6
489.7

$$K = \frac{(191.1)(0.20) + 298.6(0.19)}{489.7} = \frac{38.22 + 56.73}{489.7} = 0.194$$

$$C_p = \frac{(191.1)(0.2) + 298.6(0.55)}{489.7} = \frac{38.22 + 164.23}{489.7} = 0.41$$

$$\rho = \frac{191.1 + 298.6}{\frac{191.1}{140} + \frac{298.6}{57}} = \frac{489.7}{1.365 + 5.239} = 74.2$$

$$\alpha = \frac{K}{C_p \rho} = \frac{0.194}{(0.41)(74.2)} = .00638$$

$$\frac{\alpha \theta}{R^2} \qquad F_o = \frac{(.00638)(1)}{(.9375)^2} = .00725 \qquad Bi = \frac{hR}{K} = \frac{(1.14)(.9375)}{0.194} = 5.5$$

Stream 1C

Dry Waste 102.7
PE 275.1
377.8

$$K = \frac{(102.7)(0.20) + (275.1)(0.19)}{377.8} = \frac{20.54 + 52.27}{377.8} = 0.193$$

$$C_p = \frac{(102.7)(0.20) + (275.1)(0.55)}{377.8} = \frac{20.54 + 151.3}{377.8} = 0.45$$

$$\rho = \frac{377.8}{102.7/100 + 275.1/57} = \frac{377.8}{1.027 + 4.826} = 64.5$$

FORM 9007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 004		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLL
FINAL			DATE 6-16-93	DATE
VOID				
SHEET 6 OF 21			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Stream 1C (cont)

$$\alpha = \frac{0.193}{(0.45)(64.5)} = 0.00665$$

$$F_o = \frac{(.00665)(1)}{(.9375)^2} = 0.00757 \quad Bi = \frac{(1.14)(.9375)}{0.193} = 5.5$$

Stream 2A

Dry Waste	289.5
PE	214.4
	503.9

$$K = \frac{(289.5)(0.30) + (214.4)(0.19)}{503.9} = \frac{86.85 + 40.74}{503.9} = 0.25$$

$$C_p = \frac{(289.5)(0.25) + (214.4)(0.55)}{503.9} = \frac{72.38 + 117.9}{503.9} = 0.38$$

$$\rho = \frac{503.9}{\frac{289.5}{111} + \frac{214.4}{57}} = \frac{503.9}{2.61 + 3.76} = 79.1$$

$$\alpha = \frac{0.25}{(0.38)(79.1)} = 0.0083$$

$$F_o = \frac{(0.0083)(1)}{(.9375)^2} = 0.00944 \quad Bi = \frac{(1.14)(.9375)}{0.25} = 4.3$$

$$Q/Q_o = 0.95$$

Stream 2B

	Lbs
Dry Waste	121.4
PE	179.9
	301.3

$$K = \frac{(121.4)(0.1) + (179.9)(0.19)}{301.3} = \frac{12.14 + 34.18}{301.3} = 0.15$$

$$C_p = \frac{(121.4)(0.3) + (179.9)(0.55)}{301.3} = \frac{36.42 + 98.95}{301.3} = 0.45$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

WRAP CALC. SET NO. 004		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLL
FINAL			DATE 6-16-93	DATE
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SHEET 7 OF 21			DATE	DATE
J.O 6237008				

Stream 2B cont

$$\rho = \frac{301.3}{\frac{121.4}{77} + \frac{179.9}{57}} = \frac{301.3}{1.577 + 3.156} = 63.7$$

$$\alpha = \frac{0.15}{(0.45)(63.7)} = .0052$$

$$Fo = \frac{(.0052)(1)}{(.9375)^2} = 0.0060 \qquad Bi = \frac{(1.14)(.9375)}{0.15} = 7.1$$

Stream 2C

	Lbs
Dry Waste	49.7
PE	298.6
	348.3

$$k = \frac{(49.7)(0.2) + (298.6)(0.19)}{348.3} = \frac{9.94 + 56.7}{348.3} = 0.191$$

$$Cp = \frac{(49.7)(0.1) + (298.6)(0.55)}{348.3} = \frac{4.97 + 164.23}{348.3} = 0.49$$

$$\rho = \frac{348.3}{\frac{49.7}{142} + \frac{298.6}{57}} = \frac{348.3}{0.355 + 5.239} = 62.3$$

$$\alpha = \frac{0.191}{(0.49)(62.3)} = 0.0063$$

$$Fo = \frac{(.0063)(1)}{(.9375)^2} = 0.0071 \qquad Bi = \frac{(1.14)(.9375)}{0.191} = 5.6$$

Stream 5A1

	Lbs
Dry Waste	470.8
PE	313.8
	784.6

$$k = \frac{(470.8)(1.0) + (313.8)(0.19)}{784.6} = \frac{470.8 + 59.62}{784.6} = 0.68$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 004		REV	COMP. BY	CHK'D. BY
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FINAL			DATE 6-16-93	DATE
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J.O 6237 008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Stream 5A1 (cont)

$$C_p = \frac{(470.8)(0.05)+(313.8)(0.55)}{784.6} = \frac{23.54+172.59}{784.6} = 0.25$$

$$\rho = \frac{784.6}{\frac{470.8}{408}+\frac{313.8}{57}} = \frac{784.6}{1.154+5.505} = 117.8$$

$$\alpha = \frac{0.68}{(0.25)(117.8)} = 0.023$$

$$F_o = \frac{(0.023)(1)}{(.9375)^2} = 0.026 \qquad B_i = \frac{(1.14)(.9375)}{0.68} = 1.6$$

Stream 5B

Dry Waste 419.9
PE 279.9
699.8

$$K = \frac{(419.9)(8.0)+(279.9)(0.19)}{699.8} = \frac{3359.2+53.2}{699.8} = 4.88$$

$$C_p = \frac{(419.9)(0.11)+(279.9)(0.55)}{699.8} = \frac{46.19+153.95}{699.8} = 0.29$$

$$\rho = \frac{699.8}{\frac{419.9}{240}+\frac{279.9}{57}} = \frac{699.8}{1.750+4.910} = 105.1$$

$$\alpha = \frac{4.88}{(0.29)(105.1)} = 0.160$$

$$F_o = \frac{(0.160)(1)}{(.9375)^2} = 0.182 \qquad B_i = \frac{(1.14)(.9375)}{4.88} = 0.22$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 004	REV	COMP. BY	CHK'D. BY
PRELIM. ✓	0	KDV	RLH
FINAL		DATE 6-16-93	DATE
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SHEET 9 OF 21		DATE	DATE
J.O 6237008			

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Stream 6

	Lbs
Dry Waste	160.2
PE	266.9
	427.1

$$K = \frac{(160.2)(0.1)+(266.9)(0.19)}{427.1} = \frac{16.02 + 50.71}{427.1} = 0.156$$

$$C_p = \frac{(160.2)(0.25)+(266.9)(0.55)}{427.1} = \frac{40.05 + 146.80}{427.1} = 0.44$$

$$\rho = \frac{427.1}{\frac{160.2}{90} + \frac{266.9}{57}} = \frac{427.1}{1.78 + 4.68} = 66.1$$

$$\alpha = \frac{0.156}{(0.44)(66.1)} = 0.00536$$

$$F_o = \frac{(0.00536)(1)}{(.9375)^2} = 0.0061 \qquad B_i = \frac{(1.14)(.9375)}{0.156} = 6.9$$

Stream 7

	Lbs
Dry Waste	233.1
PE	232.0
	465.1

$$K = \frac{(233.1)(0.3)+(232.0)(0.19)}{465.1} = \frac{69.93 + 44.08}{465.1} = 0.25$$

$$C_p = \frac{(233.1)(0.3)+(232.0)(0.55)}{465.1} = \frac{69.93 + 127.6}{465.1} = 0.42$$

$$\rho = \frac{465.1}{\frac{233.1}{90} + \frac{232.0}{57}} = \frac{465.1}{2.59 + 4.07} = \frac{465.1}{6.66} = 69.8$$

$$\alpha = \frac{0.25}{(0.42)(69.8)} = 0.0085$$

$$F_o = \frac{(.0085)(1)}{(.9375)^2} = 0.0097 \qquad B_i = \frac{(1.14)(.9375)}{0.25} = 4.3$$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Raytheon Company

W2AP CALC. SET NO. 004		REV	COMP. BY	CHK'D. BY
PRELIM.	✓	0	KDV	RLH
FINAL			DATE 6-16-93	DATE
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SHEET 10 OF 21			DATE	DATE
J.O 6237008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Stream 8

	Lbs
Dry Waste	160.2
PE	266.9
	427.1

$$K = \frac{(160.2)(0.20)+(266.9)(0.19)}{427.1} = \frac{32.04+50.71}{427.1} = 0.194$$

$$C_p = \frac{(160.2)(0.2)+(266.9)(0.55)}{427.1} = \frac{32.04+146.80}{427.1} = 0.42$$

$$\rho = \frac{427.1}{\frac{160.2}{90}+\frac{266.9}{57}} = \frac{427.1}{1.78+4.68} = 66.1$$

$$\alpha = \frac{0.194}{(0.42)(66.1)} = 0.0070$$

$$F_o = \frac{(.0070)(1)}{(.9375)^2} = 0.0080 \qquad B_i = \frac{(1.14)(.9375)}{0.194} = 5.5$$

SUMMARY

STREAM NO.	(1 hr) Fo	Bi	(24 hrs) Fo	Q/Q₀	
1B	0.00725	5.5	0.174	0.55	
1C	0.00757	5.5	0.182	0.55	
2A	0.00944	4.3	0.227	0.57	
2B	0.0060	7.1	0.144	0.53	Min
2C	0.0071	5.6	0.170	0.55	
5A1	0.026	1.6	0.624	0.72	←
5B	0.182	0.22	4.37	0.81	Max ←
6	0.0061	6.9	0.146	0.53	Min ←
7	0.0097	4.3	0.233	0.56	
8	0.0080	5.5	0.192	0.60	

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A Raytheon Company

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J.O 6227008				

NAME OF COMPANY DOE/WHC - WRAP 2A UNITS

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Calculate Cooling Curve for Stream 6 (Slowest cooling rate)

$F_o = (.0061)(\theta)$ $B_i = 6.9$

$\theta = 1.63$ hrs $F_o = 0.01$ $Q/Q_o = 0.09$

$225 \times .09 = 20°$ $T = 300 - 20 = 280°F$

$\theta = 8.2$ hrs $F_o = 0.05$ $Q/Q_o = 0.26$

$225 \times .26 = 58°$ $T = 300 - 58 = 242°F$

$\theta = 16.4$ hrs $F_o = 0.10$ $Q/Q_o = 0.44$

$225 \times .44 = 99°$ $T = 300 - 99 = 201°F$

$\theta = 41.0$ hrs $F_o = 0.25$ $Q/Q_o = 0.70$

$225 \times 0.70 = 157°$ $T = 300 - 157 = 143°F$

$\theta = 82$ hrs. $F_o = 0.50$ $Q/Q_o = 0.90$

$225 \times 0.90 = 202°$ $T = 300 - 202 = 98°F$

$\theta = 61.5$ hrs $F_o = .375$ $Q/Q_o = 0.81$

$225 \times .81 = 182°$ $T = 300 - 182 = 118°F$

$\theta = 28.7$ hrs $F_o = .175$ $Q/Q_o = 0.60$

$225 \times .60 = 135°$ $T = 300 - 135 = 165°F$

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NAME OF COMPANY DOE/WIIC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Calculate cooling curve for Stream 5B, extruded with polyethylene. (Fastest cooling rate)

$F_o = 0.182\,(\theta)$ $Bi = 0.22$

$\theta = 1.37$ hrs $F_o = 0.25$ $Q/Q_o = 0.11$

$225 \times 0.11 = 25°$ $T = 300 - 25 = 275°F$

$\theta = 2.75$ hrs $F_o = 0.50$ $Q/Q_o = 0.20$

$225 \times 0.20 = 45°$ $T = 300 - 45 = 255°F$

$\theta = 5.50$ hrs $F_o = 1.00$ $Q/Q_o = 0.34$

$225 \times .34 = 77°$ $T = 300 - 77 = 223°F$

$\theta = 13.74$ hrs $F_o = 2.5$ $Q/Q_o = 0.67$

$225 \times .67 = 151°$ $T = 300 - 151 = 149°F$

$\theta = 27.47$ hrs $F_o = 5.0$ $Q/Q_o = 0.84$

$225 \times 0.84 = 189°F$ $T = 300 - 189 = 111°F$

$\theta = 55$ hrs $F_o = 10.0$ $Q/Q = 0.97$

$225 \times .97 = 218$ $T = 82°F$

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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

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Calculate cooling curve for Stream 5A1, extruded with polyethylene

Assume starting temp = 300°F $\Delta T = 300 - 75 = 225°F$

$$\alpha = \frac{k}{C_p \rho} = \frac{0.68}{(0.25)(117.8)} = 0.023 \qquad F_o = \frac{(0.023)(\theta)}{(.9375)^2} = 0.0263\,\theta$$

$$Bi = \frac{(1.14)(.9375)}{0.68} = 1.6$$

$\theta = 0.38$ hrs $\quad F_o = 0.01 \quad Q/Q_o = 0.03$

$T = 300 - 0.03(225) = 293°F$ (7)

$\theta = 1.9$ hrs $\quad F_o = 0.05 \quad Q/Q_o = 0.10$

$T = 300 - 0.10(225) = 277°F$ (23)

$\theta = 3.8$ hrs. $\quad F_o = 0.10 \quad Q/Q_o = 0.20$

$T = 300 - 0.20(225) = 255°F$ (45)

$\theta = 9.5$ hrs. $\quad F_o = 0.25 \quad Q/Q_o = 0.41$

$T = 300 - 0.41(225) = 208°F$ (92)

$\theta = 19$ hrs $\quad F_o = 0.50 \quad Q/Q_o = 0.65$

$T = 300 - 0.65(225) = 154°F$ (146)

$\theta = 38$ hrs $\quad F_o = 1.0 \quad Q/Q_o = 0.86$

$T = 300 - 0.86(225) = 106°F$ (194)

$\theta = 95$ hrs $\quad F_o = 2.5 \quad Q/Q = 1.0$

$T = 300 - 1.0(225) = 75°F$

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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES

Calculate cooling curve for Stream 3, vibro with polyethylene.

Assume maximum temperature of mixture = 300°F

	lbs
PE	115.3
Waste	269.0
	384.3

$$K = \frac{(115.3)(0.19) + (269.0)(0.12)}{384.3} = \frac{21.91 + 32.28}{384.3} = 0.141$$

$$C_p = \frac{(115.3)(0.55) + (269.0)(0.30)}{384.3} = \frac{63.42 + 80.7}{384.3} = 0.375$$

$$\rho = 57.70$$

$$\alpha = \frac{0.141}{(0.375)(57.70)} = 0.00652 \qquad F_o = \frac{(0.00652)(\theta)}{(.9375)^2} = 0.00741\ \theta$$

$$Bi = \frac{hR}{K} = \frac{(1.14)(.9375)}{0.141} = 7.6$$

$\theta = 1.35$ hrs $\quad F_o = 0.01 \quad Q/Q_o = 0.09$

$T = 300 - 0.09(225) = 280°F$ (20)

$\theta = 6.75$ hrs $\quad F_o = 0.05 \quad Q/Q_o = 0.27$

$T = 300 - 0.27(225) = 239°F$ (61)

$\theta = 13.5$ hrs $\quad F_o = 0.10 \quad Q/Q_o = 0.45$

$T = 300 - 0.45(225) = 199°F$ (101)

$\theta = 33.74$ hrs. $\quad F_o = 0.25 \quad Q/Q_o = 0.70$

$T = 300 - 0.70(225) = 142°F$ (158)

$\theta = 67.5$ hrs $\quad F_o = 0.50 \quad Q/Q_o = 0.90$

$T = 300 - 0.90(225) = 97°F$ (203)

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

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United Engineers & Constructors
A Stone & Webster Company

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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVE

Calculate cooling curve for macro encapsulation of lead (Stream 5C2) in polyethylene. Assume polyethylene at 333°F and see if final equilibrium temperature is 300°F.

Basis:

Waste (Lead)	620.6	lbs
PE	329.8	lbs
Drum	50.0	lbs
	1000.4	lbs

$$(620.6)(0.03)(T-60)+(50)(0.12)(T-60)=(329.8)(0.55)(333-T)$$

$$(18.62+6)(T-60) = 181.39(333-T)$$

$$24.62T - 1477.2 = 60{,}402.9 - 181.39\,T$$

$$206.01\,T = 61{,}880$$

$$T = 300\,°F \quad OK$$

Lead $\dfrac{620.6 \text{ lbs}}{710 \text{ lb/ft}^3} = 0.874 \text{ ft}^3$

$\dfrac{0.874}{6.66} = 13.1\%$ of volume is lead (90% fill)

For cooling assume k, C_p, ρ are polyethylene for bulk of drum.

	Avg of PE and Lead
$k = 0.19$ BTU/hr ft²(°F/ft)	$k = 13.1$
$C_p = 0.55$ BTU/lb °F	$C_p = 0.21$
$\rho = 57$ lb/ft³	$\rho = 142.7$

$$\alpha = \frac{k}{C_p\rho} = \frac{0.19}{(0.55)(57)} = .00606 \qquad \alpha = \frac{13.1}{(0.21)(142.7)} = 0.437$$

$$F_o = \frac{\alpha\,\theta}{R^2}$$

the lower α; the slower the cooldown rate

$$B_i = \frac{hR}{k}$$

		BTU	
Heat loss from lead	$(620.6)(0.03)(300-75)$ (225)	= 4,189	[illegible]
Heat loss from PE	$(329.8)(0.55)(300-75)$	= 40,813	88.1%
Heat loss from Drum	$(50)(0.12)(300-75)$	= 1,350	2.9%
		46,352	

FORM 5007 REV. 7/79 **GENERAL COMPUTATION SHEET**

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United Engineers & Constructors
A Stone & Webster Company

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NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVE

Stream SC1 (cont)

Assume drum is all PE for cooldown calc.

Estimate h using Trane p. 70 data and Product correction factor of 0.40

$\Delta T = 300 - 75 = 225°F$

$U = 2.7 + 0.6\left(\frac{25}{100}\right) = 2.85 \times 0.40 = 1.14$ BTU/hr ft² °F
@ 2.0°F ΔT

Try $\theta = 1.45$ hrs $\quad F_o = \frac{\alpha\theta}{R^2} = \frac{.00606(\theta)}{(.9375)^2} = 0.0069\,\theta$

$F_o = (.0069)(1.45) = 0.01$

$B_i = \frac{hR}{k} = \frac{(1.14)(0.9375)}{0.19} = 5.6$

$Q/Q_o = 0.08 \quad \Delta T = 225 \times .08 = 18 \quad 300 - 18 = 282°F$

$\theta = 7.25$ hours

$F_o = .0069(7.25) = 0.05 \quad Q/Q_o = 0.24$

$\Delta T = 225 \times 0.24 = 54° \quad 300 - 54 = 246°F$

$\theta = 14.5$ hrs

$F_o = .0069(14.5) = 0.10 \quad Q/Q_o = 0.42$

$\Delta T = 225 \times 0.42 = 95° \quad T = 300 - 95 = 205°F$

$\theta = 36.2$ hrs

$F_o = .0069(36.2) = 0.25 \quad Q/Q_o = 0.68$

$\Delta T = 225 \times 0.68 = 153° \quad T = 300 - 153 = 147°F$

$\theta = 72.4$ hrs

$F_o = .0069(72.4) = 0.50 \quad Q/Q_o = 0.90$

$225 \times 0.90 = 203 \quad T = 300 - 203 = 97°F$

FORM 5007 REV. 7/79 GENERAL COMPUTATION SHEET

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United Engineers & Constructors
A Raytheon Company

NAME OF COMPANY DOE/WHC -WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE / WASTE COOLING CURVES

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WASTE AND BINDERS PHYSICAL PROPERTY DATA

Waste Feedstreams	Treated Bulk Density (lb/ft³)	Treated Particle Density (lb/ft³)	Heat Capacity (BTU/lb°F)	Thermal Conductivity (BTU/hr ft²(°F/ft)	Moisture Content (Wt%)
1A	100	130	0.2	0.3	10
1B	60	140	0.2	0.2	4
1C	69	100	0.2	0.2	44
1D	75	105	0.2	0.2	–
2A	88	111	0.25	0.3	10
2B	55	77	0.3	0.1	55
2C	75	140	0.1	0.2	75
2D	40	50	0.3	0.1	50
3	45	56	0.3	0.12	–
4	60	100	0.2	0.3	–
5A1 (amalgamated mercury)	408	408	0.05	1.0	–
5A2 (bulk mercury)	40	56	0.3	0.1	–
5B	200	240	0.11	8	–
5C1 (elemental lead)	710	710	0.03	20	–
5C2 (bulk lead)	80	105	0.3	0.1	–
5D	450	450	0.1	30	–
6	90	90	0.25	0.1	10
7	35	90	0.3	0.3	--
8	90	90	0.2	0.2	10
Binders					
VES Resin (Derakane 470-36)	65	65	0.29	0.08	--
Polyethylene	57	57	0.55	0.19	–

FORM 5007 REV. 1/79 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors
A Burns & Roe Company

NAME OF COMPANY: DOE/WHC - WRAP 2A

SUBJECT: COOLING CURVE FOR 100% POLYETHYLENE OR STREAM SC1 WITH POLYETHYLENE

UNITS

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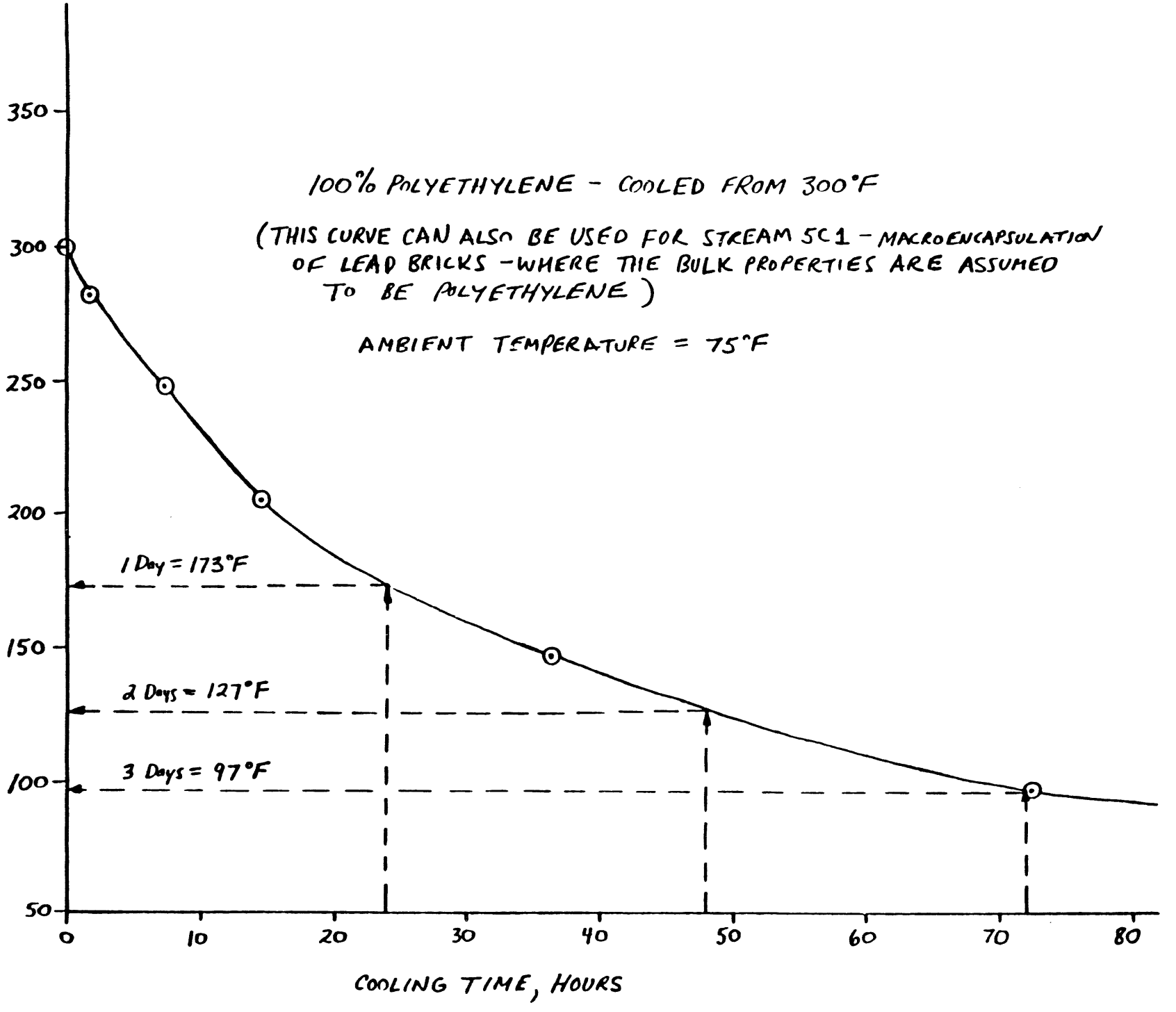

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A Raytheon Company

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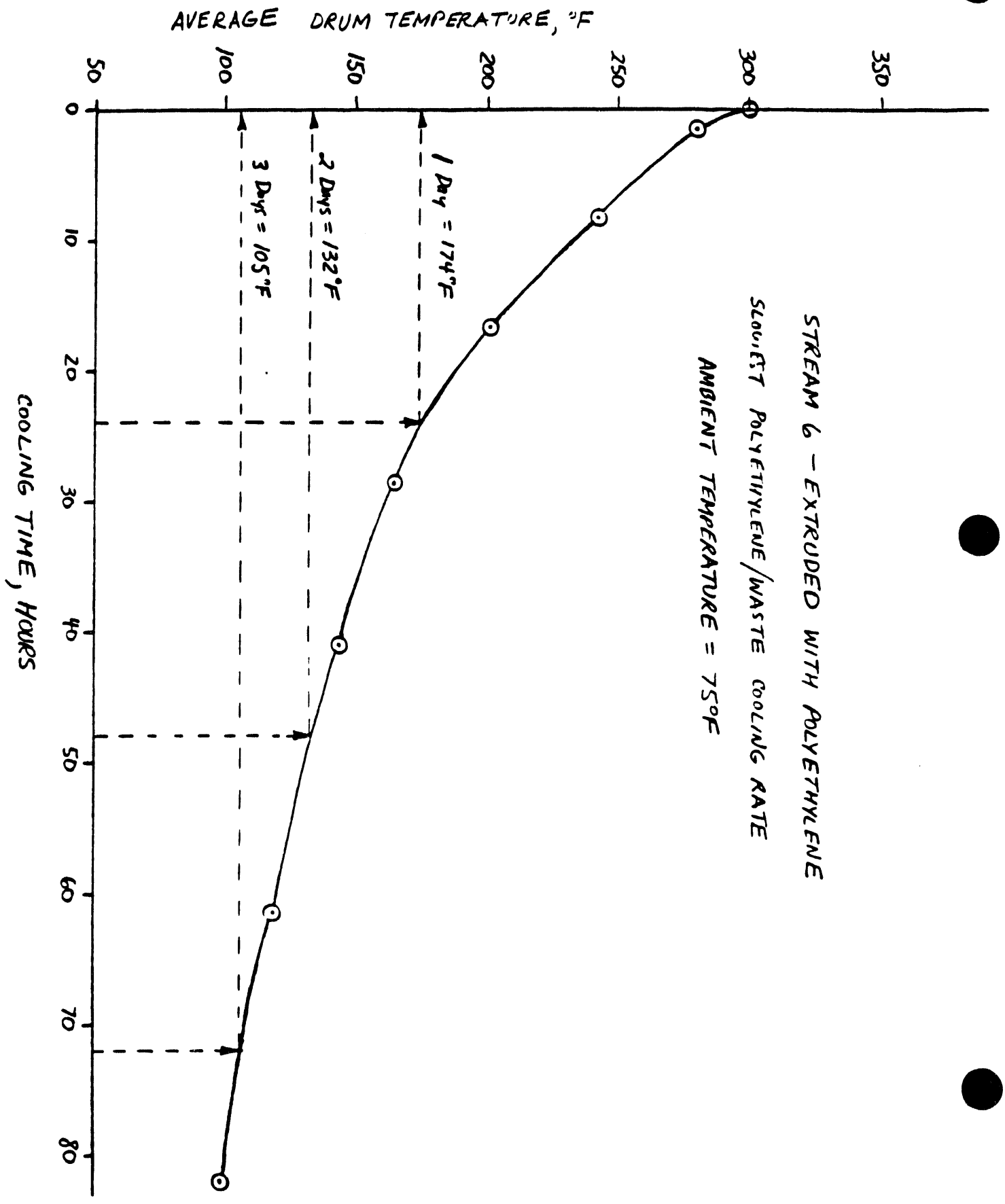
NAME OF COMPANY DOE/WHC-WRAP 2A UNITS

SUBJECT COOLING CURVE FOR EXTRUSION OF STREAM 6 WITH POLYETHYLENE



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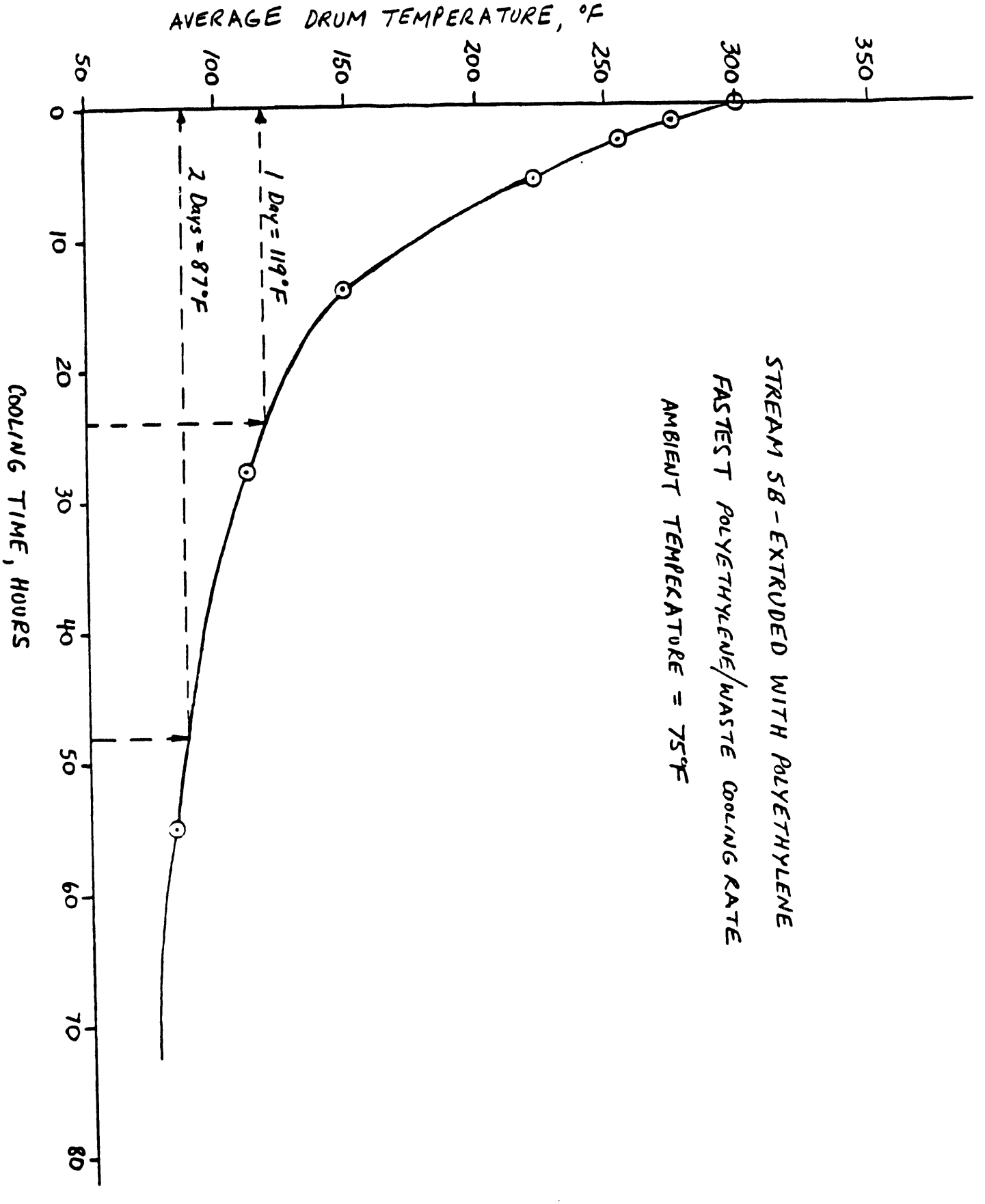
NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT COOLING CURVE FOR EXTRUSION OF STREAM 5B WITH POLYETHYLENE



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A Raytheon Company

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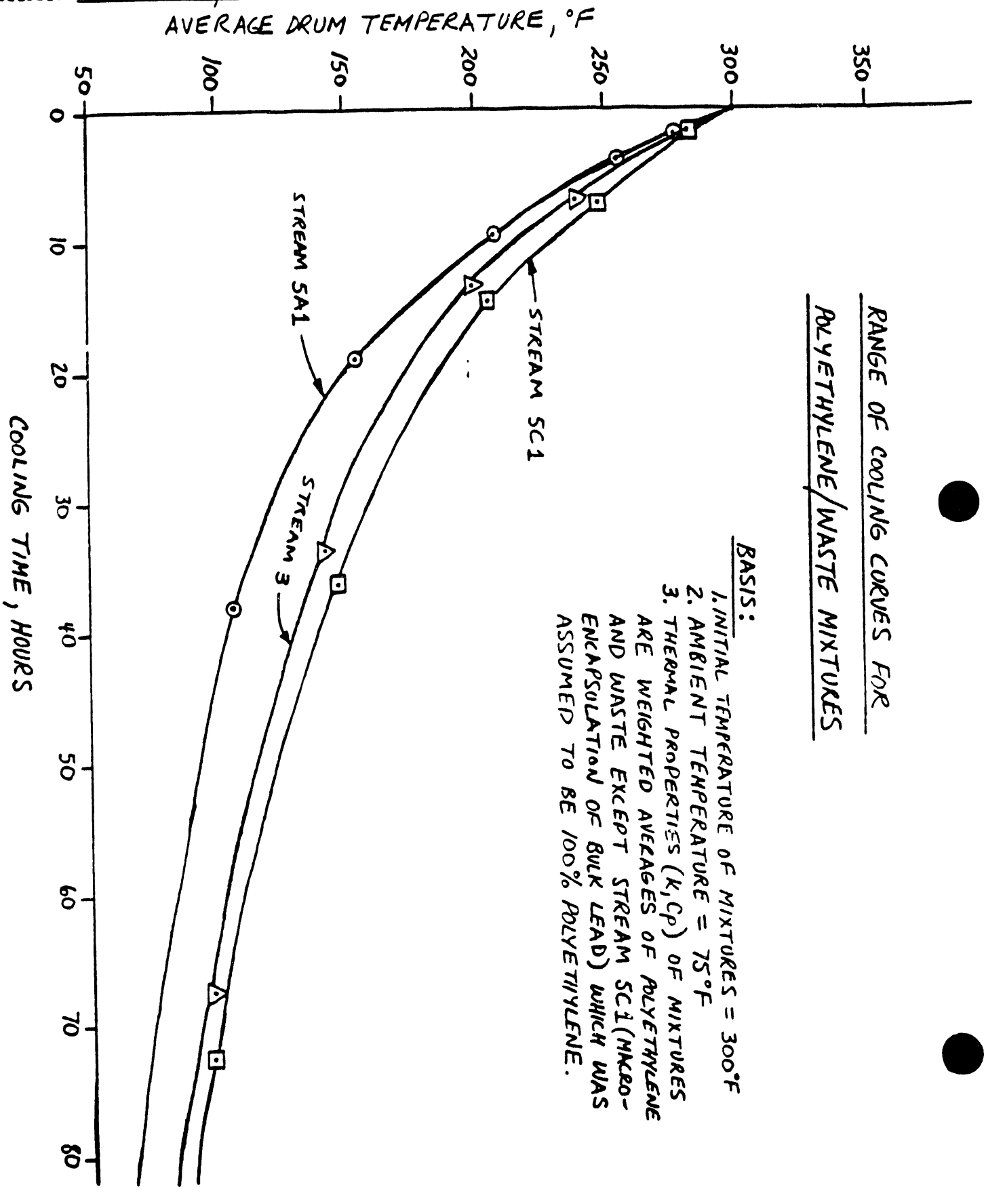
NAME OF COMPANY DOE/WHC - WRAP 2A UNIT/S

SUBJECT CALCULATION OF POLYETHYLENE/WASTE COOLING CURVES



RANGE OF COOLING CURVES FOR POLYETHYLENE/WASTE MIXTURES

BASIS:

1. INITIAL TEMPERATURE OF MIXTURES = 300°F
2. AMBIENT TEMPERATURE = 75°F
3. THERMAL PROPERTIES (K, Cp) OF MIXTURES ARE WEIGHTED AVERAGES OF POLYETHYLENE AND WASTE EXCEPT STREAM 5C1 (MACRO-ENCAPSULATION OF BULK LEAD) WHICH WAS ASSUMED TO BE 100% POLYETHYLENE.

WASTE RECEIVING AND PROCESSING FACILITY

TITLE: PLANT MAINTAINABILITY EVALUATION

Revision: 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A Raytheon Company
Western Operations

PLANT MAINTAINABILITY EVALUATION

Prepared by: L. Dutton Date: 1/7/94

Reviewed by: J Bubble Date: 1/10/94

Approved by: Date: 1/10/94

Approved by: Date: 1/10/94
Project Manager

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APPENDICES

APPENDIX 1 MAINTENANCE PLAN
APPENDIX 2 LIST OF EVALUATED EQUIPMENT
APPENDIX 3 DATA SHEETS
APPENDIX 4 DOSE RATE ASSESSMENT FOR CONTAMINATED SORTING MANIPULATOR

1.0 OBJECTIVE

1. The objective of this study is to determine:

   a. The proposed method of maintenance to be employed for each major item of plant and equipment, (eg., insitu maintenance or move to a "hot" maintenance area etc.), in order to (1) develop a WRAP Module 2A Facility Maintenance Philosophy/Plan and (2) provide a detail basis on which an ALARA cost benefit analysis can be undertaken;

   b. The overall process/facility requirements for major equipment maintenance, (eg., adequate maintenance space envelopes around equipment, special maintenance tools, specialized maintenance rooms etc.) to ensure that adequate provisions are made in the process and facility designs to accommodate maintenance needs.

1.1 Scope

1. This study will evaluate plant and equipment maintenance needs by reviewing and assessing detailed requirements for major equipment items as follows:

   a. Reviewing and updating the CDR plant and equipment list in relation to the current status of applicable ACDR studies.

   b. Utilizing the updated plant and equipment list to highlight plant and equipment items that will be included in the evaluation.

   c. For the items identified in b. above, develop a maintenance requirements data sheet that shall contain as a minimum the following information:

      1) Equipment item number.

      2) Equipment title.

      3) Preliminary equipment description; eg., outline performance requirements.

      4) Operational mode; eg., run-to-fail, planned replacement etc.

      5) Description of maintenance required; eg., minor - seal, bearing or switch replacement, major - shredder cutter replacement and durations for replacement, etc.

      6) Proposed maintenance location; eg., in situ maintenance, in situ decontamination and transfer to dedicated maintenance facility, transfer to dedicated maintenance and decontamination facility etc.

      7) Special maintenance requirements; eg., tools, installed lifting equipment, transfer containers, tenting flanges on containment, forklift truck access etc.

d. Obtain as much "hard" information on each equipment item as possible in order to complete a maintenance data sheet for each item. To complete these sheets as accurately as possible a concerted effort will be undertaken to obtain the following:

1) Catalog cut sheets for major plant items. Ideally widely differing equipment types should be included to ensure that dissimilar maintenance needs (worst and best) are evaluated. This will ensure that in a lowest bid procurement situation the equipment that has the most demanding maintenance needs could be accommodated; (eg. shredder could be electrically or hydraulically powered, the latter has more components associated with it requiring more space, maintenance etc.).

2) If obtainable, manufacturers drawings, maintenance manuals, spare parts lists, maintenance schedules etc.

2. Reviewing and assessing general requirements for grouped equipment items (eg., conveyors, pumps etc.) as follows:

a. Determine the general maintenance requirements for the majority of items in each group, (eg., run-to-fail, component replacement, unit replacement etc.).

b. Determine if any special maintenance facilities will be required for these groups of equipment.

3. Prepare an outline maintenance plan. This will consist of a summary table of maintenance requirements and facilities identified in paragraphs 1, 2 and 3. This table shall include:

a. Plant item number or equipment group and description.

b. Method of maintenance; ie., run-to-fail (lubrication maintenance only), in situ, component replacement, unit replacement etc.

c. Special maintenance provisions needed; ie., decontamination facilities, "hot" maintenance room, transfer containers etc.

4. Assess the impact on the facility affinity diagram of any new maintenance/ decontamination requirements and recommend changes as appropriate.

1.2 Background

1. The design philosophy for WRAP Module 2A will be developed from the Module 2A CDR. Where appropriate, equipment, concepts or practices that were developed for WRAP Module 1 will be applied to WRAP 2A. Equipment located inside gloveboxes or confinement enclosures where possible will be constructed in modular form from readily available propriety components. The modules should be readily accessible from strategically positioned gloveports or easily removed by suited personnel.

2. The use of proven low cost equipment capable of many thousand of cycles before failure. For example the use of suitably sized standard industrial pneumatic cylinders. These cylinders usually have a life of 10^5 cycles, these are combined with easy release mechanisms at each end such as indent pins and use push pull or quick disconnects on the pneumatic lines, then replacement from gloveports or man access is quick and simple.

3. The majority of equipment disposed from the open sort and segregate enclosures on the operations floor can be double bagged and removed from confinement. For the removal of larger items, a temporary structure will be assembled to contain the release of airborne contamination. This structure will be decontaminated before it is disassembled.

4. Major pieces of process equipment will be connected by custom built fabrications. The equipment will be classified as a Zone 1 confinement, replacement of a major piece of process equipment and will require special procedures to determine the method of removal and transfer to a designated area for disposal or maintenance.

1.3 Purpose and Need

1. The Plant Maintenance Evaluation is necessary to define the overall process facility maintenance requirements for major items of equipment. Final equipment selection shall consider the maintainability and service life of that particular piece of equipment. It is essential to determine at an early stage the space requirements and equipment needs to completely remove a major piece of equipment from its location and transfer it to a designated area for disposal or maintenance.

2.0 SUMMARY

1. This evaluation has considered the maintainability of 32 major plant items. The duration between lubrication intervals, probable component life expectancy, and equipment disposal routes have been determined. In addition, design criteria recommendations are made in relation to equipment configurations, etc. that will improve or assist in simplifying maintenance tasks. The evaluation recommends that, in general, equipment should be run until it fails, with equipment being maintained in-situ. However, there is a need to remove large items of equipment to the box breakdown cell for size reduction and disposal.

2. Contact maintenance will be performed on all components in the Zone 2 area that do not break the Zone 1 confinement. Zone 1 contact maintenance such as box breakdown or open and sort will be authorized by a work permit from a pre-approved work plan. This will be suited work where the operative will have his own breathing air supply. Zone 1 confinement could be within a temporary structure erected around a failed piece of equipment that requires replacement, such as the shredder or crusher. There could also be an occasion where a bearing replacement is required where the bearing forms the barrier between Zone 1 and Zone 2. This can be replaced by more localized methods. Container delidding/relidding confinement area may resemble a glovebox type configuration, access to these mechanisms would be by gloveport.

3. As recommended in the Value Engineering Assessments, most Gloveboxes were replaced by Process Enclosures and a number of pieces of major plant equipment were changed. Maintenance data and documents were obtained for all but 7 pieces of new equipment. This information will be developed upon receipt of vendor data.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Recommendations

1. The WRAP 2A Title I design should detail disposal routes from the containment to the Box Breakdown Cell for the larger items of equipment. Provision for craneage and manoeuvering clearances need to be allowed. A removable panel at Box Breakdown is required for the movement of the failed equipment into this area. Considerations should be given to the transfer from a Zone 2 area to a Zone 1.

2. Considering the arduous tasks the telescoping manipulator will encounter, it is proposed that an alternative be used. UE&C is recommending the use of a more substantial piece of equipment that has been used in the construction and demolition industry for many years. Holmhed Systems AB (Brokk) have recently developed a remote tool change station for use in this type of environment. BNF plc has recently installed three of the fixed station manipulators in a similar environment. The equipment is being installed at present ready for commissioning and pre hand over testing late 1994. The ease of maintenance and low down time compared to the telescoping manipulator suggests it is more appropriate to the function.

3. Consideration should be given to the location of lifting equipment above the empty drum compactor to assist with replacement of the primary actuator and the two secondary bolster actuators.

4. An assessment should be made of the feasibility and methodology of removing the Schilling Manipulator via an extended Bagless Transfer tube for transfer to a decontamination and maintenance area.

5. The mercury evaporator requires a make and break connection from Zone 1. The equipment now requires a secondary confinement. An alternative configuration without any make and break would be preferable.

3.2 Conclusions

1. Six items of equipment listed in **Appendix 2** formed part of WRAP Module 1 process equipment. This equipment has been purpose designed and can be maintained in situ. The individual components that make up the item of equipment are run to fail, lubrication being the only maintenance performed. If failure does occur there will be no adverse effects detrimental to the equipment function. Motors, bearings, switches, gaskets, hoses and actuators will be run-to-fail.

2. Larger items of equipment will be removed from the process within a portable confinement barrier. This will either be constructed from bolt together panels sealed with a mastic or strippable coating material, or a PVC structure. Any openings left by the removal of equipment will be bagged while the replacement unit is lifted in place. The failed equipment will be completely encapsulated in PVC before transportation from the area. Lifting beams will be located within the vicinity of the equipment to aid removal of the item for localized maintenance, or complete removal from the area to Box Breakdown for disposal.

3. Larger items of equipment located in the Zone 1 area in Open and Sort may be removed entirely and disposed of via the waste box route. The new equipment will enter the same way or via the removable panel, the use of overhead craneage will be required to effect the replacement.

4. Preventative maintenance, lubrication and visual checking can be instigated on most of the equipment within the Zone 2 area. The equipment located in the Zone 1 architectural room on the operating floor, would mean man entry into confinement, an assessment would probably determine that the equipment located in this area would be run to fail.

4.0 UNCERTAINTIES

1. The depth to which a core drilled sample is required is undetermined, if the sample is restricted to 8 inches depth, then air would suffice as a drill bit cooling medium. If a full depth sample is required, water cooling would be the alternative.

2. The baseline documentation does not state clearly if the open and sort processes, debris, particulate, and special waste have to have segregated areas. From and maintainability standpoint, one large open area with free standing equipment would be easier to work on rather than close confinement walls. The access to this area could be gained by using standard change room philosophy.

5.0 BASIS FOR STUDY

5.1 Criteria

5.1.1 FDC Requirements

1. The criteria for developing operability and maintainability requirements shall be subject to the following FDC requirements.

   The design shall reflect the following order of preference for performing maintenance.

   a. Adjust item or unit in place.

   b. Repair item or unit by contact with radiation dose rates consistent with ALARA Principals.

   c. Replace item or unit with a spare unless it is more economical to perform remote maintenance or remove , decontaminate, repair and return it to service.

   d. Any maintenance requiring personnel entry into ventilation zone 1 areas.

2. Equipment items that require special and unique maintenance tools shall be identified. Special instructions shall be included with the equipment and any special tools required to maintain equipment shall be provided by the project.

3. The following concepts shall be applied in order to meet the plant capacity requirements:

   a. Maximize equipment interchangeability

   b. Use existing Hanford plant standards

   c. Locate complex components including electrical devices or those having a higher probability of failure in contact maintenance areas.

   d. Operate power transmission devices below 75% of manufacturers rating.

   e. Select pumps to operate in the middle of their flow and head range.

   f. Provide adequate equipment materials for the operating environment. (The use of stainless steel is highly promoted.) Materials of construction shall be non-combustible and resistant to corrosion.

   g. Limit confinement enclosure only to that required.

   h. Use commercially available equipment.

   i. Identify equipment repair methods and exit routes.

   j. Provide lag storage for process flow interruptions affected by maintenance.

4. All surfaces shall have finishes that ease decontamination in accordance with DOE order 6430.1A (DOE 1989). Selected processes process confinement enclosures (EG cells) and processing areas that require frequent decontamination shall be fully lined with stainless steel on the walls floors and sumps, special wall coatings that can be easily decontaminated shall be used on walls floors and ceilings in other process areas where infrequent decontamination is required. The finish shall be a two coat system with differing colors to identify chipped paint.

5. Adequate space and environmental quality for equipment maintenance and repair, material storage shall be provided in close proximity to locational needs. The size options for the decontamination facilities should be reviewed to ensure all equipment can be decontaminated , inspected, or repaired while processing needs are being fulfilled.

5.1.2 SDRD Requirements Additional to FDC

1. The complexity of the repair and maintenance activities shall be commensurate with the skill level of maintenance personnel who work primarily to detailed written procedures.

2. The design basis for maintenance within process enclosures shall be personnel working through glove penetrations. Human factor limitations (reach, strength, dexterity, endurance) shall be carefully considered where gloved hand personnel involvement is required.

3. Instrumentation and equipment monitoring systems shall be designed to facilitate trouble shooting and replacement

4. Low accessibility equipment shall be designed to minimize in-place preventative maintenance during the expected useful life.

5. Remote operated mechanical arms will not be installed for maintenance purposes.

6. Handling enclosure equipment, e.g., installed in gloveboxes, shall be modular for convenient removal and replacement. Modules shall be sized to fit into 55 gal and/or 85 Gal drums for removal from the glovebox.

7. To minimize the chance of operator injury, modules requiring removal shall be provided with smooth surfaces, rounded edges and corners, and good visibility of interfacing elements.

8. Equipment modules shall be configured for ease of removal by simple lateral or vertical motions; i.e., shall have easily accessible lifting device attachment point; shall be provided with ample wrench to keeper type bolts; and shall be provided with round and diamond pilot pins to simplify reinstallation.

9. Adequate visual access shall be provided to support maintenance through proper lighting and placement of windows or CCTV cameras for direct viewing. Use of mirrors is not acceptable.

10. Glovebox installed devices shall permit component-level trouble shooting by extending wiring leads outside the glovebox. Independent functioning modules are exempt from this requirement where troubleshooting to the module level can be performed.

5.2 Assumptions

1. The Plant Maintainability Evaluation will be limited to those items listed in Appendix 2, these are the major items of equipment. The type of equipment selected for this evaluation are those recommended in the relevant studies or detailed on the PFD's.

2. Hydraulic and Pneumatic actuators will not be maintained. This is not cost effective, the replacement of 'O' rings and nose bearings are difficult to undertake within confinement and the quality of replacement in this environment is also suspect. They will be transferred from containment via 55 Gal or 85 Gal drum and re-introduced into the process for ultimate disposal.

3. Motors, Gearboxes, Bearings, Seals, Teflon slides, Hydraulic and Pneumatic hoses will be will be run to fail. Lubrication will be used where possible.

4. Switches, either contact or retro-reflective shall be the bayonet type, this will allow replacement of the switch and not the entire cable.

5. A temporary confinement area will be erected in a Zone 2 area around a failed piece of process equipment that constitutes a Zone 1 confinement.

6. Large pieces of failed equipment will be routed to Box Breakdown for size reduction. The transfer of large items can be routed out of the process cell via decontamination and surface check area, then via transport system back into Box Breakdown. If the overbagged equipment is not suitable to transfer through the Zone 3 transport corridor. There is a removable panel in the connecting wall from the process cell to Box Breakdown that can be used.

6.0 EVALUATION DISCUSSION

1. From the list outlined in **Appendix 2** the only item of equipment that will require hands on maintenance requiring fume hood operation is the Sorting Manipulator. All other equipment is maintained in situ with the failed equipment being disposed of and larger items such as the shredder, Crusher, Extruder, etc., will be run to fail. The larger pieces of equipment may be transported to the Box Breakdown Cell for ultimate disposal.

2. The following cost trade-off evaluation will consider **disposal** of the sorting manipulator arm vs. **decontamination and maintenance.**

6.2 Cost Estimate

	Item	Unit Cost	Capital Cost
1.	Replacement due to degradation of equipment due to decontamination:		
	Wrist Assay	5,565[1]	
	Potentiometer Hose Set	6,952[1]	
		12,517	
2.	Decontamination Bath & Fumehood		15,000[2]
3.	Fume Hood		9,000[2]
4.	HVAC & Services		5,000
5.	Special Maintenance Tools		2,000[1]
6.	Extended Length Transfer Tube		1,000
7.	Decontamination Fluid ($10/gal) 90 Gal Tank	1,800	
8.	Disposal of Decon Fluid (within confines of WRAP Module 2A)		—
9.	Replacement of a Complete Arm Segment	9,289[1]	
10.	Complete HVF Arm	47,350[1]	
	Total Capital Cost		32,000
	Total Replacement of Arm Segment (9,289) Plus Decon Damaged Components (12,517) Decontamination Fluid (1,800)		23,606
	Total Labor (Decon + 16 hrs Maint @ $100/hr)		2,000
			25,606

If we divide the capital cost of $32,000 over 30 years we can add $1,066 per year to unit costs
This gives us a grand total of 25,606 + 1,066 = 26,672 per arm
The cost of a new arm is 47,350
The cost savings are therefore 47,350 - 26,672 = 20,678 per arm and 21,744 for any further arms maintained that year.
All costs in $ @ Sept. 1993 MV
This calculation has assumed new decontamination fluid will be used for each arm. This may not be the case, but it is a worst condition.

(1) Reference letter OUF0030 - Lisa Nishikawa Shilling Development/L. Dutton UE&C-BNFL.
(2) Reference telecon TC93065.008 VWR Scientific/L. Dutton UE&C.

2. Failure of the Sorting Manipulator arm will require removal from the carriage by unbolting and the disconnection of hoses and cables. The arm will be physically placed into a bagless transfer container for removal and transfer to the decontamination bath. The unbolting of the arm will require man entry into the Zone 1 area.

   Sections of the arm cannot be dismantled within confinement without unlacing the Hydraulic hoses and instrumentation cables. Decontamination will be carried out with these items in situ. Due to the effects of the decontamination fluid, some electronic components may be degraded, a replacement cost has been allowed for in the calculation.

   The decontamination bath will consist of a tank 5'0"x 2'0" x 1'0", a pump and strategically placed nozzles will give jet agitation, the tank will be enclosed with a fume hood and have a Bagless Transfer container port located at one end. A submersible basket will carry the manipulator arm, this will be manually raised and lowered within the enclosure, an adjacent fume hood connected in series will accept the arm via a connecting door, the arm may be withdrawn from the raised basket into the maintenance hood.

   The arm should be submersed in 5% citric acid for 4 hours with jet agitation for 15 min per hour then air dried and monitored, this should have reduced the surface contamination from an estimated 1.2×10^9 dpm/100 cm^2 to 0.012×10^9 dpm/100 cm^2 to facilitate hands on maintenance. (See Dose Rate Assessment, Appendix 4.)

APPENDIX 1

MAINTENANCE PLAN ACDR

PLANT ITEM NUMBER	NAME	DESIGN BASIS FOR MAINTENANCE			
		RUN TO FAIL	IN-SITU MAINTENANCE	SPECIAL MAINTENANCE PROVISION	REMARKS
SH-06-101 SH-05-101 SH-05-561	SHREDDER	Motor/Gearbox Bearings Blades Main Drive Shaft	Motor/Gearbox Some Bearings	The equipment should be mounted 6" above the operating floor to allow for equipment removal.	Due to the size and weight of the shredder blades and shaft it is inconceivable to consider their individual replacement unless the vendor decides to re-design the equipment..
ST-06-101 ST-05-521	SORTING TABLE				--
DO-05-501 DO-05-561A,B DO-05-601	SIMPLE DOUBLE LID - DRUM ENTRY/EXIT	Pneumatic Actuators Switches Bearings Vacuum Gasket	Pneumatic Actuators Switches Bearings Vacuum Gasket	Window and gloveports are required on the hinge side of the equipment to allow maintenance of the shot bolt cylinder and shaft guides.	--
DO-05-601	BAGLESS TRANSFER PORT (SAMPLES)	Braded Hose Door Slide Bush "O" Rings	Braded Hose Door Slide Bush	A bagging ring should be provided around the port for replacement of the 'O' rings.	The Five "O" ring set will need changing probably three times within the plant life. This will be a greenhouse operation.
DO-05-620	SPHINCTER PORT (CONSUMABLE ENTRY)	Sphincter Cartridge	Lubrication	Window and gloveports to access equipment.	The removal of an indent pin will allow the failed unit to be displaced by the new one.
RT-05-501 RT-06-101 RT-05-521	DELIDDER/RELIDDER	Vacuum Cups Pneumatic Actuators Pneumatic Motor Vacuum Generator Solenoid Valves Air/Oil Intensifier Linear Thruster Rotary Actuator Bearings	Vacuum Cups Pneumatic Actuators Pneumatic Motor Vacuum Generator Solenoid Valves Air/Oil Intensifier Linear Thruster Rotary Actuator Bearings	The equipment will be designed so individual components can be changed easily by the use of indent pins.	Man entry into a Zone 1 for maintenance operations.

MAINTENANCE PLAN ACDR (CONTINUED)

PLANT ITEM NUMBER	NAME	DESIGN BASIS FOR MAINTENANCE			
		RUN TO FAIL	IN-SITU MAINTENANCE	SPECIAL MAINTENANCE PROVISION	REMARKS
CM-05-581	EMPTY DRUM COMPACTOR	Platen Actuator Bolster Actuator Drum Location Actuators Peristaltic Drive Platen Guide Wheels Bolster Guide Wheels Hydraulic Hose	Platen Actuator Bolster Actuator Drum Location Actuators Peristaltic Drive Platen Guide Wheels Bolster Guide Wheels Hydraulic Hose	Good viewing and access required to replace guide wheels. Lifting eyes on the end of the platen and bolster actuator will aid removal.	A runway beam located above the compactor will assist with actuator replacement. A sump will be required to contain hydraulic fluid in the event of seal failure.
EM-06-101 EM-05-521 EM-05-603	SORTING MANIPULATOR ASSEMBLY	Wiper Seals Linear Slide Brg Rodless Cylinder Valve Package Hydraulic Hose Hydraulic Actuator Switches Arm Joint Bush Arm Pivot Bush	Wiper Seals Linear Slide Brg Rodless Cylinder Switches Arm Joint Bush Arm Pivot Bush	Removal/replacement of the manipulator arm via an extended length sample/transfer port. Man entry will be required to undertake this function.	A cost tradeoff analysis has been undertaken comparing disposal vs. decontamination and maintenance. The results are shown in Section 6.2 of this report.
EM-05-561	TELESCOPIC POWER MANIPULATOR ASSEMBLY	Motor Clutch Hoist Cable Electrical Control Cables Hoist Drum Bearings Upper Pulley Bearing Lower Pulley Bearing Tube Guide Bearing Timing Cable Timing Cable Anchors	Motor Clutch	A laydown area is required for the telescoping mast.	The telescoping mast must be removed from the carriage to replace any of those items listed in the first column.
CR-05-501 CR-05-561	OVERHEAD CRANE OVERHEAD CRANE (45' TRAVEL)	Wheel Bearings Motor Failure Cable Festoon	Wire Rope Lubrication	A repair maintenance area should be allocated with platforming to aid periodic lubrication and rope inspection.	--
T-05-541	VOLUMETRIC FEEDER	Motor Twin Screw	--	A ½" distance piece will aid removal if the equipment required replacing within the plant life.	Seizure of the bearing or screw would necessitate replacement of the entire unit by a bagging operation.

MAINTENANCE PLAN ACDR (CONTINUED)

PLANT ITEM NUMBER	NAME	DESIGN BASIS FOR MAINTENANCE			
		RUN TO FAIL	IN-SITU MAINTENANCE	SPECIAL MAINTENANCE PROVISION	REMARKS
TC-05-501	DRUM TRANSFER CAR	Conveyor Roller Motor Wheel Bearing	Lubrication Conveyor Roller Motor Wheel Bearing	None required.	--
EX-05-401	POLYMER EXTRUDER	Twin Screws Screws Shroud	Motor Gearbox Pump Cooling System Vacuum Pump Heating Element Twin Screws Screw Shroud	The feed tube to the waste container should be re-mountable to allow for screw and screw shroud replacement and allowance in confinement for withdrawal of the unit.	--
SH-05-521	CRUSHER	Motor Drive Belt Drive Chain Bearings Springs	Motor Drive Belt Drive Chain Bearings Springs Lubrication	Local confinement required to change bearings.	Vendor request to seal through shaft before bearing assembly.
SN-05-521	ROTARY SCREEN	Motor Chain Drive Support Wheels	Motor Chain Drive	--	Man access into a Zone 1 required. Chain drive cover could be manufactured in four segments to allow easier removal.
DR-05-521	MIXER DRYER	Bearings Gearbox/Motor Heating Elements Helical Screw	Bearings Gearbox/Motor Heating Elements Helical Screw	Local confinement required to change bearings.	Helical screw wear would necessitate disposal of equipment.
SN-05-522	VIBRATORY SCREEN	Vibro Motor Leaf Springs	TBD	TBD	--
CR-05-501	CLAMSHELL GRAB	Actuator Hose	--	--	Man access into a Zone 1 required.
TBD	DIVERTER GATE	Actuator Bearings Switches	Actuator Bearings Switches Lubrication	Local confinement required to change bearings.	--

MAINTENANCE PLAN ACDR (CONTINUED)

PLANT ITEM NUMBER	NAME	DESIGN BASIS FOR MAINTENANCE			
		RUN TO FAIL	IN-SITU MAINTENANCE	SPECIAL MAINTENANCE PROVISION	REMARKS
H-06-201	MERCURY EVAPORATOR	Bearings Heating System Drive Chain Motor Rotary Coupling Slide Valves Extendable Make & Break	Bearings Heating System Drive Chain Motor Rotary Coupling	The slide valves and extendable make and break equipment is in a Zone 1 area. The method of maintenance will probably be hands on via gloveports.	Vendor would have to make modification to this equipment to operate it in a secondary confinement. Replacements of thermocouple undetermined.
TBD	COMPACT HANDLER	Actuator Switches	Actuator Switches	--	Man access into a Zone 1 required.
RT-05-613	WASTE DRUM HANDLER	Wheel Bearings Actuators	Wheel Bearings Actuators	The confinement for sampling will probably be configured as a glovebox due to the hands on requirements involved in this process.	--
TBD	CONTAINER LID REPAIR SYSTEM	TBD	TBD	TBD	TBD
TBD	DRUM TIPPER	TBD	TBD	TBD	TBD
TBD	GROUT MIXER	TBD	TBD	TBD	TBD
TBD	BOX DELIDDER RELIDDER	TBD	TBD	TBD	TBD
TBD	AUTO GROUT FILL EQUIPMENT	TBD	TBD	TBD	TBD
TBD	VIBRO SORTING TABLE	TBD	TBD	TBD	TBD
TBD	STORAGE RETRIEVAL SYSTEM	TBD	TBD	TBD	TBD

APPENDIX 2

MAINTENANCE DATA SHEET STATUS				01/10/94
PAGE NO		COMPLETED	OUTSTANDING	VENDOR DATA
3-1	In Glovebox Manipulator (MOD 1 Design)	X		■
3-13	Sorting/Tipping Table	DELETED FROM PROCESS		
3-16	Overhead Bridge Crane	X		■
3-19	Delidder Relidder	X		■
3-31	Drum Lifter	DELETED FROM PROCESS		
3-34	Drum Handler Tipper	DELETED FROM PROCESS		
3-37	Simple Double Lid (Entry/Exit Port) (MOD 1 Design)	X		--
3-40	Sample Transfer Purged Port (MOD 1 Design)	X		--
3-43	Vibro Conveyor	DELETED FROM PROCESS		
3-46	Pug Mill (Scott)	DELETED FROM PROCESS		
3-49	Pug Mill (Paul-O.Abbe)	DELETED FROM PROCESS		
3-52	Shredders (Shred Pax)	X		■
3-55	Shredders (Saturn)	X		■
3-58	Chain Hoists (MOD 1 Design)	DELETED FROM PROCESS		
3-61	Sliding Hatch	DELETED FROM PROCESS		
3-64	Volumetric Feeder	X		■
3-67	Drum Transfer Car	X		■
3-70	Consumable Entry Port (MOD 1 Design)	X		--
3-73	Discharge Hopper	X		■
3-76	Drum Pusher	DELETED FROM PROCESS		
3-79	Transfer Rail	DELETED FROM PROCESS		
3-82	Airlock Transfer Tunnel	DELETED FROM PROCESS		
3-85	Weigh Hopper	DELETED FROM PROCESS		
3-88	One Trip Door System	DELETED FROM PROCESS		
3-91	Power Manipulator (Brokk)	X		■
3-94	Telescopic Power Manipulator (Cimcorp/Schilling)	X		■
3-97	Grouted Drum Slitting Saw	DELETED FROM PROCESS		
3-100	Core Drill	DELETED FROM PROCESS		
3-103	Polymer Extruder		X	▲
3-106	In Drum Mixer	DELETED FROM PROCESS		
3-109	Filter Compactor	DELETED FROM PROCESS		
3-112	Empty Drum Compactor (MOD 1 Design)	X		–
3-115	Narrow Aisle Stacker	DELETED FROM PROCESS		
3-118	Jar Mill	X		■
–	Shredded Lead Conveyor	DELETED FROM PROCESS		
–	Shredder Bin Lifting Frame	NON-MAINTAINABLE ITEM		
3-121	Diverter Tray	DELETED FROM PROCESS		
3-124	Crusher	X		■
3-127	Rotary Screen	X		■
3-130	Mixer Dryer	X		■
3-133	Vibro Screen (Debris)	X		■

MAINTENANCE DATA SHEET STATUS				01/10/94
PAGE NO		COMPLETED	OUTSTANDING	VENDOR DATA
3-136	Clamshell Grab	X		■
3-139	Diverter Gate	X		■
3-142	Mercury Evaporator	X		■
3-145	Compact Handler	X		■
3-148	Waste Drum Sampler	X		■
3-151	Container Lid Repair System		X	▲
3-154	Drum Tipper		X	▲
3-157	Grout Mixer		X	▲
3-160	Box Delidder Relidder		X	--
3-163	Auto Grout Fill Equipment		X	▲
3-166	Vibro Sorting Table		X	▲
3-169	Storage Retrieval System		X	▲

■ Vendor equipment drawings and maintenance manuals received, all lifetime durations and maintenance frequencies are shown on data sheets.
▲ Vendor data required.
-- Vendor data not required.

APPENDIX 3

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-06-101 EM-05-501, 521	SHT 1 OF 12

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/1/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/23/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

EQUIPMENT DESCRIPTION

The equipment consists of four major components:

A. The manipulator arm
B. The support carriage
C. The controller
D. The powerpack (this is external to containment)

A. The Manipulator Arm

The manipulator arms are constructed from 6061 aluminum alloy and 316 stainless steel. The arm has four major components; the base, the upper arm segment, the forearm segment and the wrist. The arm joints pivot in one direction only. The actuation is driven by a hydraulic cylinder. The wrist is driven by a small hydraulic motor and can be rotated continuously. The jaws have a parallel motion and have a maximum opening of 6 1/4".

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The Manipulator Arm

This part of the equipment will be run to fail. There is no lubrication requirement. The worst possible failure would be a hydraulic leakage from a cylinder or hose connection. This requires a major strip down to replace any of these items. Recent development trials at WHC have shown that minor problems have been encountered with the bolted joints that connect the upper arm with the forearm. There has also been recurring problems with the wrist and jaw electronics. (Pot element and pot wiper) The maintenance procedure for replacement of these items requires manual dexterity that cannot be undertaken in the confinement zone that the equipment is located in.

SPECIAL MAINTENANCE REQUIREMENTS

The Manipulator Arm

Maintenance can only be carried out in a fume hood where hands on contact is available such as replacing a bearing in an arm pivot joint. The manipulator arm is so small in cross section it may be removed from confinement via an extended length sample/transfer tube then taken to a decontamination and maintenance chamber. The levels of contamination can be reduced for hands on maintenance under a fume hood in a hot cell or maintenance area.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-06-101 EM-05-501, 521	SHT 2 OF 12

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/1/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Hydraulic Oil Leakage Visual Check	0.03	0.25	--	--	In-Situ
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-06-101 EM-05-501, 521	SHT 3 OF 12

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/1/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/23/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Arm Joint Bushing Failure	2	--	--	Fume Hood/Maintenance Room
2. Arm pivot Bushing Failure	2	--	--	Fume Hood/Maintenance Room
Major Failures				
1. Hydraulic Hose	20	--	--	Fume Hood/Maintenance Room
2. Actuator	20	--	--	Fume Hood/Maintenance Room
3. Micro Switch	20	--	--	Fume Hood/Maintenance Room

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-06-101 EM-05-501, 521	SHT 4 OF 12

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/1/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/23/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

EQUIPMENT DESCRIPTION

B. The support carriage

The support carriage is mounted on a Dual Rails System. Actuation may be performed by a rodless cylinder or chain drive dependent on distance traveled. The arm travels vertically on a carriage supported on a second Rail System, the lowest point is tied back to the confinement wall to give lateral support.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The support carriage

The dual rail systems have a life of 200 x 10^6 inches with regular greasing. This item will need minimal attention and dependant on usage will probably only require a bearing change once within the operating life of the plant.

SPECIAL MAINTENANCE REQUIREMENTS

The support carriage

There should be an area designated within confinement local to the rail system, with an removable access panel to allow man entry into the confined area to undertake bearing and seal replacement.

AIIM

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Lightly Grease Rail System	1	1	--	--	In-Situ
Minor Infrequent Tasks					
1. Replace Wiper Seal	24	8	--	--	In-Situ/Man Entry

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Bearing Seizure	8	--	--	In-Situ/Man Entry
Major Failures				
1. Rodless Cylinder	24	4	--	In-Situ/Man Entry

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

EQUIPMENT DESCRIPTION

C. The controller

The controller consists of a master controller and a slave controller which are located on the operator side of the glovebox.

Information is passed from this equipment to the valve package which would be located on the carriage with the slave arms. The slave unit is designed around an Intel 8088 16 bit microprocessor. It consists of three boards that can be easily changed out. The master controller houses all the switches that activate the system dynamics.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The controller

The slave controller and master console can be maintained without any special procedures as they will be located outside confinement. The valve package will be located inside the confinement zone, and it will require man access to remove it for repair or disposal.

SPECIAL MAINTENANCE REQUIREMENTS

The controller

The valve package should be mounted on a sub base as any maintenance on this unit must be undertaken outside confinement, probably in a fume hood in a hot maintenance room. The valve enclosure is sealed and Ingress Protection (IP) rated, therefore only the external surfaces should require decontamination. This could be undertaken in an area adjacent to the confined area within a portable greenhouse structure.

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures 1. Failure of any solenoid valves, electrical connectors, or hoses will require removal of the unit from confinement	8	--	--	Decon Chamber - Hot Maintenance Fume Hood

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

EQUIPMENT DESCRIPTION

D. The Powerpack

The powerpack is a self contained with a 7.5 HP 1750 RPM 3 Phase motor, power pack sizes, 3 Gal/min hydraulic pump, 15 gal reservoir and a heat exchanger.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The Powerpack

The powerpack is located external to confinement, therefore no special feature will be required to assist with maintenance operations.

SPECIAL MAINTENANCE REQUIREMENTS

The Powerpack

The powerpack should be housed in a sump tank that will contain the 15 gallons of fluid. As there is a risk of trace contamination over a period of years, this could require containment if any leakage were to take place.

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Replace Filter	0.25	2	--	--	In-Situ
2. Grease Motor Bearings	0.5	0.15	--	--	In-Situ
3. Check Fluid Level	0.003	0.15	--	--	In-Situ
4. Clean Strainers	2	2	--	--	In-Situ
5. Replace Fluid	12	4	--	--	In-Situ
Minor Infrequent Tasks					
1. Check System Pressure Settings	6	0.15	--	--	In-Situ

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TITLE	MANUFACTURER
MANIPULATOR	SCHILLING

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Instrument	--	--	1	In-Situ
2. Pressure Loss	2	--	--	In-Situ Filter Blockage or Fluid aeration
Major Failures				
1. Electric Motor	2	1	--	In-Situ
2. Hydraulic Pump	4	1	--	In-Situ
3. Heat Exchanger	2	2	--	In-Situ

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TITLE	MANUFACTURER
SORTING TABLE	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

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TITLE	MANUFACTURER
SORTING TABLE	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
SORTING	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

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TITLE	MANUFACTURER
15 TON OVERHEAD BRIDGE CRANE	CRANE & HOIST

EQUIPMENT DESCRIPTION

The Bridge Crane is a structural member that has a four wheeled carriage and a trolley hoist. All motions are powered from a control station located in the Zone 2 area. There will be no modifications to the standard equipment package.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The Bridge Carriage has an integral jacking system to raise the wheels of the runway beam to allow for wheel and bearing replacement. The hoist and trolley are more difficult to work on. These items require semi-strip down for bearing and seal replacement of the hoist drum and carriage wheel assembly.

SPECIAL MAINTENANCE REQUIREMENTS

Any in cell cranes should have the ability to transfer to a segregated area within box breakdown for repair/maintenance inspection, and there should be adequate platforming for replacing gearboxes, bearings, wire rope, etc.

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TITLE	MANUFACTURER
15 TON OVERHEAD BRIDGE CRANE	CRANE & HOIST

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Grease Carriage Wheel Bearings	1	4	--	--	In-Situ/Segregated Area
Inspect Rope for Damage	6	6	--	--	In-Situ/Segregated Area
Check Festoon Cable for Wear/Damage	6	--	4	--	In-Situ/Segregated Area
Check Oil Level in Motor Gearboxes	6	2	--	--	In-Situ/Segregated Area
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
15 TON OVERHEAD BRIDGE CRANE	CRANE & HOIST

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Bridge Carriage Wheel Bearing	8	--	--	In-Situ/Segregated Area
2. Hoist Carriage Wheel Bearing	8	--	--	In-Situ/Segregated Area
3. Hoist Motor Failure	16	4	--	In-Situ/Segregated Area
4. Bridge Motor Failure	16	4	--	In-Situ/Segregated Area
5. Trolley Motor Failure	16	4	--	In-Situ/Segregated Area
6. Wire Rope Failures	20	20	--	In-Situ/Segregated Area
7. Festoon Cable Stress Break	20	20	--	In-Situ/Segregated Area

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

EQUIPMENT DESCRIPTION

This equipment performs three functions:

A. Shearing the Clampband
B. Removing the Drum Lid
C. Crimping the Drum Lid to the Drum
D. Support Equipment

The drum dumper holds the drum while clampband shearing and lid removal take place. Crimping the drum lid back onto the drum is undertaken after the drum contents are removed and the sheared clampbands are removed from the equipment and loaded onto the sorting table.

A. Cutting the Clampband:

A double shear cutter is positioned so that when a drum is held in the drum dumper jaws and the delidder-relidder is positioned over the drum. A 40° actuation of the shear cutters will cut through the clampband to avoid the clamp band bolt. The shear cutters are activated in two places. The shear cutters are mounted on a rotating frame. The frame and the shear cutters are rotated to avoid the clamp band bolt. The manipulator will remove the two cut halves and deposit them on the sorting table. This equipment will most likely be a semi-custom design using the development work undertaken for WRAP Module I. The most important aspect will be to remove consumable items from the system. The present confinement configuration does not lend itself to reloading C-clips and saw blade replacement as used previously.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment will be designed with the knowledge that in-situ maintenance will be required over the operating life of the plant. All maintainable components will be designed for "easy" replacement by use of indent pins or oversized hexagon head bolts.

SPECIAL MAINTENANCE REQUIREMENTS

Maintenance access will be required into the confinement area. the quick release philosophy of the design should allow easier replacement of these items.

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Shear Cutters.	1	--	--	In-Situ
2. Vacuum Cups.	1	--	--	In-Situ
3. Lid Crimper.	1	--	--	In-Situ
4. Rotary Activator.	8	--	--	In-Situ
5. Linear Activator	4	--	--	In-Situ

Additional Time Required for Entry and Exit from Confinement

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

EQUIPMENT DESCRIPTION

B. Removing the Drum Lid:

Removing the drum lid after the clamp band has been cut is done by lowering the rotating frame until the 2 ~ 7 1/2" dia. vacuum cups contact the drum lid. The vacuum generator is pneumatically activated and the vacuum cups clamp onto the drum lid. Activation of the linear thruster will remove the drum lid from the drum.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment will be designed with the knowledge that in-situ maintenance will be required over the operating life of the plant. All maintainable components will be designed for "easy" replacement by use of indent pins or oversized hexagon head bolts.

SPECIAL MAINTENANCE REQUIREMENTS

Maintenance access will be required into the confinement area. the quick release philosophy of the design should allow easier replacement of these items.

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION	
Minor Failure					
Major Failures					
1. Vacuum Generator	0.5	--	0.5	In-Situ	Additional Time Required for Entry and Exit from Confinement
2. Leaking Vacuum Cup	1	--	--	In-Situ	

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

EQUIPMENT DESCRIPTION

C. Crimping the Drum Lid to the Drum:

The drum lid will be crimped to the drum body after drum emptying has taken place. The crimper is attached to the rotating frame. The hydraulic crimper is allowed to pivot to two positions. The first position is to clear the drum and lid, the second is the crimp position. The crimper jaws are allowed to float to absorb crimping forces within the C-frame of the crimper.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment will be designed with the knowledge that in-situ maintenance will be required over the operating life of the plant. All maintainable components will be designed for "easy" replacement by use of indent pins or oversized hexagon head bolts.

SPECIAL MAINTENANCE REQUIREMENTS

There are few components to go wrong. It is more likely that once or twice over the plant life the whole unit will have to be replaced due to general tool wear and stress cracking due to the high shock loading. This operation should take no longer than 4 hours.

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Leaking Hydraulic Cylinder	3	--	--	In-Situ
2. Crimper, Positional Cylinder Failure	1	--	--	In-Situ

These Times Do Not Account For Entry and Exit from Confinement

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-06-101 RT-05-521,501	SHT 10 OF 12

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/8/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

EQUIPMENT DESCRIPTION

D. Support Equipment

1. Carriage Assembly
   - Linear Thruster
   - Rotary Actuator
   - Hydraulic Intensifier
   - Bearing Assy
   - Wheel Assy
   - Rotary Frame

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment will be designed with the knowledge that in-situ maintenance will be required over the operating life of the plant. All maintainable components will be designed for "easy" replacement by use of indent pins or oversized hexagon head bolts. The linear thrusters have a life of 1 million cycles (18 years). A rotary actuator has an approximate life of 5 million cycles (200 years) and is non-maintainable. A hydraulic intensifier is good for 10,000 hrs (6 yrs). A bearing assembly will continue for 10 million revs. This equipment may have several components but they all have a reasonable operating life expectancy. It can be assumed that the delidder relidder will require minimal maintenance.

SPECIAL MAINTENANCE REQUIREMENTS

Maintenance access will be required into the confinement area. the quick release philosophy of the design should allow easier replacement of these items.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-06-101 RT-05-521,501	SHT 11 OF 12

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/8/93
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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-06-101 RT-05-521,501	SHT 12 OF 12
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 7/8/93 / BY: LD

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TITLE	MANUFACTURER
DELIDDER RELIDDER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Linear Thruster	8	2	1	In-Situ
2. Rotary Actuator	8	2	1	In-Situ
3. Replace Rotary Bearing	8	2	1	In-Situ
4. Hydraulic Intensifier	2	--	--	In-Situ

These Times Do Not Account For Entry and Exit from Confinement

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DH-06-103 DH-05-521,541,602	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/09/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/27/93 LD	B		C		D	
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TITLE	MANUFACTURER
DRUM LIFTER	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DH-06-103 DH-05-521,541,602	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/09/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/27/93 LD	B		C		D	
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TITLE	MANUFACTURER
DRUM LIFTER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DH-06-103 DH-05-521,541,602	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 07/09/93 BY: LD

REVISIONS (DATE & BY)								
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TITLE	MANUFACTURER
DRUM LIFTER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DH-06-102 DH-05-522 & 542	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/13/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)								
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TITLE	MANUFACTURER
DRUM HANDLER TIPPER	SETCO/CASCADE/SEW EURODRIVE

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DH-06-102 DH-05-522 & 542	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 07/13/93 / BY: LD

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TITLE	MANUFACTURER
DRUM HANDLER TIPPER	SETCO/CASCADE/SEW EURODRIVE

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DH-06-102 DH-05-522 & 542	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 07/13/93 / BY: LD

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TITLE	MANUFACTURER
DRUM HANDLER TIPPER	SETCO/CASCADE/SEW EURODRIVE

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure	1	--	--	In Situ
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-501, 561 A&B, 601	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/28/93
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TITLE	MANUFACTURER
SIMPLE DOUBLE LID (ENTRY EXIT PORT)	TBD

EQUIPMENT DESCRIPTION

This is a door system that permits the loading of material into 55 gallon drums from confinement. The drum lid will remain attached to the port door while the drum is filled. The drum lid is attached to the port door by a depression created between the port door and drum lid. The door system is fitted to a base plate that is 43" x 51" x 1/2". The diameter of the port door is 22" dia. The door is actuated by a 4" dia pneumatic cylinder and the door is locked in position by a 1 1/2" dia pneumatic actuator.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment has been designed (for Module 1) with the knowledge that in-situ maintenance will be required over the operating life of the plant. All maintainable components have been designed for "easy" replacement by use of indent pins or oversized easy to reach hexagon head bolts.

SPECIAL MAINTENANCE REQUIREMENTS

A window and gloveport arrangement will be required on the hinge side of the equipment to allow maintenance of the shot bolt cylinder and shaft guides.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-501, 561 A&B, 601	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/28/93
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TITLE	MANUFACTURER
SIMPLE DOUBLE LID (ENTRY EXIT PORT)	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Grease Pivot Bearings	1	1	--	--	In-situ
Grease Shot Bolt Linkage	1	1	--	--	In-situ
Minor Infrequent Tasks					
Replace Vacuum Gasket	24	2	--	--	In-situ, the gaskets can be preassembled on a base plate then bolted to the underside of the port door.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-501, 561 A&B, 601	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/28/93
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TITLE	MANUFACTURER
SIMPLE DOUBLE LID (ENTRY EXIT PORT)	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Shot Bolt Cylinder	2	--	--	In-Situ
Pressure Switch	1	1		In-Situ
Shaft Guides	2	--	--	In-Situ
Major Failures				
Door Actuation Cylinder Bearing Replacement	8	--	--	In-Situ
Pillow Block Bearings	12	--	--	In-Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-601	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 7/06/93 BY: LD

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TITLE	MANUFACTURER
SAMPLE TRANSFER PURGED PORT	TBD

EQUIPMENT DESCRIPTION

The port has a maximum opening of 5 1/2" dia. The canister length can vary, the unit comes with a standard canister of approximately 14" long. The unit uses the double lidded principal for item transfer in and out of containment. An air purge keeps the seals clean and free from contamination. The unit is manually operated.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment has been designed with the knowledge that in-situ maintenance will be required over the operating life of the plant. All maintainable components have been designed for "easy" replacement by use of indent pins or oversized easy to reach hexagon head bolts.

SPECIAL MAINTENANCE REQUIREMENTS

A tenting flange would be required for changing the seals. This should only occur 2 or 3 times within the lifetime of the plant. The door slide bush may wear after several years. The door will not locate correctly. This will decrease the efficiency of the purged seal. The bearing should be replaced at this time.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-601	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 7/06/93 BY: LD

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TITLE	MANUFACTURER
SAMPLE TRANSFER PURGED PORT	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Check the Flexible Braded Hose for Cracking or Deterioration	1	0.25	--	--	In-Situ
Minor Infrequent Tasks					
1. Check Internal Door Axial Slide Bush for Wear	6	1	--	--	In-Situ.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-601	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 7/06/93 / BY: LD

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TITLE	MANUFACTURER
SAMPLE TRANSFER PURGED PORT	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Replacement of 5 'O' - Rings and the purge Seal	16	--	--	In-Situ/Greenhouse

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CV-05-521	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 06/24/93 BY:

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TITLE	MANUFACTURER
VIBRO CONVEYOR	CLEVELAND VIBRATOR COMPANY

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CV-05-521	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008	DATE: 06/24/93
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TITLE	MANUFACTURER
VIBRO CONVEYOR	CLEVELAND VIBRATOR COMPANY

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CV-05-521	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 06/24/93 BY:

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TITLE	MANUFACTURER
VIBRO CONVEYOR	CLEVELAND VIBRATOR COMPANY

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure 1.				
Major Failure				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-541	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 06/24/93 BY: LD

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TITLE	MANUFACTURER
PUG MILL	SCOTT

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-541	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 06/24/93 BY: LD

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TITLE	MANUFACTURER
PUG MILL	SCOTT

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Major Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-541	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 06/24/93 BY: LD

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TITLE	MANUFACTURER
PUG MILL	SCOTT

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failure				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-541	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
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TITLE	MANUFACTURER
PUG MILL	PAUL-O.ABBE INC.

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-541	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
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TITLE	MANUFACTURER
PUG MILL	PAUL-O.ABBE INC.

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Major Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-541	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/07/93
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TITLE	MANUFACTURER
PUG MILL	PAUL-O.ABBE INC.

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failure				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-06-101 SH-05-101, 561	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/22/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
SHREDDER	SHRED PAX

EQUIPMENT DESCRIPTION

The equipment consists of a shredding chamber that houses two counter rotating shredder blade drive shafts. A mechanical direct drive gear train and two electric motors. The A2-80 is 142" x 54" x 60" and the A2 45 is 99" x 40" x 44", they are 80 Hp and 40 Hp respectively. There is an automatic overload feature that causes the motors to stop if the current exceeds the adjustable preset value. The unit comes with an ejector door after several failed cuts. The object will be ejected from the unit out of a side door.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

An assessment of previous operating statements and reports of non-nuclear installations show that this equipment has a good record for reliability and is robustly constructed. The shredder will be located into the process system by physical connection to the next piece of equipment via custom designed fabrication. The shredder chamber will form part of confinement Zone 1. The gearbox is a potential Zone 1 if the drive shaft seal leaks. The electric motors are in Zone 2.

The in-situ maintenance of the gearbox will require draining the 12 gallons of oil. This may be trace contaminated, if the shredder side oil seal has worn and leaked. The oil can be sent to WRAP Module 1 for treatment and storage.

SPECIAL MAINTENANCE REQUIREMENTS

The shredder is mounted into a support frame. This frame will be bolted down to the equipment floor. The shredder blades are located within a rectangular structure that is flanged top and bottom. It is proposed that a 1/2" distance piece be used above and below the equipment, so that a bagging operation can be performed to limit the spread of airborne contamination, so it can be contained within the equipment or ducting. When the shredder is removed from service, it can be moved to a maintenance access area that is serviced by a powered chain hoist. The shredder can be slung and lowered through the floor penetration onto a purpose made pallet located on a conveyor. It can then be either boxed and enter box breakdown via the airlock doors or it can be transferred through a removable panel located in the wall of box breakdown area by constructing a temporary confinement structure.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-06-101 SH-05-101, 561	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
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TITLE	MANUFACTURER
SHREDDER	SHRED PAX

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Grease drive shaft bearings.	0.03	1	--	--	In-Situ
2. Replace gearbox oil (check levels bi-weekly).	12	4	--	--	In-Situ
3. Check motor reducer gearbox oil.	1	1	--	--	In-Situ
Major Infrequent Tasks					
1. Replace gearbox, drive shaft bearings and seals.	120	40	8	--	In-Situ (if vendor can make necessary modifications). This may have to be undertaken within a temporary confinement structure due to the potential breach of containment when the oil seal is replaced. The oil will be contaminated waste.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-06-101 SH-05-101, 561	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/22/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/28/93 LD	B		C		D	
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TITLE	MANUFACTURER
SHREDDER	SHRED PAX

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Replace leaking seal on operator side of gearbox.	40	--	--	In-Situ (if vendor can make necessary modifications). This may have to be undertaken within a temporary confinement structure due to the potential breach of containment when the oil seal is replaced. The oil will be contaminated waste.
2. Replace bearing on operator side or inside gearbox.	40	--	--	
3. Motor failure.	8	--	--	
Major Failure				
1. Replace Shredder Blades	40	8	--	Hot Cell (Box Breakdown)
2. Replace Shredder Shaft	40	8	--	Hot Cell (Box Breakdown)
3. Replace Shredder	40	8	--	Hot Cell (Box Breakdown)

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-06-101 SH-05-101, 561	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/24/93
		CWBS NO. 1604	BY: JPB\LD

REVISIONS (DATE & BY)	A	12/28/93 LD	B		C		D	
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TITLE	MANUFACTURER
SHREDDER	SATURN

EQUIPMENT DESCRIPTION

The 52-32HT & 62-40HT Shredders 121" x 40" x 34" & 130" x 48" x 40", respectively, are hydraulically powered from a remote power pack the 52-32HT develops 150 Hp and the 62-40HT develops 200 Hp. The equipment consists of a main enclosure that houses the two shredder blade drive shafts. A gearbox is located at one end with two drive shafts connected to two separate hydraulic motors. The motors are fed by the powerpack.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

An assessment of previous operating statements and reports of non-nuclear installations show that this equipment has a good record for reliability and is robustly constructed. The shredder will be located into the process system by physical connection to the next piece of equipment via a custom designed fabrication. The shredder chamber will form the confinement Zone 1 the gearbox is a potential Zone 1 when the drive shaft seal leaks. The hydraulic motors are in a Zone 2 confinement. Access to the gearbox would have to be discussed with the vendor. The cover plate would require some re-work to allow in-situ maintenance.

SPECIAL MAINTENANCE REQUIREMENTS

The shredder is mounted into a support frame. This frame will be bolted down to the equipment floor. The shredder blades are located within a rectangular structure that is flanged top and bottom. It is proposed that a 1/2" distance piece be used above and below the equipment, so that a bagging operation can be performed to limit the spread of airborne contamination, so it can be contained within the equipment or ducting. When the shredder is removed from service, it can be moved to a maintenance access area that is serviced by a powered chain hoist. The shredder can be slung and lowered through the floor penetration onto a purpose made pallet located on a conveyor. It can then be either boxed and enter box breakdown via the airlock doors or it can be transferred through a removable panel located in the wall of box breakdown area by constructing a temporary confinement structure.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-06-101 SH-05-101, 561	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/24/93
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REVISIONS (DATE & BY)	A	12/28/93 LD	B		C		D	
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TITLE	MANUFACTURER
SHREDDER	SATURN

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Greasing the Hydraulic Motors	0.25	1	--	--	In-Situ
2. Greasing the Shredder Shaft Bearings	0.75	3	--	--	In-Situ
Minor Infrequent Tasks					
1. Replace Gearbox Drive Shaft Bearings & Seals	120	40	4	--	In-Situ (if vendor can make necessary changes). This may have to be undertaken within a temporary confinement structure due to the potential breach of containment when the oil seal is replaced. The oil will be contaminated waste.
2. Remove Debris from Underside of Shredder	3	2	--	--	

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-06-101 SH-05-101, 561	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	06/24/93
		CWBS NO. 1604	BY: JPB\LD

REVISIONS (DATE & BY)	A	12/28/93 LD	B		C		D	
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TITLE	MANUFACTURER
SHREDDER	SATURN

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Leaking Oil Seal on Operator Side of Gearbox	40	--	--	In-Situ. This may have to be undertaken within a temporary confinement structure due to the potential breach of containment when the oil seal is replaced. The oil will be contaminated waste.
2. Replace Bearing on Operator Side of Gearbox	40	--	--	
3. Motor Failure	24	--	--	
Major Failure				
1. Replace Shredder Blades	40	8	--	Hot Cell (Box Breakdown)
2. Replace Shredder Shaft	40	8	--	Hot Cell (Box Breakdown)
3. Replace Shredder	40	8	--	Hot Cell (Box Breakdown)

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-06-102, 103 CR-05-521, 522, 523, 541, 542, 543 & 601	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/8/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
CHAIN HOISTS 1 TON 2 TON & 3 TON	BUDGIT - LIFT TECH INTERNATIONAL

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-06-102, 103 CR-05-521, 522, 523, 541, 542, 543 & 601	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/8/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
CHAIN HOISTS 1 TON 2 TON & 3 TON	BUDGIT - LIFT TECH INTERNATIONAL

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-06-102, 103 CR-05-521, 522, 523, 541, 542, 543 & 601	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/8/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
CHAIN HOISTS 1 TON 2 TON & 3 TON	BUDGIT - LIFT TECH INTERNATIONAL

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-06-102, 103, 201, 202, 304, 305, 522, 542	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	6/30/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
SLIDING HATCH	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-06-102, 103, 201, 202, 304, 305, 522, 542	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	6/30/93
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TITLE	MANUFACTURER
SLIDING HATCH	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-06-102, 103, 201, 202, 304, 305, 522, 542	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	6/30/93
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TITLE	MANUFACTURER
SLIDING HATCH	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER T-05-541	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 06/24/93 BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
VOLUMETRIC FEEDER	KTRON (ACRODYNE)

EQUIPMENT DESCRIPTION

The approximate size of the equipment is 8'-0" X 4'-0" X 5'-0". It consists of twin spiral screws that meter the material through the feeder. The feeder is constructed from 300 series stainless steel. The 5 Hp motor is connected to a right angle gearbox which in turn drives the spiral screws. The equipment is controlled by a K-Commander 2028 US control unit. This can be mounted remotely.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This product from Acrodyne requires minimal maintenance. The gearbox is non-lubricated. The equipment is designed on a modular basis, items are readily interchangeable.

SPECIAL MAINTENANCE REQUIREMENTS

At some time within the plant life, the entire unit may require removal from the process system. A portable confinement structure will be erected around the work area. It is then proposed to have 1/2" distance pieces at the interfaces with adjacent equipment. This will aid the containment of airborne surface contamination from those surfaces that have been intimately in contact with the waste material. The proposal is to remove the makeup piece and contain both the failed equipment and the stationary equipment/confinement. Before removal of the failed component, replacement operations would be in the reverse order.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER T-05-541	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 06/24/93 / BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
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TITLE	MANUFACTURER
VOLUMETRIC FEEDER	KTRON (ACRODYNE)

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Grease Brg on Electric Motor	0.25	1	--	--	In-Situ
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER T-05-541	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 06/24/93 / BY: LD

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TITLE	MANUFACTURER
VOLUMETRIC FEEDER	KTRON (ACRODYNE)

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION	
Minor Failure					
1. Replace Motor	2	1	--	In-Situ	
Major Failure					
1. Replace Twin Screws	40	--	--	In-Situ (See Special Maintenance Requirements)	This will have to be undertaken within a temporary confinement structure due to a breach of containment when the screws are withdrawn
2. Replace Hopper	40	--	--	In-Situ (See Special Maintenance Requirements)	

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TC-05-501	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/16/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
DRUM TRANSFER CAR	TBD

EQUIPMENT DESCRIPTION

The equipment consists of a fabricated frame. A non power roller conveyor is located on the top of the frame. The car runs on a vee track at one side and a flat rail at the other. The car is powered by an electric motor. The car measures approximately 40" x 40" x 14" high. It is designed to carry 55 gallon and 85 gallon drums. Drums are transferred onto the car from a powered roller conveyor. The transfer device stays with the powered rollers.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The maintainable components associated with this equipment are high reliability items that are used in high volume production material handling installations. Maintenance will be minimal. Roller bearings are sealed for life 10 million revs and the electric motor and cabling will be run to fail.

SPECIAL MAINTENANCE REQUIREMENTS

None Required.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TC-05-501	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/16/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
DRUM TRANSFER CAR	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TC-05-501	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 7/16/93 / BY: LD

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TITLE	MANUFACTURER
DRUM TRANSFER CAR	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION	
Minor Failure					
Major Failures					
1. Conveyor Motor	0.5	1	--	In Situ	Additional Time Will Be Required for Man Entry
2. Transfer Drive Motor	1	1	--	In Situ	
3. Conveyor Roller Seizure	0.5	--	--	In Situ	
4. Transfer Car Wheel BRG Seizure	2	--	--	In Situ	

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-620	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	7/16/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
CONSUMABLE ENTRY PORT	TBD

EQUIPMENT DESCRIPTION

The consumable entry port allows 2", 4 1/2" or 6 1/2" dia bottles to be posted into the confinement without breach of containment, the port consists of several layers of annular rubber discs known as the sphincter, this unit has been designed for easy replacement. The bottle forms a 1/2" interference with the bristles as it is pressed into the port. An in-leakage airflow forms a barrier to the contamination. When the door on the operators side is closed the bottle can be extracted from the port by the operator or manipulator. The unit is approximately 6" dia larger than the bottle.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This unit requires minimal maintenance. The sphincter will require replacing periodically due to either a contamination problem or general wear and tear.

SPECIAL MAINTENANCE REQUIREMENTS

A window and gloveport arrangement should be positioned either side of the entry port or adjacent so the bottled item can be extracted from the port after the port door is closed.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-620	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 7/16/93 / BY: LD

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TITLE	MANUFACTURER
CONSUMABLE ENTRY PORT	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Grease Door Hinges & Swing Bolt	12	0.5	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-620	SHT 3 OF 3
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TITLE	MANUFACTURER
CONSUMABLE ENTRY PORT	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Contaminated/Worn Sphincter	1	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER T-06-101A&B	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/12/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
DISCHARGE HOPPER	K-TRON-ACRODYNE

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER T-06-101A&B	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 8/12/93 BY: LD

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TITLE	MANUFACTURER
DISCHARGE HOPPER	K-TRON-ACRODYNE

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER T-06-101A&B	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/12/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
DISCHARGE HOPPER	K-TRON-ACRODYNE

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CY-06-101 CY-05,521, 541	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/05/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
DRUM PUSHER	TOL-O-MATIC

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CY-06-101 CY-05,521, 541	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/05/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
DRUM PUSHER	TOL-O-MATIC

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CY-06-101 CY-05,521, 541	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/05/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
DRUM PUSHER	TOL-O-MATIC

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER XX-06-103 & 104	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/11/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)								
	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
TRANSFER RAIL	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER XX-06-103 & 104	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/11/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
TRANSFER RAIL	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER XX-06-103 & 104	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 8/11/93 BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
TRANSFER RAIL	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER AL-06-101	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/31/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
AIRLOCK TRANSFER TUNNEL	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER AL-06-101	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/31/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
AIRLOCK TRANSFER TUNNEL	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER AL-06-101	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/31/93 / BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
AIRLOCK TRANSFER TUNNEL	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TO-05-524A&B & 541	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/12/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)								
	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
WEIGH HOPPER	K-TRON (ACRODYNE)

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TO-05-524A&B & 541	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/12/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
WEIGH HOPPER	K-TRON (ACRODYNE)

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TO-05-524A&B & 541	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	8/12/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
WEIGH HOPPER	K-TRON (ACRODYNE)

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-524A&B, 544	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/30/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
ONE TRIP DOOR SYSTEM	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-524A&B, 544	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/30/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
ONE TRIP DOOR SYSTEM	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DO-05-524A&B, 544	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	07/30/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
ONE TRIP DOOR SYSTEM	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-05-561	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
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TITLE	MANUFACTURER
POWER MANIPULATOR	BROKK

EQUIPMENT DESCRIPTION

This hydraulically operated arm consists of a fixed position rotating module that houses all the control valves that operate each joint and the operating tools. The slewing system consists of a hydraulic motor and planetary gearing; there is an optional 55° slewing system which consists of two double acting hydraulic cylinders. All piston rods are hard chrome plated. The arm sections are actuated by conventional linear hydraulic actuators, three in total. All hydraulic hoses are located external to the arm structural section. The arm has a maximum pivotal reach of 18'-0" and a max height reach of approximately 15'-0". The arm joints can be lubricated by a central lubricating system. The tool end of the arm has an auto tool change system. The tools vary from hammer drills, nibblers, to crushers.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment was designed for the construction/demolition industry. This type of equipment has a proven track record. The manipulator has been overdesigned to cope with the excessive stresses equipment like this will have to endure. Therefore, very little planned maintenance will be required.

SPECIAL MAINTENANCE REQUIREMENTS

Possibly the control valves and individual hoses should have quick disconnect couplings to allow easy replacement of failed equipment.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-05-561	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
POWER MANIPULATOR	BROKK

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Check for Abrasion on Hoses.	6	1	--	--	In-Situ } Man Entry Required
2. Lubrication.	2	1	--	--	In-Situ } Man Entry Required
3. Check Tool Wear.	6	1	--	--	In-Situ } Man Entry Required

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-05-561	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
POWER MANIPULATOR	BROKK

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Hydraulic Actuator	TBD			In-Situ
2. Hydraulic Hose	TBD			In-Situ } Man Entry Required
3. Control Valves	TBD			In-Situ } Man Entry Required
4. Hydraulic Motor	TBD			In-Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-05-561	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	09/13/93
		CWBS NO. 1604	BY: JPB/LD

REVISIONS (DATE & BY)	A		B		C		D	
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TITLE	MANUFACTURER
TELESCOPIC POWER MANIPULATOR	CIMCORP/SCHILLING

EQUIPMENT DESCRIPTION

The telescoping tube manipulator is mounted to a carriage system of a bridge crane, the pay load capacity is 5000 lb. extension speed 0 to 15 ft/min variable. The assembly is made up of a hoist box assembly, gear reducer assembly and a telescoping tube, the telescoping tube is activated by cable. All electrical controls are passed down the inside of the tube under a protective cover, the construction is hard anodized aluminum with stainless steel wear strips and stainless steel guide rollers. The bearings are sealed for life. The hoist is driven by a DC braked motor with planetary gear reduction. There is a pawl and ratchet mechanism to stop any free fall of the tube in the event of a cable breakage. This must be manually disengaged if the cable fails at any time.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The telescoping tube must be detached from the carriage to maintain the bearings or the tube guides. Only when the assembly is blocked on the bench can the top plate be removed and the hoist and electric cables be removed. The hoist cable is removed by driving out retaining pins. The hoist drum bearings should be pushed out and lubricated at this time.

SPECIAL MAINTENANCE REQUIREMENTS

A laydown area will be required for telescoping tube maintenance. The manipulator can be maintained in-situ. The maintenance requirements are similar to the sorting manipulator. Appendix 3-1, decontamination can be undertaken using strippable coatings. The manipulator can be maintained in the segregated area at the far end of the box breakdown cell.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-05-561	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 09/13/93 BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
TELESCOPIC POWER MANIPULATOR	CIMCORP/SCHILLING

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Host cable inspection	6	2	1	--	In situ
2. Lubricate gear reducer	12	4	--	--	In situ } Man Entry Required
3. Lubricate drum and ratchet	12	8	1	--	In situ } Man Entry Required
4. Lubricate bevel gears	12	4	1	--	In situ
Minor Infrequent Tasks					
1. Light lubrication of tube guide bearings.	24	2	--	--	In situ } Man Entry Required

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EM-05-561	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 09/13/93 / BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
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TITLE	MANUFACTURER
TELESCOPIC POWER MANIPULATOR	CIMCORP/SCHILLING

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Limit Switches	*			
Major Failures				
1. Geared Motor	*			
2. Clutch	*			
3. Hoist Cable	*			
4. Electrical Control Cables	*			
5. Hoist Drum Bearings	*			
6. Upper Pulley Bearing	*			
7. Lower Pulley Bearing	*			
8. Tube Guide Bearings	*			
9. Timing Cables	*			
10. Timing Cable Anchor	*			

* This information is not available Ref. OUF0033 FAX, M. Price/L. Dutton Cimcorp/UE&C 09/14/93.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-561	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/13/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)								
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TITLE	MANUFACTURER
GROUTED DRUM SLITTING SAW	BEHRINGER

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-561	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/13/93 / BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
GROUTED DRUM SLITTING SAW	BEHRINGER

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-561	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008	DATE: 08/13/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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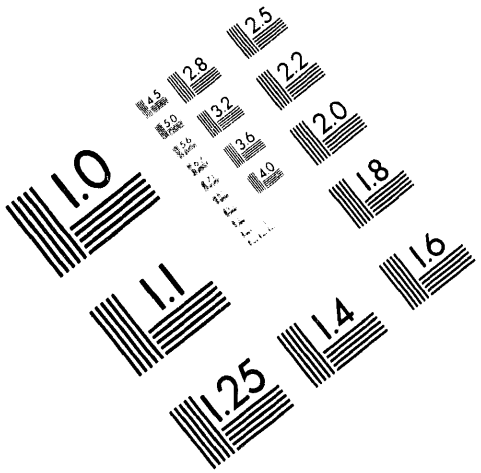
TITLE	MANUFACTURER
GROUTED DRUM SLITTING SAW	BEHRINGER

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				



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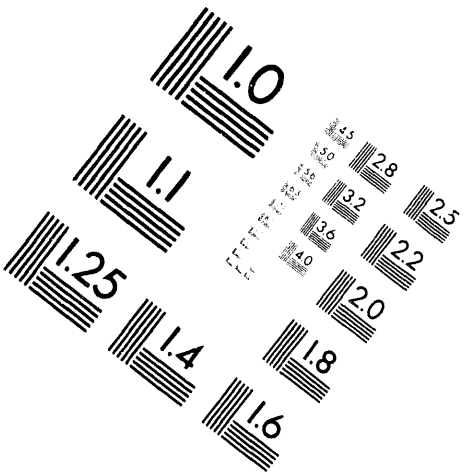

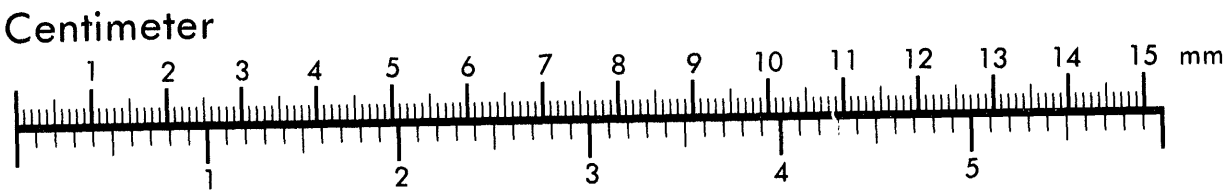

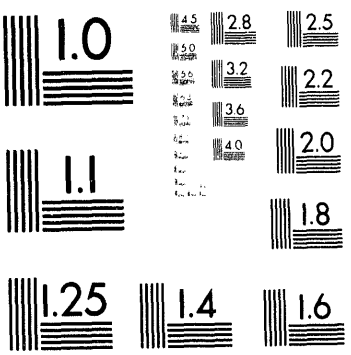

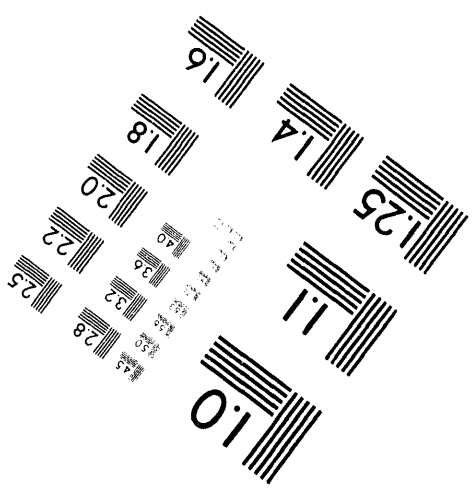

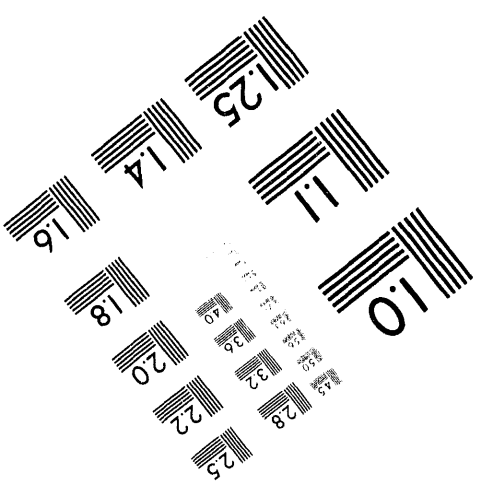

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-612	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/10/93
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REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
CORE DRILL	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-612	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/10/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
CORE DRILL	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-612	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/10/93 / BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
CORE DRILL	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EX-05-401	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/13/93 / BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
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TITLE	MANUFACTURER
POLYMER EXTRUDER	BERSTORFF

EQUIPMENT DESCRIPTION

The ZE75A x 33 LD Extruder consists of a 160 Kw motor that provides 250 lbf (141100 Nm) of torque at the input shaft. The drive is transmitted to the gearbox via an autoguard overload protection unit. The gearbox is fitted with a pumped lubrication system, 45l/ min @ 4bar, and the output shaft, with 495 lbf(2200 Nm) of torque, directly drives the 4" diameter twin screws.

To achieve the correct temperature for mixing the waste and polyethylene thoroughly, there are electric heating coils and tempered water cooling units. The water passes through cooling chambers within the barrel liner. External to this are the heating elements covered by a protective isolating hood. A degassing barrel is strategically located to draw off the process gasses. The waste will enter the process via a feeding barrel.

The Polymer enters the front end of the machine, as pelletized or granular feed stock, where there are three defined heat zones; initial heating (200/300 °F), fluid zone (300/450 °F) and waste amalgamation (200/ 250 °F). The material will exit the extruder at this temperature and enter the waste drum via a 2 7/8"outlet.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

All the items requiring routine planned maintenance are located outside the glovebox. The major items requiring maintenance are the twin screws and screw shroud. The twin screws can be extracted using an extraction device. The screw shrouds are manufactured in 12" long modular sections. Berstorff can make the shroud in one complete section. This can be extracted with the screws this option is recommended for this application.

SPECIAL MAINTENANCE REQUIREMENTS

There should be an allowance at the end of the glovebox for the removal of the last module and the screw and shroud support stand. This will enable the screws and shroud to be withdrawn from the extruder into a transfer container and will facilitate disposal of the worn or failed equipment and its subsequent replacement.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EX-05-401	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/13/93 / BY: LD

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TITLE	MANUFACTURER
POLYMER EXTRUDER	BERSTORFF

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
1. Replace Gearbox Oil	24	2	--	--	In-Situ (First Oil Change After 6 Months)
2. Clean Double Oil Filter Screen	6	2	--	--	In-Situ (Driving Balls, Sliding & Guiding Disc)
3. Lubricate Autoguard Coupling After Each Switching.	--	1	--	--	In-Situ
4. Grease Twin Screw Radial Bearings	24	2	--	--	In-Situ (Grease Gun)
5. Grease Shaft Sealing Rings	8	1	--	--	In-Situ (Grease Gun)
Minor Infrequent Tasks					
1. Check Pressure Control Device Thermometer, Manometer & Thermostatic Valves	30	--	2	2	In-Situ
2. Check System For Oil Leaks	24	1	--	--	In-Situ
3. Clean Water Passages	60	8	--	--	In-Situ (Clean with 15% Hydrochloric Acid 30 min. at room temp.)

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER EX-05-401	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

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TITLE	MANUFACTURER
POLYMER EXTRUDER	BERSTORFF

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
1. Reset Autoguard Coupling	1	--	--	In-Situ (Outside Containment) This must be lubricated at the time of re-setting.
Major Failures				
1. Motor	4	2	--	In-Situ (Outside Containment)
2. Gearbox Pump	4	--	--	In-Situ (Outside Containment)
3. Cooling System				
a. Water Tank (leaking)	4	--	--	In-Situ (Outside Containment)
b. Circulation Pump	2	1	--	In-Situ (Outside Containment)
c. Filter	1	--	--	In-Situ (Outside Containment)
d. Heat Exchanger	4	2	--	In-Situ (Outside Containment)
4. Vacuum Pump (Removal of Volatiles)	2	1	--	In-Situ (Outside Containment)
5. Heating Element	4	2	--	In-Situ
6. Seizure or Excessive Wear of Twin Screws	24	10	10	In-Situ (Removal to box breakdown for size reduction)

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER M-05-402, 408, 409 & 410	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/08/93
		CWBS NO. 1604	BY: LD

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TITLE	MANUFACTURER
IN DRUM MIXER	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER M-05-402, 408, 409 & 410	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.000 CWBS NO. 1604	DATE: 08/08/93 BY: LD

REVISIONS (DATE & BY)	A	12/29/93 LD	B		C		D	
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TITLE	MANUFACTURER
IN DRUM MIXER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER M-05-402, 408, 409 & 410	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/08/93 / BY: LD

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TITLE	MANUFACTURER
IN DRUM MIXER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CM-05-561	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

REVISIONS (DATE & BY)								
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TITLE	MANUFACTURER
FILTER COMPACTOR	

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CM-05-561	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

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TITLE	MANUFACTURER
FILTER COMPACTOR	

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CM-05-561	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/13/93 BY: LD

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TITLE FILTER COMPACTOR	MANUFACTURER

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CM-05-581	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/09/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
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TITLE	MANUFACTURER
EMPTY DRUM COMPACTOR	TBD

EQUIPMENT DESCRIPTION

The WRAP Module 1 Empty Drum Compactor has been used as a basis. The equipment consists of an outer structure. A powered transfer car transports the empty 55 gallon waste drum to the compactor. The drum is located by a bolster and compacted by the platen.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

All the individual components will be run to fail. There is minimal lubrication requirements. The worst failure would be hydraulic leakage from the hydraulic actuator seal into the compactor containment. The failure of other components probably will not be that catastrophic. The equipment will be designed with consideration for in-situ maintenance. Access to all replaceable items will be reviewed at detail design.

SPECIAL MAINTENANCE REQUIREMENTS

There should be the required height consideration to allow replacement of the compaction cylinder and bolster cylinders. A lifting eye mounted on the rear of these actuators and a structural lifting beam in the building roof would aid removal of this equipment. A bagging flange around the drum centralizing equipment would assist operations if the device needed replacing due to a pivot bearing failure.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CM-05-581	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/09/93
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TITLE	MANUFACTURER
EMPTY DRUM COMPACTOR	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Lightly Grease Guide Track	12	2	--	--	In-Situ } There is No Time Allowance for Man Entry and Exit from Confine-ment

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CM-05-581	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/09/93 / BY: LD

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TITLE	MANUFACTURER
EMPTY DRUM COMPACTOR	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION	
Minor Failure					
1. Lighting Failure	--	0.5	--	In-Situ	There is No Time Allowance for Man Entry and Exit from Confine-ment
2. Switches	--	2	2	In-Situ	
Major Failures					
1. Platen Actuator	8	--	--	In-Situ	There is No Time Allowance for Man Entry and Exit from Confine-ment
2. Bolster Actuator	8	--	--	In-Situ	
3. Drum Location Actuators	3	--	--	In-Situ	
4. Transfer Car Peristaltic Drive	4	--	--	In-Situ	
5. Platen Guide Wheels	20	--	--	In-Situ	
6. Bolster Guide Wheels	20	--	--	In-Situ	

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-08-101	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 09/27/93 BY: LD

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TITLE	MANUFACTURER
NARROW AISLE STACKER	MATERIAL HANDLING COMPANY

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-08-101	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	09/27/93
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TITLE	MANUFACTURER
NARROW AISLE STACKER	MATERIAL HANDLING COMPANY

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-08-101	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 09/27/93 BY: LD

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TITLE	MANUFACTURER
NARROW AISLE STACKER	MATERIAL HANDLING COMPANY

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER X-06-201 A&B	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/10/93
		CWBS NO. 1604	BY: LD

REVISIONS (DATE & BY)								
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TITLE	MANUFACTURER
JAR MILL	PAUL O. ABBE

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER X-06-201 A&B	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/10/93 BY: LD

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TITLE	MANUFACTURER
JAR MILL	PAUL O. ABBE

PLANNED MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Routine Tasks				
Minor Infrequent Tasks				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER X-06-201 A&B	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/10/93 BY: LD

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TITLE	MANUFACTURER
JAR MILL	PAUL O. ABBE

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER X-05-522	SHT 1 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 CWBS NO. 1604	DATE: 08/06/93 BY: LD

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TITLE	MANUFACTURER
DIVERTER TRAY	TBD

EQUIPMENT DESCRIPTION

DELETED FROM PROCESS

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER X-05-522	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	08/06/93
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TITLE	MANUFACTURER
DIVERTER TRAY	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER X-05-522	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 08/06/93 / BY: LD

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TITLE	MANUFACTURER
DIVERTER TRAY	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-521	SHT 1 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	12/30/93
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TITLE	MANUFACTURER
CRUSHER	McLANAHAN

EQUIPMENT DESCRIPTION

The triple-roll crusher is composed of two basic elements: a single roll crushing primary feed roll against a curved crushing plate and a double row of crush rollers below performing secondary reduction. The rolls are adjustable to vary the product size. The frame is a welded carbon steel construction, roller bearings are self aligning, alloy steel toothed rolls for primary and secondary crushings. The equipment also features a tramp iron protection system, i.e., any un-crushable item larger than the final product size will be released from the crusher. There are compression springs mounted on the crushing plate once the uncrushable item has passed through the machine it automatically re-sets and continues operations.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The frame fabrication has been designed to allow the crusher rolls to be extracted through a removable end panel. The drive system is mounted externally to the crushing frame. Thus it is hands-on maintenance in a Zone 2 area. The crushing plate can be replaced, it is considered that with the usage and material passing through the equipment, it will last the plant life. The crushing roll bearings and actuation devices are mounted external to the crushing chamber, thus Zone 2 maintainable.

SPECIAL MAINTENANCE REQUIREMENTS

The crushing roll drive shaft penetrates the crushing chamber without a dust seal. A diverter plate will keep 95% of debris within the chamber. WRAP Module 2A will required these penetrations sealed by the manufacturer. Assuming the crushing rollers last the life of the plant, there will be no special maintenance requirements.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-521	SHT 2 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
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TITLE	MANUFACTURER
CRUSHER	McLANAHAN

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Grease Crusher Roll Bearings	1	0.5	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SH-05-521	SHT 3 OF 3

CUSTOMER & LOCATION	PROJECT	UE&C JOB NO.	DATE:
DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	12/30/93
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TITLE	MANUFACTURER
CRUSHER	McLANAHAN

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Motor	1	3	--	In Situ
2. Drive Belt	4	1	--	In Situ
3. Drive Chain	8	--	--	In Situ
4. Bearing	8	--	--	In Situ
5. Tramp Protection Springs	16	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SN-05-521	SHT 1 OF 3
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TITLE	MANUFACTURER
ROTARY SCREEN	McLANAHAN

EQUIPMENT DESCRIPTION

The screen is supported on four wheeled rollers. The rotary screen is driven by a chain and sprocket arrangement direct to an electric motor drive. The unit is mounted on a sub frame and is fully enclosed by a fabricated carbon steel housing. The internal fins are welded to the mesh screen. The fins direct the material flow through the unit. Items less than the screen size pass through the mesh and fall by gravity through a hopper positioned below the rotary screen. The material larger than the mesh size will be transported through the equipment and continue into the process.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The rotary screen will be located in a Zone 1 confinement area thus maintenance on the chain drive, motor or wheel rollers will have to be by man access. The motor will be a relatively simple operation. The chain drive will require the removal of 5'-0" diameter guard before the chain can be accessed. The drum support roller bearings require the screen to be raised to allow for bearing replacement. This will be unlikely as the bearings have a rated life of 10 million revs. It is more likely that the seals will deteriorate and the bearings will be become noisy.

SPECIAL MAINTENANCE REQUIREMENTS

The removal of the chain guard is presently a two-man operation. The manufacturer could make the chain guard in four pieces to make this a one-man operation. Replacement of the screen support bearings will not be considered due to the enormity of the task in a Zone 2 area. It would be a better option to ensure sealed-for-life bearings and lip seals were used within the bearing housing to give a secondary degree of confinement.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SN-05-521	SHT 2 OF 3

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DOE-RL/WHC HANFORD, WA	WRAP FACILITY MODULE 2	6237.008	12/30/93
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TITLE	MANUFACTURER
ROTARY SCREEN	McLANAHAN

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SN-05-521	SHT 3 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008	DATE: 12/30/93
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TITLE	MANUFACTURER
ROTARY SCREEN	McLANAHAN

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION	
Minor Failure					
Major Failures					
1. Motor	1	3	--	In Situ	There is No Allowance for Man Entry or Exit
2. Chain Drive	8	--	--	In Situ	
3. Support Rollers	--	--	--	Dispose of equipment or major stripdown required.	

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DR-05-521	SHT 1 OF 3
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TITLE	MANUFACTURER
MIXER DRYER	CHRISTIAN ENGINEERING

EQUIPMENT DESCRIPTION

The mixer dryer is comprised of two major components, the heated screws and a containment vessel. The number of screws is dependant on the throughput requirement. The screws are intermeshed. This provides some additional mixing, ensuring the material is uniformally dried. The screws convey the product in one direction. This four screw unit can be driven so the material circulated within the compartment. Once the desired drying has been obtained, the direction of a pair of screws can be changed to empty the vessel. Intermediate condensate drains are provided along the vessel. The electric heating is provided to the jacketed vessel and down the center of the hollow screws. The unit is powered by a geared motor.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The maintainable components of the mixer dryer are external to the processing elements. These items, motor, gearbox, heating elements are in a Zone 2 area. Long term, the helical screws may wear due to product abrasion and the shaft seals will leak.

SPECIAL MAINTENANCE REQUIREMENTS

When the shaft seals leak, the gearbox and end bearings must be removed. This operation may be carried out with the equipment in situ, using a portable confinement arrangement. If the screw flights fail or wear to a point that the heating conduction or material transfer is effected, the entire unit must be replaced using the portable confinement method.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DR-05-521	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 12/30/93 / BY: LD

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TITLE	MANUFACTURER
MIXER DRYER	CHRISTIAN ENGINEERING

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Grease End Bearings	6	0.5	--	--	In Situ
2. Check Oil Level on Gearbox	6	0.5	--	--	In Situ
3. Check Heating Elements	6	0.5	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER DR-05-521	SHT 3 OF 3
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TITLE	MANUFACTURER
MIXER DRYER	CHRISTIAN ENGINEERING

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Geared Motor	1	3	--	In Situ
2. Screw Support Bearings	8	--	--	In Situ (There is now allowance for assembly of a separate confinement structure)
3. Screw Flights	--	--	--	Dispose of Equipment

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SN-05-522	SHT 1 OF 3

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TITLE	MANUFACTURER
VIBRATORY SCREEN	CLEVELAND VIBRATOR COMPANY

EQUIPMENT DESCRIPTION

The equipment consists of a vibratory trough with a screen in the lower portion. The mechanical shaker assembly is directly attached to the trough. The trough is mounted on a series of leaf springs. This assembly is mounted on a base frame. The shaker assembly is a totally enclosed, geared counter rotating mechanism, with a self-contained oil bath for lubrication. Two weights are mounted on individual shafts which are geared together, one rotates clockwise, the other counter-clockwise. The chute transfer items larger than 3mm to the large item removal box located below the debris line. Particulate smaller than 3mm continues through the process. The equipment will be contained within a custom-designed structure with access to the maintainable components.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

This equipment has a good record of low maintenance. The first failure to occur is usually the off-set weights that induce the vibration. These are trimmed then bolted in place. After 2 to 3 years they wear loose and need re-tightening. This can be carried out in situ. The other failure is stress cracking or fatigue in the trough support springs. This can occur after 20,000 to 30,000 hours operation.

A cost/benefit analysis is required to determine if in situ access to the equipment is required or the unit will be removed from service for operational adjustments.

SPECIAL MAINTENANCE REQUIREMENTS

Good access is required around the motor and spring location area. Periodic adjustment to the shaker assembly is required.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SN-05-522	SHT 2 OF 3
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TITLE	MANUFACTURER
VIBRATORY SCREEN	CLEVELAND VIBRATOR COMPANY

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Re-set Counterbalance Weight	24	8	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER SN-05-522	SHT 3 OF 3

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TITLE	MANUFACTURER
VIBRATORY SCREEN	CLEVELAND VIBRATOR COMPANY

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Vibro Motor Failure	24	8	--	In Situ
2. Trough Leaf Springs	24	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-05-501	SHT 1 OF 3
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TITLE	MANUFACTURER
CLAMSHELL GRAB	TBD

EQUIPMENT DESCRIPTION

This hydraulically operated unit consists of two quarter segment, cylindrical fabrications that are connected by a support frame. The two clamshells are held together under their own weight. The hydraulic actuator forces them apart to discharge the load. The unit can be configured so that the operator can open the grab only on a slack rope condition. Therefore, this equipment can be considered fail safe.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The hydraulic actuators are good for 10^5 cycles. This equipment should be low usage either for loading of special waste product bottles into the disposal container or large heavy items from the debris line.

SPECIAL MAINTENANCE REQUIREMENTS

None Required.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-05-501	SHT 2 OF 3
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TITLE	MANUFACTURER
CLAMSHELL GRAB	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER CR-05-501	SHT 3 OF 3
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TITLE	MANUFACTURER
CLAMSHELL GRAB	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION	
Minor Failure					
Major Failures					
1. Hydraulic Actuator	4	--	--	In Situ	There is No Time Allowance for Man Entry/Exit into the Zone 1 Confinement
2. Feed Hose to Actuator	4	--	--	In Situ	

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 1 OF 3
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TITLE	MANUFACTURER
DIVERTER GATE	DCL

EQUIPMENT DESCRIPTION

The flat blade diverter valve is a heavy duty carbon steel weldment. The fabrication forms an inverted "Y" shape. There is a through shaft at the intersection. This is supported by sealed-for-life ball bearings, mounted external to the weldment. A shallow vee double wall blade provides strength and smooth catch free profile, this is welded to the pivot shaft. The blade is actuated to one of two positions by a pneumatic actuator also mounted external to the weldment.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The actuator, limit switches and support bearings are all mounted externally to the diverter. The bearings are good for 10 million revs and the actuator has a 10^5 life expectancy. This equipment should require minimal attention. Due to the waste passing through the equipment and not holding up there, the levels of activity on the support bearings should be minimal. Therefore, if a bearing replacement is required, localized containment of the area should be achievable.

SPECIAL MAINTENANCE REQUIREMENTS

None Required.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 2 OF 3

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TITLE	MANUFACTURER
DIVERTER GATE	DCL

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 3 OF 3
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TITLE	MANUFACTURER
DIVERTER GATE	DCL

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Pneumatic Actuator	2	--	--	In Situ
2. Support Bearings	8	--	--	In Situ - This operation would break confinement. Local confinement may be required dependent on the amount of activity present.
3. Limit Switches	--	2	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER H-06-201	SHT 1 OF 3

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TITLE	MANUFACTURER
MERCURY EVAPORATOR	PAUL-O. ABBE INC.

EQUIPMENT DESCRIPTION

This evaporator is a 42" rota cone vacuum dryer approximately 21 ft^3 capacity with 13 ft^3 operating volume. All contact parts of the evaporator are constructed from 304 stainless steel. The only service penetration into the vacuum cone is a 1 1/4" vacuum line with a thermwell mounted in line. The ends of the rota cone are valved to retain the material while heating and evaporation take place. The rota cone is jacketed for oil heating. The evaporator is mounted on two trunnion bearings. The trunnions are hollow to accept the vacuum lance on one side and the heating medium through the other trunnion. Connections are made via rotary couplings. Rotation is performed using a sprocket and chain coupled to a low geared motor. The make and break connection to the evaporator will be a remotely operated retractable device due to the exposed contaminated faces, secondary confinement will be required.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

Due to the confinement problem at the make and break entry/exit, it will be necessary to have a secondary confinement. If it can be engineered, the confinement barrier should pass through the trunnion area of the equipment then the roto cone drive support bearings and rotary couplings can be located outside the secondary confinement. The make and break connections to the process would be the only items of equipment requiring special maintenance considerations.

SPECIAL MAINTENANCE REQUIREMENTS

Due to the rotating nature of the evaporator, an expandable joint will be required and a remotely controlled side valve. Maintenance penetrations in the secondary confinement will be required.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER H-06-201	SHT 2 OF 3
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TITLE	MANUFACTURER
MERCURY EVAPORATOR	PAUL-O. ABBE INC.

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Grease Bearings	12	0.5	--	--	In Situ
2. Check Calibration of Thermocouple	6	--	1	2	In Situ
3. Check for Oil Leakage in Heating System	3	0.5	--	--	In Situ Visual
4. Check Wear on Drive Chain	12	2	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER H-06-201	SHT 3 OF 3
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TITLE	MANUFACTURER
MERCURY EVAPORATOR	PAUL O. ABBE INC.

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Extendable Make and Break Connection	TBD	--	--	In Situ } These items are within a secondary confinement zone
2. Entry Exit Valves	TBD	--	--	In Situ }
3. Trunnion Bearings	8	--	--	In Situ
4. Rotary Coupling (Vacuum)	8	--	--	In Situ
5. Rotary Coupling (Oil)	16	--	--	In Situ
6. Rotor Cone Drive Chain	8	4	--	In Situ
7. Motor	4	4	--	In Situ
8. Control Switching	--	2	2	In Situ

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TITLE	MANUFACTURER
COMPACT HANDLER	TBD

EQUIPMENT DESCRIPTION

The majority of compacted drum handlers use a 5 or 6 finger grapple centrally actuated by one hydraulic or pneumatic cylinder. The final size of the compact is accurately determined by the bolster of the compactor. Therefore, the amount of movement by the grippers can be kept to a minimum. This has the advantage of a close stacking configuration.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The compact handlers have a central lifting eye with a double quick release coupling to the actuator. The compact handler will operate within a confinement suspended from a hoist. Allowance should be made to ensure that the compact handler can be accessed for disconnection and reconnection of a new unit.

SPECIAL MAINTENANCE REQUIREMENTS

The confinement structure shall posses the required access to disconnect the failed unit and reconnect a replacement.

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 2 OF 3
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TITLE	MANUFACTURER
COMPACT HANDLER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
COMPACT HANDLER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Actuator	TBD	--	--	In Situ

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TITLE	MANUFACTURER
WASTE DRUM SAMPLER	TBD

EQUIPMENT DESCRIPTION

This equipment is mounted on a rail system translated by a linear drive. The carriage supports a reciprocating mechanism that will enter the waste drum. The hot end of the manipulator can be fitted with interchangeable tools that enable the equipment to take a dry or wet sample. Once the sample has been taken the carriage will be retracted to allow the sample to be deposited into a sample bottle. All actuations are pneumatically operated with limit and proximity switches for control.

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

The drum sampler will be located in a confined area. Due to the nature of this equipment and its maintenance requirements. The confinement will probably resemble a glovebox configuration. This will give gloved access to the entry exit port and the waste drum sampler. Samples will be removed by bagless transfer.

SPECIAL MAINTENANCE REQUIREMENTS

Access to the sampler and tool change area as this will probably be a manual operation, as well as loading the samples into a transfer container.

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TITLE	MANUFACTURER
WASTE DRUM SAMPLER	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					
1. Lubricate Linear Slides	12	1	--	--	In Situ
2. Remove Waste from Tools and Actuator	3	4	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER RT-05-613	SHT 3 OF 3
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TITLE	MANUFACTURER
WASTE DRUM SAMPLER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				
1. Linear Actuator	4	--	--	In Situ
2. Tool Actuator	6	--	--	In Situ
3. Wheel Bearing	6	--	--	In Situ

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 1 OF 3

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TITLE	MANUFACTURER
CONTAINER LID REPAIR SYSTEM	TBD

EQUIPMENT DESCRIPTION

TBD

GENERAL MAINTENANCE REQUIREMENTS SUMMARY

SPECIAL MAINTENANCE REQUIREMENTS

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 2 OF 3
CUSTOMER & LOCATION DOE-RL/WHC HANFORD, WA	PROJECT WRAP FACILITY MODULE 2	UE&C JOB NO. 6237.008 / CWBS NO. 1604	DATE: 1/5/94 / BY: LD

REVISIONS (DATE & BY)	A		B		C		D	
	E		F		G		H	

TITLE	MANUFACTURER
CONTAINER LID REPAIR SYSTEM	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 3 OF 3
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	E		F		G		H	

TITLE	MANUFACTURER
CONTAINER LID REPAIR SYSTEM	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

UNITED ENGINEERS & CONSTRUCTORS A Raytheon Company	MAINTENANCE DATA SHEET ☒ CDR ☐ TITLE I ☐ TITLE II ☐ TITLE III	ITEM NUMBER TBD	SHT 1 OF 3
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TITLE	MANUFACTURER
DRUM TIPPER	TBD

EQUIPMENT DESCRIPTION

TBD

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Minor Infrequent Tasks					

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TITLE	MANUFACTURER
DRUM TIPPER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

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TITLE	MANUFACTURER
GROUT MIXER	TBD

EQUIPMENT DESCRIPTION

TBD

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Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
GROUT MIXER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

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TITLE	MANUFACTURER
BOX DELIDDER RELIDDER	TBD

EQUIPMENT DESCRIPTION

TBD

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TITLE	MANUFACTURER
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	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
BOX DELIDDER RELIDDER	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

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TITLE	MANUFACTURER
AUTO GROUT FILL EQUIPMENT	TBD

EQUIPMENT DESCRIPTION

TBD

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TITLE	MANUFACTURER
AUTO GROUT FILL EQUIPMENT	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
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Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
AUTO GROUT FILL EQUIPMENT	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

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TITLE	MANUFACTURER
VIBRO SORTING TABLE	TBD

EQUIPMENT DESCRIPTION

TBD

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Minor Infrequent Tasks					

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TITLE	MANUFACTURER
VIBRO SORTING TABLE	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

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TITLE	MANUFACTURER
STORAGE RETRIEVAL SYSTEM	TBD

EQUIPMENT DESCRIPTION

TBD

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TITLE	MANUFACTURER
STORAGE RETRIEVAL SYSTEM	TBD

PLANNED MAINTENANCE	MAINTENANCE ACTIVITY TIMES (HOUR)				MAINT. ACTIVITY LOCATION
	FREQ/ MO	MECH HR	ELECT HR	INST HR	
Minor Routine Tasks					
Minor Infrequent Tasks					

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TITLE	MANUFACTURER
STORAGE RETRIEVAL SYSTEM	TBD

BREAKDOWN MAINTENANCE	MECH HR	ELECT HR	INST HR	MAINT. ACTIVITY LOCATION
Minor Failure				
Major Failures				

APPENDIX 4

DOSE RATE ESTIMATE FOR CONTAMINATED SORTING MANIPULATOR

Contamination Prior to Decon = 200,000 cps/cm^2 = 5.405E-06 Ci/cm^2

Contamination After Decon = 2,000 cps/cm^2 = 5.405E-08 Ci/cm^2

ISOTOPE*	Percent of Total	Specific Source Prior to Decon	Specific Source After Decon	Total Source Prior to Decon	Total Source After Decon
Cs-137	5.9	3.189E-07	3.189E-09	2.073E-03	2.073E-05
Ba-137	5.89	3.184E-07	3.184E-09	2.069E-03	2.069E-05
Sr-90	1.27	6.864E-08	6.864E-10	4.462E-04	4.462E-06
Y-90	1.28	6.918E-08	6.918E-10	4.497E-04	4.497E-06
Pu-241	25.44	1.375E-06	1.375E-08	8.938E-03	8.938E-05
Am-241	1.61	8.702E-08	8.702E-10	5.656E-04	5.656E-06
Pu-239	1.69	9.134E-08	9.134E-10	5.937E-04	5.937E-06
Pu-240	0.86	4.648E-08	4.648E-10	3.021E-04	3.021E-06
Pu-238	0.29	1.567E-08	1.567E-10	1.019E-04	1.019E-06
Ru-103	4.23	2.286E-07	2.286E-09	1.486E-03	1.486E-05
Rh-103	4.22	2.281E-07	2.281E-09	1.483E-03	1.483E-05
Sn-113	4.56	2.465E-07	2.465E-09	1.602E-03	1.602E-05
I-129	0.1	5.409E-09	5.409E-11	3.513E-05	3.513E-07
Eu-155	0.19	1.027E-08	1.027E-10	6.675E-05	6.675E-07
Pm-147	4.96	2.681E-07	2.681E-09	1.743E-03	1.743E-05
Ru-106	18.75	1.013E-06	1.013E-08	6.587E-03	6.587E-05
Rh-106	18.76	1.014E-06	1.014E-08	6.591E-03	6.591E-05

* Taken From SDRD

** Assuming a 6500 cm^2 Disk Source

Dose Rate at 1cm from Source Prior to Decon (From ISOSHLD): 54 mRem/hr

Dose Rate at 1cm from Source After Decon (From ISOSHLD): 0.54 mRem/hr

PRELIMINARY ALARA ASSESSMENT FOR DECON OF SORTING MANIPULATOR

1. Cost of Decontamination Equipment:

Replacement of Wrist Assay & Potentiometer Hose Set	25034
($12517/replacement, twice in plant life)	15000
Decontamination Bath and Fume Hood	9000
Fume Hood	5000
HVAC and Services	2000
Special Maintenance Tools	1000
Extended Length Transfer Tube	2700
Decontamination Fluid	0
($900/year)	84034
Disposal of Decontamination Fluid	

2. Assumed Cost of No Decontamination Total 0

3. Contact Dose to Maintenance Worker (no decon): 51.8 rem

   (0.054rem/hr)(16 hrs/main)(2 times/yr)(30 years) =

4. Contact dose to Maintenance Worker (with decon): 0.5 rem

   (0.00054rem/hr)(16 hrs/main)(2 times/yr)(30 years)

5. Cost Benefit Ratio:

$$\frac{\$46317 - \$0}{51.8 - 0.5 \text{ rem}} \quad 1638 \text{ \$/rem}$$

Note: Criteria and Methodology to determine the cost benefit of the measure is identical to the WRAP-1 Facility Design ALARA Assessment.

Criteria for WRAP-1 was:
- Below 2500 $/rem the measure is considered cost effective
- Between 2500 and 8300 $/rem the measure may be cost effective
- Above 8300 $/rem the measure is not cost effective

CONCLUSTION

Based upon the current source term data, estimated contamination levels, equipment costs and maintenance times, the cost/benefit ratio falls below the lower limit of 2500 $/rem and is considered to be cost effective.

WASTE RECEIVING AND PROCESSING FACILITY

TITLE: **WRAP 2A ACDR PRELIMINARY FIRE HAZARDS/BUILDING CLASSIFICATION ASSESSMENT**

Revision: 1

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A **Raytheon** Company
Western Operations

WRAP 2A ACDR FIRE HAZARDS/BUILDING CLASSIFICATION ASSESSMENT

Prepared by: _____ Date: 3/1/94
Fire Protection Engineer

Reviewed by: _____ Date: 3/1/94
Senior Engineer

Approved by: _____ Date: 3/1/94
Engineering Manager

Approved by: _____ Date: 3/1/94
Project Manager

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WRAP 2A ACDR
PRELIMINARY FIRE HAZARDS ASSESSMENT

1.0 OBJECTIVE

1.1 Background

1. The purpose of the WRAP 2A facility is to provide treatment for radioactive solid wastes, specifically non-thermal treatment of contact (CH) mixed low-level waste (MLLW).

2. All Module 2A waste will be received in boxes or drums that are CH and designated as MLLW Category 1 and Category 3 as defined in WHC-EP-0063-3, *Hanford Site Solid Waste Acceptance Criteria* (Willis 1991).

3. All waste received at the facility will be characterized for dangerous and radionuclide constituents, in accordance with WAC 173-303 and other regulations, prior to receipt. Individual MLLW items will be treated as required, with deactivation, macro encapsulation, stabilization, and immobilization being the primary treatments. Small volumes of MLLW which require special processing shall be held in storage for campaigning in a specialty process enclosure provided as part of Module 2A.

4. Sources of waste to be treated include secondary solids from Hanford Site liquid effluent treatment facilities (LETF), thermal treatment facility ash, other WRAP modules, storage, and onsite and offsite waste generators.

5. The Tri-Party agreement, and WAC 173-303, limit the application of the Uniform Fire Code (and by implication, the Uniform Building Code) to occupancies containing ignitive or reactive wastes. Other UFC/UBC hazardous material categories (eg, radioactive or pyrophoric materials) are not considered under the Tri-Party agreement. Therefore, unless either ignitive or reactive wastes, as defined in the Uniform Fire Code, are present, the requirements of the UFC and UBC do not apply. The <u>only</u> exception to this statement is that the Uniform Building Code does apply re seismic design requirements.

6. The governing life safety document is NFPA 101, 1991 edition, "Safety to Life from Fire in Buildings and Structures". Only NFPA 101 occupancy classifications/designations will be used, unless ignitive or reactive waste materials are identified.

1.2 Purpose

1. The purpose of this assessment is to:

   a. Identify the Uniform Fire Code Article 80 (and Uniform Building Code Table 9-A) categories of waste potentially present; in particular, ignitives and reactives;

   b. Identify the UFC and UBC "exempt amounts" for ignitive or reactive materials which may be present in each waste stream;

   c. Identify implications to the project (eg, building construction) if either ignitives or reactives are present in amounts in excess of the UFC/UBC exempt amounts;

d. Establish, with the project Architect, NFPA 101, and (if required) UBC building occupancies, and materials of construction;

e. Outline an approach to performing the Title 1 and 2 Fire Hazards Analysis (FHA).

2. This assessment will deal mainly with the process portion of the building. The administrative areas will not greatly affect the final fire hazards analysis.

2.0 SUMMARY

1. This assessment reviewed each of the waste streams and the encapsulation processes to identify presence of ignitable and reactive materials. For this assessment, ignitable and reactive materials are taken to mean any substance which is identified directly, or by implication, in Article 80 or Appendix VI-A of the Uniform Fire Code, Table 9-A of the Uniform Building Code, NFPA 49, or NFPA 325M. As noted above, however, the only constituents of interest in so far as UFC/UBC classification is concerned are ignitable or reactive wastes or materials.

   a. Waste stream component and process agent characteristics were reviewed to determine if any ignitive or reactive materials, in significant (ie, greater than exempt amounts) quantities were potentially present.

   b. Many ignitive or reactive materials identified in the waste streams are expected to be present in either "nondetectable" or "negligible" quantities (Ref: WHC-SD-W100-RD-001, Rev. 0).

   c. Two (2) waste stream components, ammonium nitrate and sodium oxide, both reactives, may be present in amounts which exceed the exempt amounts of Article 80 or the Uniform Fire Code, based on quantities indicated in WHC-SD-W100-RD-001, and WHC-SC-W306-TI-001.

   d. Not withstanding the quantities indicated in the two documents just referenced, the design of this plant is based on the understanding that ammonium nitrate and sodium oxide , as specific compounds, will not be allowed in the WRAP 2A facility in sufficient quantity such that the total inventory of either ammonium nitrate or sodium oxide at any given time will exceed the UFC Article 80 exempt amounts (10 pounds and 100 pounds, respectively).

2. Based on the FDC (WHC-SD-W100-FDC-001, Rev. 2), no reactives (e.g., zirconium, etc.) are considered to be present in the WRAP 2A facility, even though such metals are listed as chemical components in WHC-SD-W306-TI-001.

3. Expected average and maximum drum contents, were provided by WHC (Ref: WHC-SD-W306-TI-001, Rev. 0). The drum inventory provided in this same document has not been used since the inventory was based on a plant layout which is no longer applicable. This data, when revised and agreed upon, will be used during Title design to establish maximum and average fire loads in the building. Refer to WHC-SD-W100-RD-001 and WHC-SD-W306-TI-001 for detailed information on quantities.

4. Expected quantities of process agents were obtained from process engineers. A summary of the expected quantities of the various agents is found in **Table 1**.

5. A building occupancy was established, taking into consideration the hazardous components identified, and the expected quantities of waste drums and process agents.

   a. Occupancy and physical separation requirements are based solely on NFPA 101.

   b. The NPFA 101 occupancy for this facility has been determined to be "Special Purpose Industrial", in accordance with Chapter 28 or NPFA 101.

6. Other related issues have been identified and addressed. These include the design of HVAC systems, and fire suppression systems within the glovebox enclosures.

7. An approach to the FHA has been outlined. Inputs required from WHC have been identified.

8. Possible design basis fires have been discussed.

9. "Code" issues requiring clarification have been identified.

3.0 CONCLUSIONS

1. Since the amount of all ignitive or reactive material in the facility is understood to be below the UBC/UFC exempt amounts, these Codes do not apply. Therefore the entire facility can be considered a Special Purpose Industrial Facility, per NFPA 101, Chapter 28.

2. The major fire hazard to be addressed is the polyethylene (PE) beads used in the process. PE is treated as a Class A combustible solid, and a Class III-B combustible liquid (flash point > 200 °F). The major hazard associated with PE is the production of combustible gases at elevated temperatures (over 572 °F), and possibly hazardous combustion products.

3. It seems unlikely that the PE encapsulated waste need be considered as a point of origin for a fire. The PE encapsulated waste does need to be considered as a fuel source for a fire which exposes the drums.

4. No specific fire or explosion hazards associated with the grouting process, or the grout agents, have been identified.

5. The decontamination agents identified as being present in the facility are all everyday detergents; no chemical solvents or solutions will be present for decontamination on a regular basis. There is thus no identified hazard due to decontamination agents.

6. The building construction is NPFA 220 Type II-000. Specific areas of the building will require fire resistance rated construction; eg, two (2) hour fire resistance rated construction is required to separate the Process HVAC room from the rest of the facility. Refer to the architectural drawings for further discussion and information.

TABLE 1
WRAP 2A PROCESS AGENTS SUMMARY OR QUANTITIES

Basis: Conversations with RE&C process engineers

AGENT		QUANTITY OF AGENT		
		OUTSIDE	INSIDE	SUBTOTAL
Polyethylene Process		(quantity in cubic feet)		
	Low density polythylene	3,500	175	3,675
Total		3,500	175	3,675
Grouting Process		(quantity in cubic feet)		
	Ordinary Portland Cement	600	20	620
	Blast Furnace Slag	2,400	60	2,460
	Pulverized Fly Ash	2,400	60	2,460
Total		5,400	140	5,580

7. Additional study and assessment, possibly including limited fire modeling, will be required during Title design to determine adequacy of HVAC duct penetrations through fire walls, in lieu of fire dampers.

8. Fire areas need to be determined during Title design based on estimated costs (including costs of demolition, decontamination, disposal, salvage, and restart) and functional considerations.

9. Final occupancy classification and building construction type will be established during Title design in conjunction with the project architect.

4.0 FIRE HAZARDS ASSESSMENT

4.1 General

1. An inventory of the feed and product waste containers, along with the chemical components of the waste feed and product containers, is found in **Table 2**.

2. The chemical source terms are taken from WHC-SD-W306-TI-001. The drum inventory from this document is not used due to changes in the building layout since that document originated, and due to the current use of boxes for the waste product stream. The inventory used is based on UE&C Drawing H-2-140599.

3. All drum quantities listed in **Table 2** are "Drum Equivalents." Each waste (product) box has been taken as equal to 8 waste (product) drums.

4. The inventory is not broken down into individual fire areas. At this time, the entire building is considered a single fire area. Two hour fire rated walls are provided as required by the DOE Fire Protection Standard and other documents, but are not considered in the initial estimate of the MPFL. If the DOE MPFL criteria are exceeded, then the facility will be divided into smaller fire areas as required.

4.2 Process Descriptions

1. Grout Processes

There are three grouting agents which will be used, either singly or in a blend. The agents are: ordinary portland cement (OPC), granulated blast furnace slag (BFS), and pulverized fly ash (PFA). Information on typical physical and chemical properties of all three agents are described in References (Para. 5.4) 3, 4, and 5, attached to this document. The quantities of agents stored, both inside and outside, are listed in **Table 1**.

There are two grout process lines: the vibro-grout process, and the mixed grout process. The primary difference in the two processes is the grout agent: In the vibro-grout process, a single agent is mixed with water and added (with the aid of vibration) to a product container box containing waste materials. The mixed grout process involves a blend of two (or more) grout agents, which are mixed with water and waste, and then metered into a product container box.

TABLE 2

WRAP 2A DRUM CHEMICAL SOURCE INVENTORY

Total Drum Chemical Inventory

Component	Ave. Feed Drums (kg)	Qty Drums (DE's)	Max. Feed Drum (kg)	Qty Drums (DE's)	Ave. Prod. Drum (kg)	Qty Drums (DE's)	Max. Prod. Drum (kg)	Qty Drums (DE's)	Total Qty (kg)	Total Qty (lbs)
Ammonia	0	93	0.45	2	0	468	0.2	5	1.9	4.19
Ammonium Nitrate **	0	93	7.9	2	0	468	4	5	35.8	78.94
Acetone	0	93	3	2	0	468	1.5	5	13.5	29.77
Beryllium	0.19	93	7	2	0.1	468	3.5	5	95.97	211.61
Cadmium **	0.86	93	90	2	0.43	468	45	5	686.22	1513.12
Manganese **	0	93	0.6	2	0	468	0.3	5	2.7	5.95
Mercury	1.74	93	44	2	0.8	468	22	5	734.22	1618.96
Nitric Acid	0.96	93	35	2	0.5	468	17.5	5	480.78	1060.12
Phosphoric Acid	8.4	93	50	2	2.2	468	25	5	2035.8	4488.94
Sodium Hydroxide **	1.8	93	37	2	0.9	468	19	5	757.6	1670.51
Sodium Oxide **	0	93	48	2	0	468	25	5	221	487.31
Uranyl Nitrate Hexahydrate	0	93	6.1	2	0	468	3.1	5	27.7	61.08
Zirconium metal **	0.01	93	0.9	2	0.005	468	0.5	5	7.57	16.69
Total reactive or ignitive component									1710.89	3772.51
Total Feed Drums										95
Total Product Drums										473
Total Drums										568

NOTES:

1. Components marked ** are identified as ignitive or reactive; it is assummed that cadmium, manganese, and zirconium arenot present, based on WHC-SD-W100-FDC-001.
2. Source: WHC-SD-W306-TI-001, Rev. 0; WHC-SD-W100-RD-001, Rev. 0; & UE&C Drwg. H-2-140599.
3. DE = Drum Equivalent

Primary bulk storage of grouting agents, for both processes, is outside the building in bulk storage silos. The grout agents are transported via dense phase pneumatic conveyors into the building where the agent is placed into "day storage bins". Each bin is equipped with a bin vent type air filter to clean the transport air prior to its discharge into the exhaust air system. Transport of the grout agents downstream of the day bins is by mechanical screw conveyor into batch tanks, where the grout is mixed with water and added to the waste drums. An option to the batch process is to utilize a continuous mixer to mix the grout and water, and convey the mixed grout into the waste drums. In either event, the dry grout is utilized in a closed system, equipped with filters at "normal" points of air exhaust. The possibility of leaks at piping and equipment connections does exist, but can be minimized by proper installation and by proper maintenance practices.

2. Polyethylene Encapsulation Process

Low density polyethylene is used to encapsulate waste in this process. The process basically involves heating solid polyethylene beads to above their melting point (approximately 260 °F), mixing the liquid polyethylene with the waste, and extruding the PE/waste mix into appropriate waste containers.

Bulk storage for polyethylene beads is outside (see **Table 1**).

4.3 Fire Protection

1. The design goal of the fire protection system is to provide safe and reliable fire protection, alarm, and detection systems with adequate interlocks, supervisory signals, and alarms to alert operators against unsafe system operating conditions. The fire protection, detection and alarm systems incorporate best available technology, comply with the requirements of DOE and WHC criteria, and conform to NFPA Codes, standards, guidelines and recommendations.

2. The water supply for the fire protection system will be taken from an existing 12" potable (sanitary) water main. Two separate tie-ins will be supplied to the facility from this existing main. The fire protection system will consist of a gridded sprinkler system, which is "zoned" as required to accommodate the individual areas of the facility. Sectional control valves, complete with valve tamper devices, will be provided to allow isolation portions of the sprinkler system (ie, zones), and prevent a single active component failure from disabling the complete fire protection system. Sprinkler system control valves, and associated alarm and supervisory devices, will be located in a non-contaminated (non-SWP) area.

3. Automatic wet pipe sprinkler protection, conforming to NFPA 13, is provided throughout the facility. Office and administrative area sprinkler systems will be designed to meet NFPA 13 Ordinary Hazard Group 1 criteria; the process area sprinkler system will be designed to meet NFPA 13 Ordinary Hazard Group 2 criteria. In waste container storage areas, the system will be designed to meet the NFPA 231 criteria, as determined by the commodity classification. The commodity classification will be determined during Title design.

4. Preaction or limited volume sprinkler systems evaluated in Title design, for possible use in specific process enclosures where wet pipe sprinkler systems and/or large volumes of water could pose cleanup or criticality problems.

5. An automatic fire alarm and detection system, complete with manual pull boxes, will be provided throughout the facility. All alarm initiating devices and notification appliances will be electrically supervised by the fire alarm system. All trouble, supervisory, and alarm signals will annunciate both at the facility fire alarm control panel (FACP) and at an approved central alarm facility. Alarm signals will also annunciate locally, via alarm chimes and strobes, as required.

6. Based on the WRAP 1 project maximum possible fire loss (MPFL) costs, the MPFL for WRAP 2A is expected to be less than $150M, including the direct capital costs, as well as the indirect costs of clean-up, decontamination, and restart. This assumption needs to be confirmed during Title design. The current assumption is based on engineering judgement, and lower anticipated levels of radioactive and hazardous contamination. The basis for this is the source term documentation.

7. Fire barriers are provided in the facility, as required by DOE criteria. Two (2) hour fire resistance rated barriers are provided to separate the Process HVAC room (the final HEPA filter plenums) from the rest of the facility, in accordance with DOE Filter Plenum Fire Protection Standard (March 1993. DRAFT Rev. 4). The Control and Computer Rooms are separated from the rest of the building by one (1) hour fire resistance rated construction, as required by DOE/EP-0108 Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems (January 1984).

8. In addition to the rated fire barriers, barriers for radiation shielding are provided in the process area. These barriers are concrete and, while not necessarily fire resistance rated, provide non-combustible physical separation around some process areas expected to have high fire loads. These barriers are not considered to limit the MPFL, but are expected to help limit the maximum credible fire loss (MCFL).

9. Redundant fire protection for the facility is provided in accordance with DOE 5480.7A. Redundant fire protection system for this facility consist of a combination of automatic suppression, automatic detection, occupant warning, manual fire alarms and fire alarm reporting systems combined with the Hanford Fire Department.

4.4 Uniform Fire Code Article 80, Hazardous Materials

1. Refer to WHC-SD-W100-RD-001 and WHC-SD-W306-TI-001 for details on the quantity and type of materials to be expected in the feed and product containers. Refer to **Table 3**, "Waste Components", for a summary of the waste components, there NFPA classification, and the exempt amounts for each category.

Refer to **Table 4** "Process Agents" for a summary of the various agents proposed for use in the grouting process and the polyethylene (PE) encapsulation process. None of the agents proposed have been identified as hazardous, therefore, no exempt quantities for them are established.

NOTE: The Tri-Party Agreement limits the application of the Uniform Fire Code to ignitive and reactive materials. All ignitive or reactive materials processed by WRAP 2A will be below the exempt amounts established in Article 80 of the Uniform Fire Code. The following discussion of Article 80 of the UFC is also limited to general requirements, and those for ignitive and reactive materials. The general requirements have been discussed solely for their value as good engineering practice.

2. Sec. 80.301: General
   a. 80.301 (a) 2

   Storage of hazardous materials, within any control area, in excess of exempt amounts specified in Sections 80.302 through 80.315 shall be in accordance with this division.

   A control area is an area whose boundaries are formed by one or more of the following: occupancy separations with a minimum of one-hour fire-resistive ratings, or the exterior wall, roof, or foundation of the building. In no case shall the number of control areas within a building exceed four (4). (Section 80.108 (b)).

   b. 80.301 (a) 3 D

   Separation of incompatible hazardous materials shall be in accordance with Section 80.301(n).

   c. 80.301 (l)

   Unless exempted or otherwise provided in Sections 80.302 through 80.315, rooms, buildings, or areas used for the storage of solid and liquid hazardous materials shall be provided with a means to control spillage and to contain or drain off spillage and fire protection water. This includes providing a minimum 4" sill to prevent flow of liquids to adjacent areas, and designing the area to provide secondary containment.

   Secondary containment must contain the largest single spill, plus 20 minutes of fire flow.

   d. 80.301 (p)

   Indoor storage areas and buildings must be provided with an automatic sprinkler system, designed for Ordinary Hazard Group 3 with a minimum of 3000 sq. ft. design area (0.18 gpm/sf). Note: This is more stringent than the SDRD requirement to comply with NFPA 13, Ordinary Hazard Group 2 (0.17 gpm/sf). Also note, Ord. Hazard 3 no longer exists in NFPA 13.

   e. 80.301 (q)

   Unless exempted or otherwise provided for in Sections 80.302 through 80.315, indoor storage areas of hazardous materials shall be provided with explosion control.

TABLE 3
WRAP 2A WASTE COMPONENTS
SUMMARY OF LISTED COMPONENTS & CHARACTERISTICS

Basis: WHC-SD-W100-RD-001, Waste Receiving and Processing Module 2A Feedstream Specification, Rev. 0; WHC-SD-W306-TI-001, Radiological and Chemical Source Terms for Solid Waste Operations Complex, Rev. 0

WASTE COMPONENT	COMMENTS	NFPA 49/325M HAZARD DESIGNATION				UFC ART. 80 SECTION	UFC EXEMPT AMOUNTS (STORAGE)
		H	F	R	O		
Ammonia	Irritant, explosive in confined areas, moderate fire and explosion hazard when exposed to heat or flame.	3	1	0	-	N/A	N/A
Ammonium Nitrate	Irritant, powerful oxidizer which supports combustion, explosive hazard if heated in confinement.	2	0	3	a	80.306 80.309	500 lbs 10 lbs
Acetone	Vapor is a fire and explosion hazard, Class 1B flammable liquid	1	3	0	-	N/A	N/A
Beryllium	Moderate fire hazard, can be explosive in dust form, emits toxic fumes (oxide of beryllium)	4	1	0	-	N/A	N/A
Cadmium	Weak fire and explosive hazard, will burn with toxic fumes	?	?	?	b	80.308	4 lbs
Manganese	Flammable and moderately explosive (dust or powder).	3	2	1	-	80.309	"unlited"
Mercury	Toxic, nonflammable, emits toxic fumes when exposed to fire.	3	0	0	-	N/A	N/A
Nirtric Acid	Noncombustible, but is an oxidizer.	3	0	0	a	80.306	500 lbs
Phosphoric Acid	Noncombustible, contact with metals may liberate hydrogen gas.	2	0	0	-	N/A	N/A
Sodium Hydroxide	DO NOT USE WATER ON SODIUM HYDROXIDE FIRES	3	0	1	c	80.309	"unlimited"
Sodium Oxide	Strong oxidizing agent which greatly supports combustion.	3	0	2	a	80.306 80.309	20 lbs 100 lbs
Uranyl Nitrate Hexahydrate	UNKNOWN	?	?	?	?	UNKNOWN	UNKNOWN
Zirconium	May be pyrophoric, powder is very susceptible to ignition by static electricity	1	4	1	b	80.308 80.309	4 lbs "unlimited"

NOTES:

1. All exempt quantities are based on the building being fully sprinklered, and assume the hazardous material is not within a storage cabinet.
2. The NFPA Hazard Designations are as follows: H = Health
   F = Flammability
   R = Reactive
   O = Other hazard, where: a = Oxidizer
   b = Pyrophoric
   c = Water reactive, do not use water on fire.

TABLE 4
WRAP 2A PROCESS AGENTS
SUMMARY OF COMPONENTS & CHARACTERISTICS

Basis: MSDS for OPC, vendor data and industry information for other agents.

PROCESS	POLY. AGENT	HAZARDS AND CHARACTERISTICS	UFC ART. 80 SECTION	UFC EXEMPT AMOUNTS
Polyethylene Encapsulation	Low density polyethylene	Per study by Hughes Assoc for Rocky Flats, polyethylene melts to become a flammable fluid; no data available on flash point; treat as a Class A combustible solid and a Class IIIB combustible liquid.	N/A	N/A
Grouting	Ordinary Portland Cement (OPC)	Class 2 health and Class 1 reactive hazard (NFPA designations). Noncombustible.	80.309	"unlimited"
	Blast Furnace Slag (BFS)	No data found, assume similar to OPC.		
	Pulverized Fly Ash (PFA)	No data found, assume similar to OPC.		

3. Section 80.305: Flammable Solids

a. Flammable solids include organic solids (eg, cellulose nitrate), inorganic solids (eg, potassium sulfide, and sulfur), combustible metals (eg, zirconium, magnesium and cesium), and combustible dusts and powders, including metals (eg, sawdust, plastics, and most powdered metals).

b. Amounts of flammable solids in excess of the exempt amounts, in any one control area, mandate an H3 occupancy for the room or building affected. NOTE: Combustible dusts (see above), which are not present in the WRAP 2A facility, are not considered here.

c. The plastics which will be present (eg, polyethylene) will not be present in the form of dust, but rather are larger "beads", and are thus not considered a hazard in this category.

d. The flammable metals which will be present (eg, zirconium) are assumed to be present only in large particles, and not in the form of dusts. The flammable hazard is thus considered to be negligible.

4. Section 80.306: Liquid and Solid Oxidizers

a. Oxidizers include the following: Gases such as oxygen and oxides of fluorine and chlorine; liquids such as bromine, hydrogen peroxide, nitric acid, and sulfuric acid; and solids such as chlorates, iodine, nitrates, nitrites, perchlorates, and peroxides.

b. Exempt amounts vary, based on the class of the oxidizer. If the exempt amounts are exceeded, the hazardous occupancy becomes as follows: Class 4 - H1; Class 3 - H2; and Class 2 and 1 - H3.

c. Smoke and heat venting is required when the amounts of oxidizers exceed the exempt amounts; explosion control is required only for Class 4 oxidizers in excess of the exempt amounts.

d. Oxidizers are potentially present in the waste streams (ammonium nitrate and sodium oxide) in quantities in excess of the UFC Article 80 exempt amounts. However, the plant has been designed with the understanding that such materials will not be present in the building in amounts exceeding the exempt amounts at any one time. The requirements of this section therefore do not apply.

6. Section 80.308: Pyrophoric Materials

a. Pyrophoric materials include the following: Gases such as diborane and silane; liquids such as diethyl aluminum chloride and triethyl boron; and solids such as lithium, plutonium, potassium, sodium and thorium.

b. Amounts over the exempt amount require building construction to comply with requirements for H2 or H3 occupancies for gases or solids and liquids, respectively.

c. The pyrophoric metals which will be present (eg, zirconium) are assumed to be present only in large particles, and not in the form of dusts. The pyrophoric hazard is thus considered to be negligible.

7. Section 80.309: Unstable (Reactive) Materials

a. Unstable materials range from those which become unstable at elevated temperatures and pressures to those readily capable of detonation or explosion at normal temperatures and pressures. Unstable materials include sodium perchlorate and styrene.

b. Hazardous occupancies, if exempt amounts are exceeded, are as follows: Class 4 - H1; Class 3 (detonatable) - H1; Class 3 (non-detonatable) - H2; Class 2 - H3; and Class 1 (gas) - H3. Smoke and heat venting are required, as is secondary containment, and liquid tight floors, if the exempt amounts are exceeded.

c. Reactives are potentially present in the waste streams (ammonium nitrate and sodium oxide) in quantities in excess of the UFC Article 80 exempt amounts. However, the plant has been designed with the understanding that such materials will not be present in the building in amounts exceeding the exempt amounts at any one time. The requirements of this section therefore do not apply.

4.5 Other Flammable and Combustible Materials, and Hazards

1. In addition to the waste streams and process agents identified above and in the accompanying tables, there are numerous "normal" combustibles to be found throughout the facility.

These "normal" combustibles include Class A materials, such as paper and rags, which are found in every business and industrial occupancy. These materials will not determine the occupancy classification, or the construction type, of the facility. They are thus not considered in this preliminary assessment, even though they may contribute greatly to the total fire load in the facility.

2. Some floor and wall finishes will also be combustible, and will need to be evaluated for the final fire hazard analysis. However, like the Class A combustibles just discussed, these finishes will not determine the occupancy of the facility, and are therefore not considered in detail in this assessment. The potential for foam insulation in wall and roof panels to add to the combustible loading for any fire will be addressed in the Title I FHA.

3. The polyethylene beads used in the PE encapsulation process are most likely the largest "non-hazardous" (ie, not listed in UFC Art. 80) combustible material. There are no unusual fire or explosion hazards associated with polyethylene, and no NPFA hazardous material designations. PE will release combustible gases at temperatures in excess of 572 °F. and may release hazardous decomposition products, depending on the temperature and other materials present. Complete combustion results in only carbon dioxide and water.

The melting temperature of PE is given as approximately 250 °F. No flash point is established, however, it must be above the melting temperature. The melted PE can thus be considered a Class III-B combustible liquid.

4. The decontamination agents anticipated to be used in the WRAP 2A facility are "everyday detergents". Due to the low anticipated radiation levels, agents such as caustic, and nitric or oxalic acids, are not likely to be required. Solvents (as yet not identified) will be present, infrequently and in small quantities, only during maintenance periods. It is assumed that appropriate administrative controls, and maintenance procedures (eg, fire watches) will be established as required.

4.6 Building Occupancies

1. Given the understanding that there are no ignitive or reactive materials present at any one time in excess of the UFC/UBC exempt amounts, the facility does not need to be classified per the UBC.

2. The NFPA 101, "Life Safety Code", classification for the entire facility, including the administrative portions of the building, is "Special Industrial". Special Industrial facilities are covered in Chapter 28 of NFPA 101.

4.7 Building Implications

1. There are no special requirements in NFPA 101, Chapter 28, for the type of building construction.

4.8 Other Issues

1. Filter Plenums (DOE Filter Plenum Fire Protection Standard, March 1993, DRAFT REV. 4).

a. REQUIREMENTS: Listed 1-1/2 hour fire rated dampers are required in ducting which is not required to continuously operate as a part of the confinement system, and which penetrate 2 hour fire rated construction. Ref: Paragraph 6.2.1.

Fire dampers shall not be utilized in ducting which penetrates fire rated construction when the ducting is an integral part of a nuclear air filter system required to operate continuously as part of the confinement system. Such ducting shall be made part of the fire rated construction (eg, by enclosing the duct) or shall be qualified by engineering analysis to be 2 hour fire rated. Ref: Paragraph 6.2.3.

Fixed combustible gas analyzers should be provided in final filter enclosures which are subject to receiving flammable or combustible gases or vapors. Ref: Paragraph 7.3.

Prefilters, duct entrance filters, and fire screens are required. The prefilters can be located anywhere in the exhaust system, at least 36" upstream from the final HEPA filter. Ref: Paragraph 8.1.1 and 8.1.3.

Fire screens must be located upstream from prefilters and final filter plenums. Ref: Paragraph 8.2.

Heat detectors or pilot sprinkler heads shall be provided in the ducting prior to final filter plenums, and in the final filter plenums. Ref: Paragraph 9.2.1 and 9.2.2.

"Automatic and manual water deluge spray systems shall be provided inside all final filter plenums for protection of the filters where plenum filters have a leading filter surface area greater than 16 square feet." Ref: Paragraph 10.1.1.

Install a demister in the final filter plenum, if a prefilter is not provided. Ref: Paragraph 10.2.1

Install a ventilation air cooling system if normal operating temperatures are expected to exceed 200 °F. Ref: Paragraph 11.3.1.

Install lighting in the final filter plenum, in front or between filter banks where automatic sprinkler heads are located. Ref: Paragraph 11.5.1.

b. IMPACTS ON DESIGN: Fire dampers, <u>or</u> "rated construction of ducts" will be required where ducts penetrate 2 hour fire rated construction.

Gas analyzers may be required in the final filter plenum.

Heat detectors will be required in all ducting prior to final filter plenums, and in final filter plenums.

Deluge systems will be required inside at least some of the final filter plenums. Prefilters may be required in the final filter plenum; if prefilters are not provided, demisters will be required in plenums protected by deluge systems.

An air cooling system may be required.

Lighting will be required in at least some of the final plenums.

c. IMPLICATIONS: Ducting needs to be designed to incorporate the fire dampers and/or rated construction. An engineering analysis may be required to justify construction features of the ducting.

A means of draining, containing, and handling contaminated deluge system water must be provided.

An analysis of the ventilation system operations must be conducted to determine the normal expected operating temperatures and if cooling of the air stream is required.

2. Shredding Operations

a. PROBLEM: The process involves shredding drums (and contents) in both the Shred and Direct Repack line and the Special Waste Processing/Repack line. Shredding of drums, by its very nature, potentially produces sparks, heat and friction.

b. IMPLICATIONS: Due to the potential for small amounts of VOC's, flammable liquids, and flammable metals (eg, zirconium) the shredding operations are judged to be a highly hazardous area, and a likely point of origin for fires.

c. IMPACTS ON DESIGN: The fire potential in the shredder area will require careful design of an extinguishing system, including an assessment of the impacts of dry chemical agent (or other suppressant) on the shredding equipment.

A means of inerting, containing, or safely venting a potential explosion may be required. Since confinement is a key safety issue, it is judged to be unacceptable to vent an explosion. The remaining alternate is to inert the process equipment lines whenever shredding operations are occurring, or to provide extremely fast acting explosion suppression systems.

3. Encapsulation Process

a. CONCERN: The temperatures involved in the PE encapsulation process are on the order of 300 to 350 °F (extruder), to 450 °F (macro encapsulation). This could exceed the ignition or flash temperature of some components of the waste. This could result in ignition of waste during the encapsulation process, which would then involve the PE material in the fire.

PE produces toxic and irritating fumes during burning. This will require self-contained breathing apparatus for emergency personnel, and may require additional mechanical ventilation equipment to remove vapors. PE needs to be at temperatures over 572 °F before combustible gases are released. It is assumed that no toxic or irritating gases are released until at least this temperature, either. It is therefore considered that off-gassing of the PE does not pose a hazard.

A fire within an item of process equipment may not be adequately protected against by the process area fire protection systems.

b. IMPLICATIONS: Additional means of fire detection/protection may be required in the process equipment. Additional ventilation may be required to prevent accumulation of combustible, toxic, or irritating gases. Process controls may be able to mitigate this potential situation.

4. Building Shell

a. REQUIREMENT: DOE 6430.1A, Section 0111-99.0.1 contains the requirement that "In no case shall the total combustible loading located in a fire area exceed the fire resistance rating of the area enclosure. This shall be documented in a fire risk analysis."

b. IMPLICATION: This Section has been specifically invoked by the FDC, para. 5.2.1. This implies, at least, that the building shell (and any internal fire areas) must be rated for fire resistance, and that the rating must be substantiated in the FHA.

c. IMPACT: Section 1161-2 of DOE 6430.1A also addresses this issue. RE&C has submitted a deviation request to these two sections to Mr. A. W. Kellogg at the Richland Operations Office of DOE (Reference letter UDL0437.007, dated Sept. 7, 1993). This deviation request is for the WRAP Module 1 project. At the time of this report, it is assumed that the deviation request will be approved. Approval of this request will establish a precedent for using non-rated building construction in non-reactor nuclear facilities. If the WRAP 2A FHA to be performed in Title I design so indicates (i.e. the MPFL limits are exceeded), UE&C will submit a similar deviation request. This request, if required, will be issued as early in Title Design as possible.

4.9 FHA Approach

1. The approach taken to the FHA to be performed in Title I and Title 2 design is based on the directives contained in DOE Order 5480.7A, issued 2-17-93.

a. The FHA will take the form of a narrative document, with tables, figures, mathematical analyses, and other reports attached to the FHA as required to support the document.

b. The overall format and content will be similar to the Final Fire Hazards Analysis produced for WRAP Module 1.

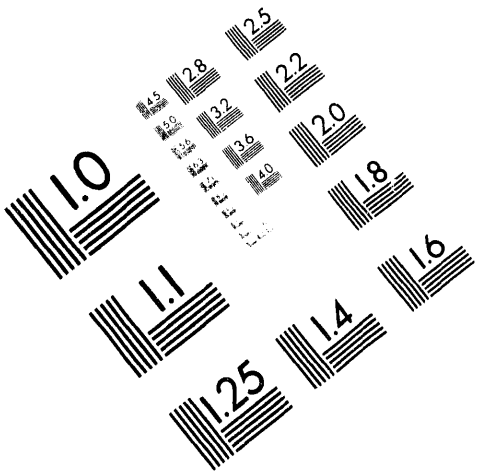
c. The 15 elements of a fire hazards analysis identified in paragraph 9.a.(3) of DOE 5480.7A will each be addressed.

d. Damage potential (for both the maximum credible fire loss and the maximum possible fire loss) will be based upon a mutually agreeable definition.

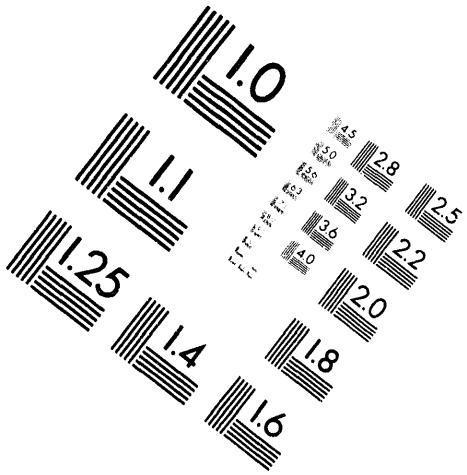
It is proposed that the maximum credible fire loss (MCFL) be based upon the <u>greatest total</u> value of equipment contained within any design area of the sprinkler system.

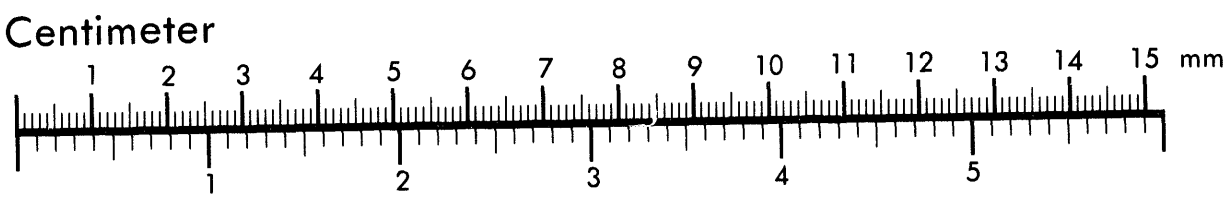
It is also proposed that the maximum possible fire loss (MPFL) be based upon the total value of the equipment, and structure within a fire area, where a fire area is bound by fire-resistance construction (walls, floor, and ceiling, as appropriate) with fire-resistance ratings of 3 hours. For the "first pass" at the MPFL, the entire facility will be considered to be a single fire area. <u>If</u> the MPFL exceeds $150M (DOE 5480.7A), the facility will be subdivided into fire areas as required to limit the MPFL in any single area to less than $150M.

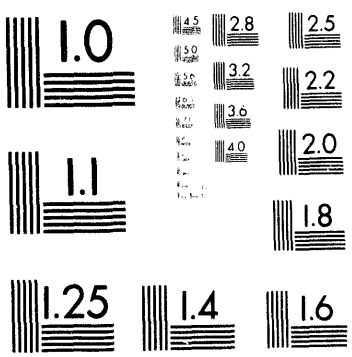
e. The MPFL and MCFL values will include the additional costs of demolition, decontamination, disposal, salvage, and restart.

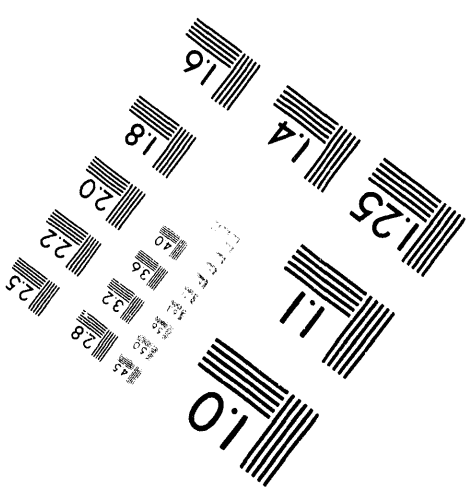


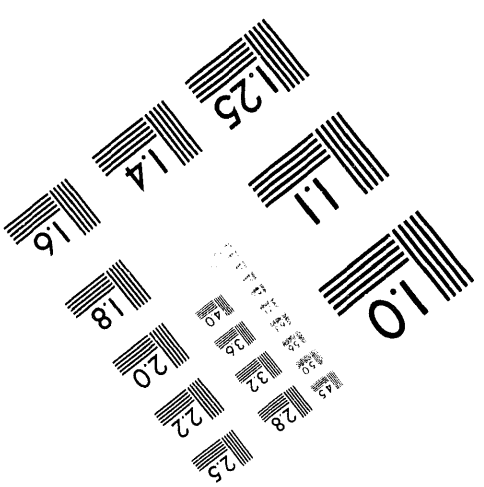
Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202











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BY APPLIED IMAGE, INC.

f. DOE Order 5480.7A allows, but does not mandate, the use of fire models. The difficulty of determining a complete description of a design basis fire (DBF) (ie, fire growth rate, peak rate of heat release, quantity of fuel, etc), and of "bounding" a maximum possible fire, make the use of a fire model of questionable value for the WRAP 2A facility. The lack of applicable data re fire characteristics of the waste, and the behavior of waste in drums and containers, increases the difficulty of modeling the fire.

g. The dollar limits of DOE 5480.7A re MPFL's and the need for 3 hour fire barriers will be used; ie, if the MPFL exceeds $150 million, then redundant fire protection and 3 hour fire barriers between fire zones will be utilized. If 3 hour barriers are required, then FM Data Sheet 1-22 (Maximum Foreseeable Loss Fire Walls) will be used.

i. A request for a formal interpretation will be required to determine if this facility is a "vital facility" or "vital program" as defined by DOE 6430.1A. A request for a determination of the maximum acceptable time out of service is also required.

j. The potential for fire to spread between fire areas, and from one piece of equipment to another will be assessed based on physical separations, and rating of fire barriers, if any. The assessment will probably not use a fire model, for the reasons discussed above. The assessment will necessarily involve an considerable amount of engineering judgement.

k. "Fuel packages" will be identified and "quantified" (ie, the amount of fuel present will be estimated) for the purpose of establishing building occupancies. These fuel packages will also be used in proposing one or more design basis fires. Fuel packages which consist of waste feed drums and product containers will be based on chemical source term data provided by WHC. Unless agreement can be reached on a modeling procedure, the fuel packages will not be utilized in a quantitative analysis of fire severity.

m. The DBF will assume the presence of an ignition source adequate to initiate combustion of the involved fuel package(s). The likelihood of ignition will not be assessed.

n. Fire areas will be established using estimates of all appropriate costs, and considering the function of each building area, and building layout. It is not possible to establish preliminary fire areas without cost data, including the costs of demolition, decomination, disposal, salvage, and restart. Therefore, for the purposes of this report, the entire facility is considered a single fire area.

2. Input from WHC will be required in order to prepare an acceptable and complete Fire Hazards Analysis. Required input includes, but is not limited to, the following items.

a. The definitions of "critical process equipment" and "high value property" (the 6th and 7th elements of an FHA listed in DOE 5487.7A) will be jointly developed and agreed upon by WHC and RE&C.

b. Input from WHC is required to develop the costs of demolition, decontamination, disposal, salvage, and restart for both the MCFL and MPFL.

c. If a fire model is to be utilized for any purpose, including assessment of HVAC duct design, early and complete agreement re the "details" of a DBF must be achieved between all involved parties. This requires WHC input re the fire characteristics of the waste forms (eg, peak rate of heat release, growth and decay coefficients, fuel quantities). It is proposed that a meeting between the Raytheon Engineers and Constructors fire protection engineer, and WHC fire protection engineer(s) take place prior to the start of Title design to establish the approach to be taken for all fire modeling. In addition, periodic meetings to review the modelling results should be held.

d. WHC input is required re the fire department response; potential for a toxic, biological, or radiation incident; emergency planning; and security consideration elements of the FHA.

4.10 Design Basis Fire(s)

1. One possible DBF can be found in a study (**REFERENCES** 5.4 #1) done by Hughes Associates for EG&G Rocky Flats Plant, Inc. in 1990. This study determined that the primary fire hazard associated with the polyethylene encapsulation process being considered is related to the storage and use of the raw PE material.

The DBF proposed by Hughes Associates assumes that the PE melts and becomes involved in a pool fire. The study assumes the presence of an adequate ignition source, and does not attempt to assess the likelihood of ignition.

One scenario involves a fire starting within the extruder, due to the hot (melted) PE igniting a combustible substance within the waste stream.

2. Work done for the Center for Explosives Technology Research (**REFERENCES** 5.4 #2) indicates that the PE encapsulated waste does not present a fire or explosion hazard in the absence of other combustible materials.

Based on this study, it is believed that a DBF will not originate in the processed waste box area. The contents of the processed waste boxes may, however, require consideration as a potential fuel for the DBF, MCFL, and/or MPFL.

This is a consideration primarily for the WHC input to the FHA re the potential of a toxic, biological or radiation incident; and the resultant demolition, decontamination, disposal, salvage, and restart costs.

3. Other potential DBFs can be developed based on the VOCs (and other wastes) present in the process equipment etc.

As discussed previously, an area of high potential for a fire involves the shredding operations. This scenario could become a DBF for the processing area.

4.11 Clarifications

1. Clarification has been received on the definition of "redundant fire protection system"; the Hanford Fire Department is a redundant system when combined with automatic fire detection.

5.0 REFERENCES

5.1 DOE Orders and Documents

1. DOE 6430.1A, General Design Criteria, 4-6-89

2. DOE 5480.7A, Fire Protection, 2-17-93

3. DOE Filter Plenum Fire Protection Standard, Mar 1993, DRAFT REV. 4

4. DOE Fire Protection Resource Manual

5.2 NFPA Documents

1. NFPA 49 - 1991, Hazardous Chemicals Data

2. NFPA 325M - 1991, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids

5.3 Building and Fire Codes

1. Uniform Building Code, 1991

2. Uniform Fire Code, 1991

5.4 Other Studies, etc.

1. Hazard Analysis Study of Polyethylene Usage in Building 374 and Alternative Locations; Hughes Associates, Inc; Sept. 27, 1990

2. CETR Report FR-91-02; Polyethylene Waste Form Evaluation of Explosion and Fire Hazards; Block-Bolten, Olsen Persson, and Sandstrom; June 8, 1991

3. Telecon, D. W. Chapin (UE&C/BNFL) to R. M. Horgos (WHC), dated 12/09/93, re WRAP 2A DECON CHEMICALS.

4. ASTM Standard C 150 - 92, Standard Specification for Portland Cement

5. PFA Bulletin, PFA in Grouts, published by Ash Marketing, Central Electricity Generating Board, London, England

6. Cement Wasteform Properties, by D. J. Lee, Atomic Energy Establishment, Dorchester, England, and C. R. Wilding, Harwell Laboratory, Oxfordshire, England

5.5 Material Safety Data Sheets

1. Ammonia
2. Ammonium Nitrate
3. Acetone
4. Beryllium
5. Cadmium
6. Manganese
7. Mercury
8. Nitric Acid
9. Phosphoric Acid
10. Sodium Hydroxide
11. Sodium Oxide
12. Zirconium
13. Polyethylene

5.6 Design Criteria

1. Functional Design Criteria, WHC-SD-W100-FDC-001, Rev. 2D

2. Supplemental Design Requirements Document, WHC-SD-W100-SDRD-001, Rev. A

3. Waste Receiving and Processing Module 2A Feed Specification, WHC-SD-W100-RD-001, Rev. 0

4. Radiological and Chemical Source Terms for Solid Waste Operations Complex, WHC-SD-W306-TI-001, Rev. 0

WASTE RECEIVING AND PROCESSING FACILITY

TITLE: WRAP 2A ACDR PRELIMINARY NEC CLASSIFICATION ASSESSMENT

Rev. 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A **Raytheon** Company
Western Operations

WRAP 2A ACDR NEC CLASSIFICATION ASSESSMENT

Prepared by: _____ Date: 1/10/94
Electrical Engineer

Reviewed by: _____ Date: 1/10/94
Senior Engineer

Approved by: _____ Date: 1/10/94
Engineering Manager

Approved by: _____ Date: 1/10/94
Project Manager

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ATTACHMENT A WRAP 2A PROCESS FLOW DIAGRAM

ATTACHMENT B DRAWING SK-E1 HAZARDOUS LOCATION AREA PLAN REVISION A

1.0 OBJECTIVE

1.1 Background

1. WRAP 2A will process waste forms that contain minimal volatile organic compounds (VOCs) and encapsulate them in either a polymer or grout. Even though the quantities of VOCs to be processed are expected to be minimal (less than the amount required to form an ignitable mixture) all areas, equipment and materials involved in processing these wastes need to be assessed prior to the start of Title Design.

1.2 Purpose

1. The purpose of this assessment is to review the WRAP 2A process areas and processes to determine which areas, processes and enclosures may require being designated NEC Hazardous (classified) locations and to determine what additional information will be required to perform a detailed evaluation during Title design of the facility. This is a preliminary assessment and detailed calculations to determine the exact extent of the hazard, hazardous boundaries, concentrations (LEL & HEL) and the exact electrical hazardous classifications were not performed.

2.0 PROCEDURE

2.1 Pertinent Documents

1. Waste Receiving and Processing Module 2A Feed Specification (WHC-SD-W100-RD-001, Revision 0). This document was used to determine which feedstreams contained VOCs. Some of the feedstreams specifications indicate that the actual concentration for many of the constituents is expected to be small or non-detectable. However, it should be understood that these statements are based upon average amounts expected to be encountered.

2. Radiological and Chemical Source Terms for Solid Waste Operations Complex (WHC-SD-W306-TI-001 Revision 0), section 4.4 W-100 Chemical Source Term Assumptions, provides a list of "hazardous" chemicals with average and maximum expected quantities, by weight. Ammonia, Acetone, Beryllium and Zirconium metal are the four chemicals which stand-out as hazards for this assessment. Acetone is the "worst" chemical listed due to its volatility even with small amounts. The average quantity per feed and product drum is 0.0KG; however, the maximum per feed drum is 3.0 KG and the maximum per product drum is 1.5 KG. This implies that the majority of feed drums and product drums will not contain any acetone, but that a few feed drums may contain significant amounts of acetone which will be processed through the system and end up in the product drums (see Assumption 2.2.2).

2.2 Assumptions

1. The following assumptions are the basis for the NEC Classification assessment. These assumptions are based upon the current design, operational procedures/philosophies and pertinent documents.

2. The two waste feedstream documents which form a part of the basis for this assessment are the WRAP 2A Feed Specification (WHC-W100-RD-001, Revision 0), and the Radiological and Chemical Source Terms for Solid Waste Operations Complex (WHC-SD-W306-TI-001, Revision 0). There is a basic contradiction between these two documents which must be resolved prior to detailed hazard evaluation during Title Design. The Feed Specification (section 6.1) states:

   None of the D001 wastes intended for treatment at WRAP Module 2A will be in the three D001 subcategories for ignitable liquids (i.e., none of the waste intended for treatment at WRAP 2A will have a flash point < 140°F).

   The only water-reactive substances intended for treatment in WRAP Module 2A will be strong acids and bases...

   Although WRAP Module 2A is not intended to treat wastes such as oils, solvents and alkali metals, it is expected that small quantities of these types of materials may occasionally be "discovered" during waste sorting. Upon discovery, such waste will be repackaged and returned from WRAP Module 2A to storage.

   This general waste description is also supported by individual waste characterizations found in the Feed Specification. For example, feed stream 2A lists F003 (acetone, butyl alcohol, methylisobutyl ketone). However it is also stated:

   Listed codes are by the derived-from rule; most constituents are expected to be non-detectable.

   The Source Term document includes a list of materials which should be assumed to be present in any waste feedstream to be processed in WRAP Module 2A as a bounding case. This document lists ammonia, acetone, beryllium and zirconium as potentially being present in both the waste feed and the treated product from WRAP 2A. This implies that these materials may not be removed, repackaged and returned to storage, but instead processed through the facility. The quantities of these materials listed in this document are:

Chemical	Max. Feed Drum, Kg	Max. Product Drum,kg
Ammonia	0.45	0.2
Acetone	3.0	1.5
Beryllium	7.0	3.5
Zirconium	0.9	0.5

   This implies that significant quantities of these materials may be present throughout the WRAP 2A facility and should be considered for the NEC classification assessment.

   For the purpose of this assessment, the waste characterization and operating philosophy stated in the Feed Specification was assumed. This is also consistent with statements made by WHC personnel. To summarize, it is assumed that volatile organic compounds (VOCs) with a flash point < 140°F or pyrophoric metals may potentially be present in waste feed to WRAP 2A. If such a waste is present in significant quantities, it will be detected and removed before the waste is processed through the facility. How this detection and removal is accomplished is discussed in the following paragraphs.

3. Drums previously characterized or determined through sampling to contain significant quantities of VOCs will not be processed in WRAP 2A. Waste feed lot verification sampling and analysis will be performed before a lot is accepted for processing in WRAP 2A.

4. If a vial or container of VOCs is found in a feed drum, it will be removed at the sorting tables in the Special Waste Processing and the Sludge and Particulate Processing areas. In the Debris Processing Area, the vial or container will either be removed from the sorting screen or fall through the screen and be caught in a repack drum. The repack drum will be sent to the Sludge and Particulate Processing Area where the container will be removed at the sorting table.

5. Due to the above procedures, no hazardous amounts of VOCs will reach the polyethylene (PE) polymer and grout solidification areas.

6. For Waste (Feed) Streams 2A and 2B which are processed through the dryer in the Sludge and Particulate Processing Line, the non-detectable or minimal amounts of VOCs will not form an ignitable mixture in the dryer, condenser or associated equipment.

7. Document WHC-SD-W306-TI-001 Rev. 0 lists Beryllium and Zirconium metal as being present in the feed drums. For the purpose of this assessment these items were considered to be in solid form, non-hazardous and non-pyrophoric.

2.3 Assessment

1. The following items were reviewed for VOCs and hazardous materials:

   a. Feedstreams

   b. Polymer (polyethylene) storage, processing and encapsulation

   c. Grout storage, processing and encapsulation

   d. Decontamination (decon) solutions

   e. Aqueous processes

2.3.1 Feedstreams

1. Feedstreams which contained VOCs were followed through their process steps and the areas involved. See **Table 1** and Attachment A (WRAP 2A Process Flow Diagram) for feedstreams and the areas involved.

2. Areas which may be classified as hazardous locations were then identified.

3. The feedstreams and processes were reviewed per the following criteria:

   a. Contents of the feedstream.

   b. Expected operational procedures.

c. NFPA 30-1990
NFPA 325M-1984
NFPA 70 - 1993 (NEC: Chapter 5)
NFPA 497A-1992
NFPA 497M - 1991

4. The results of the feedstream assessment are as follows:

a. All feedstreams, except for 2A and 2B, are processed at or below temperatures of 100°F. Therefore, only VOCs with a flash point below 100°F (NFPA 497M-1991, Table 2-3) were evaluated for this assessment. For feedstreams 2A and 2B which are processed through a dryer operating at 250°F, all VOCs with a flash point less than 250°F have been considered in this assessment.

b. Four feedstreams were identified as potentially having hazardous VOCs present (2A, 2B, 2C, 9B). These feedstreams and their VOCs are listed in **Table 1**.

c. Six handling and process areas were identified as areas which may be classified as NEC hazardous locations. These are shown on drawing SK-E1. Further evaluation of these areas will be required during Title Design to determine the exact hazardous classifications and classification boundaries. The areas are as follows:

1) Box Breakdown

2) Sample Management

3) Sludge and Particulate Processing.

4) Debris Processing (Debris and Repack Drum)

5) Special Waste Processing

6) Empty Drum Compaction

c. The polyethylene (PE) polymer and grout solidification areas are considered non-hazardous areas due to all VOCs having been removed from the feedstreams prior to arrival in these areas. All VOCs found in the feedstreams at the sorting table will be separated out, repacked, and returned to storage.

e. The cure storage area is non-hazardous because the VOCs will have been removed from the feedstream or diluted and encapsulated by the time they arrive in this area.

f. Final hazardous classification designation of the above areas will be dependent upon the final design of the process equipment, ventilation design, and amount of VOCs present. Based upon the information at presently available, the listed areas may have both Class I, Division I and Class I, Division 2 areas.

g. The general building areas outside the boundaries of the hazardous process areas are classified non-hazardous due to the VOCs being contained in sealed barrels

2.3.2 Polymer Storage, Processing and Encapsulation

1. The polymer used in the encapsulation process is polyethylene. The storage, processing and mixing of the polyethylene for encapsulation of other materials was reviewed per the following criteria:

   a. Expected operational procedures.

   b. NFPA 30-1990
      NFPA 325M-1984
      NFPA 70 - 1993 (NEC: Chapter 5)
      NFPA 497A-1992
      NFPA 497M - 1991

2. The results of the hazardous assessment are that no polymer storage, processes or encapsulation area/procedures require NEC classification.

2.3.3 Grout Storage, Processing and Encapsulation

1. The assessment of the grout storage, processing and encapsulation was the same as polymer storage, processing and encapsulation.

2. The results of the hazardous assessment are that no grout storage, processes or encapsulation area/procedures require NEC classification.

2.3.4 Decontamination (Decon) Solutions

1. The storage, handling and use of three decon solutions was reviewed per the following criteria:

   a. Contents of the decon solutions.

   b. Expected operational procedures.

   c. NFPA 30-1990
      NFPA 325M-1984
      NFPA 70 - 1993 (NEC: Chapter 5)
      NFPA 497A-1992
      NFPA 497M - 1991

TABLE 1

WRAP 2A ACDR
NEC ASSESSMENT - STREAM FLOW BY LOCATION

Feedstream	Where	Class 1, Div. 1 or 2, Group	What[1]
2A Ammonium Sulfate Sludge	Sample Mgmt. → Sludge & Part Processing → Polymer or Grout Solidification → Cure/Store	D	Acetone, Methyl Isobutyl Ketone (MIK), Pyridine, Methyl Ethyl Ketone (MEK), Butyl Alcohol, Cresylic Acid
2B Ion Exchange Resin	Sample Mgmt. → Sludge & Part Processing → Polymer or Grout Solidification → Cure/Store	D	Acetone, MIK, Pyridine, MEK, Butyl Alcohol, Cresylic Acid
2C Ferric Hydroxide Sludge	Sample Mgmt. → Sludge & Part Processing → Polymer or Grout Solidification → Cure/Store	D	Ammonia
9B Heterogeneous Solids/Debris	Sample Mgmt. or → Debris Processing → Grout Solidification → Cure/Store Box Breakdown	D	Acetone, Benzene, MEK, MIK, Pyridine, Toluene

[1] All chemicals listed, except for acetone, are expected to be present in minimal or non-detectable amounts. Acetone may appear in vials or containers.

2. The three decon solutions reviewed were:

   a. Caustic Solution (Sodium Hydroxide)

   b. Acidic Solution (Nitric or Oxalic Acid)

   c. Liquid Soap (Laundry Detergent)

3. The results of the hazardous assessment are that the storage, handling or use of decon solutions require no NEC classification.

2.3.5 Aqueous Processes

1. Aqueous processes such as process water, waste water streams and mixed liquid streams were reviewed with the following criteria:

   a. Contents of the aqueous streams.

   b. Expected operational procedures.

   c. NFPA 30-1990
      NFPA 325M-1984
      NFPA 70 - 1993 (NEC: Chapter 5)
      NFPA 497A-1992
      NFPA 497M - 1991

2. The results of the hazardous assessment are that no aqueous processes require NEC classification.

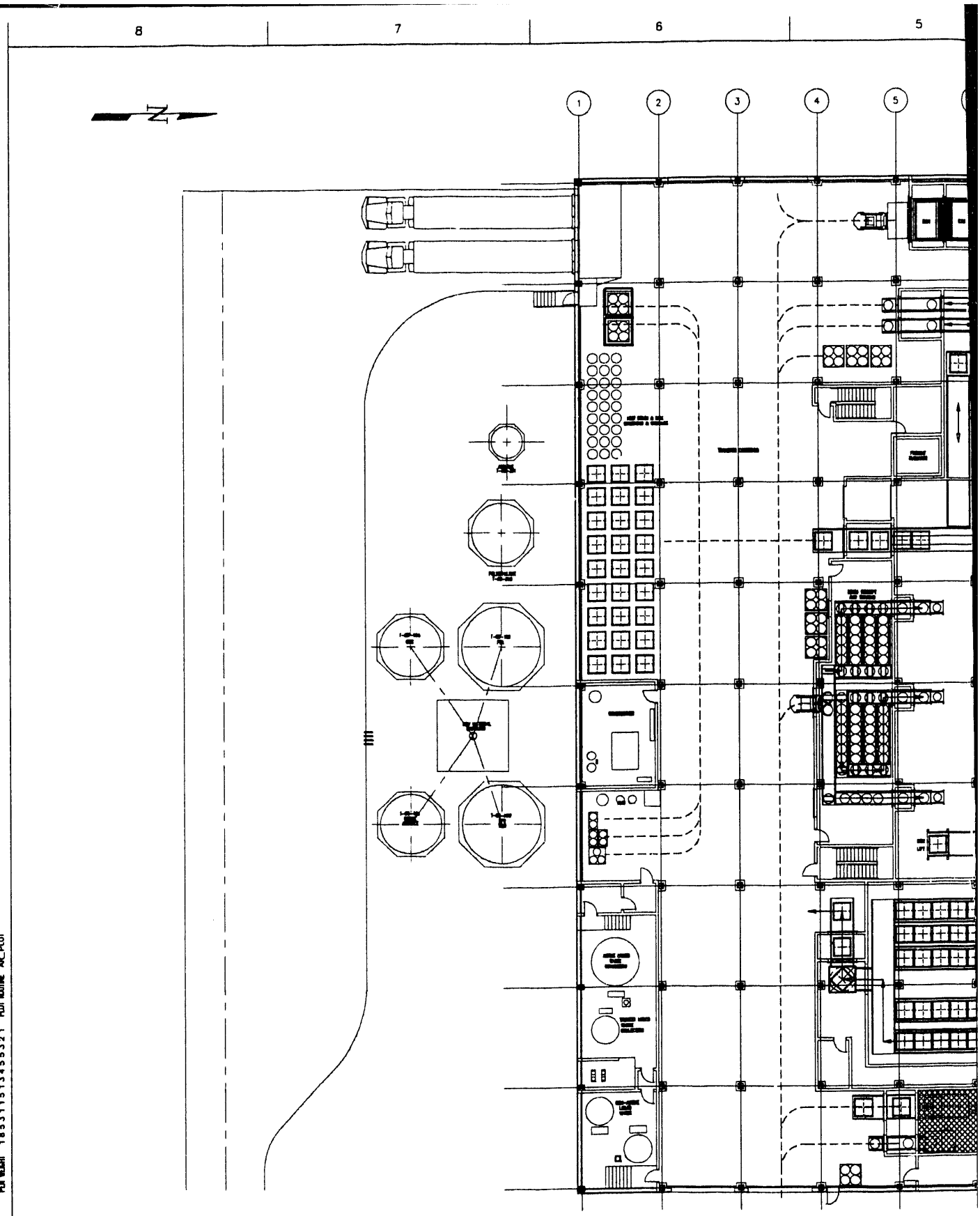
3.0 CONCLUSION

1. The hazardous areas identified by this assessment are depicted in the attached drawing SK-E1 Revision A.

2. Further evaluation of the identified hazardous areas will be required during the Title Design. These evaluations will allow for the exact classification of areas and equipment based upon detailed information about the quantities of VOCs involved, detailed design of the process areas, the type and quantity of ventilation provided and the ambient working temperatures in the process areas. The evaluation during Title Design should also include a study for the potential of mixing liquids that produce VOCs when combined, and the possibility of hydrogen being present in the cure storage area, due to chemical reactions during curing. Preliminary reports/tests indicate that hydrogen being off-gassed is not a problem. However, a more detailed review of this situation should be completed.

3. A matrixed identification of VOCs, by feedstream and quantities, needs to be supplied in the SDRD from WHC Hanford along with anticipated container sizes that may contain these VOCs early in Title design. This matrix will assist in classifying the areas, and the design of the electrical system.

4. The general areas not specifically addressed in this assessment are classified as non-hazardous.



PLAN

NOM. FIN. FLR. EL. 100'-0"

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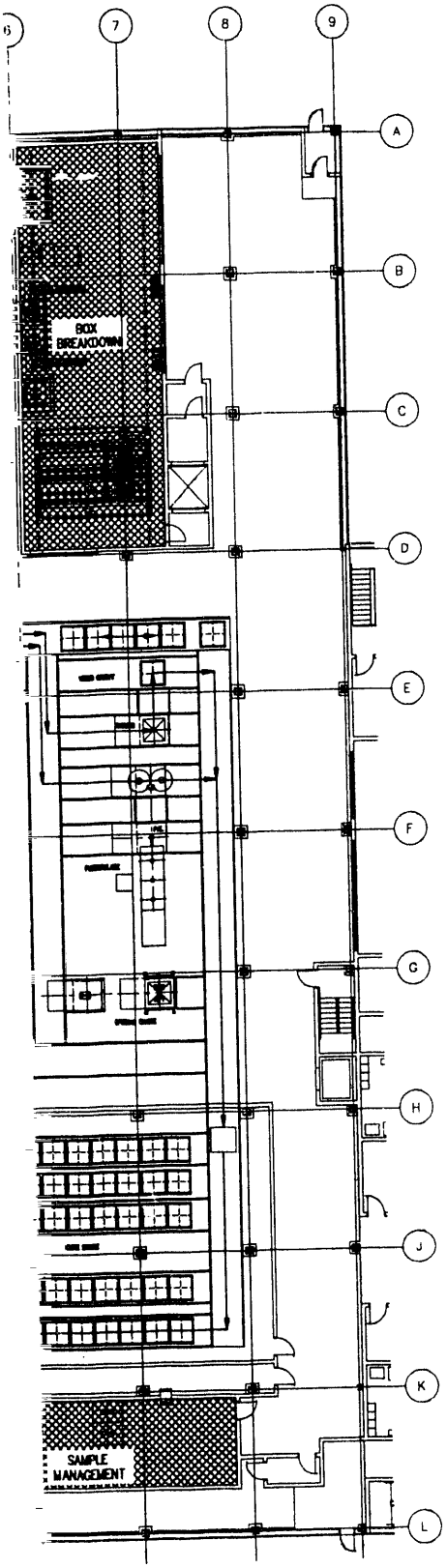
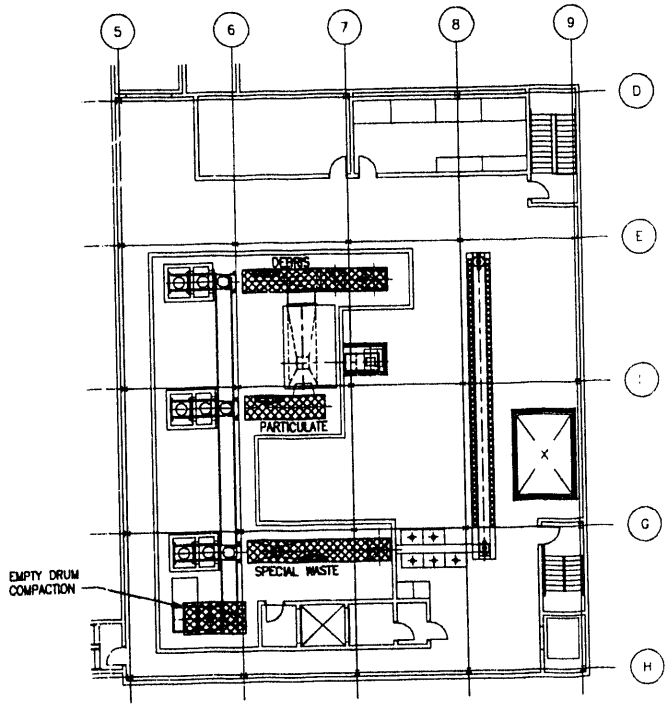
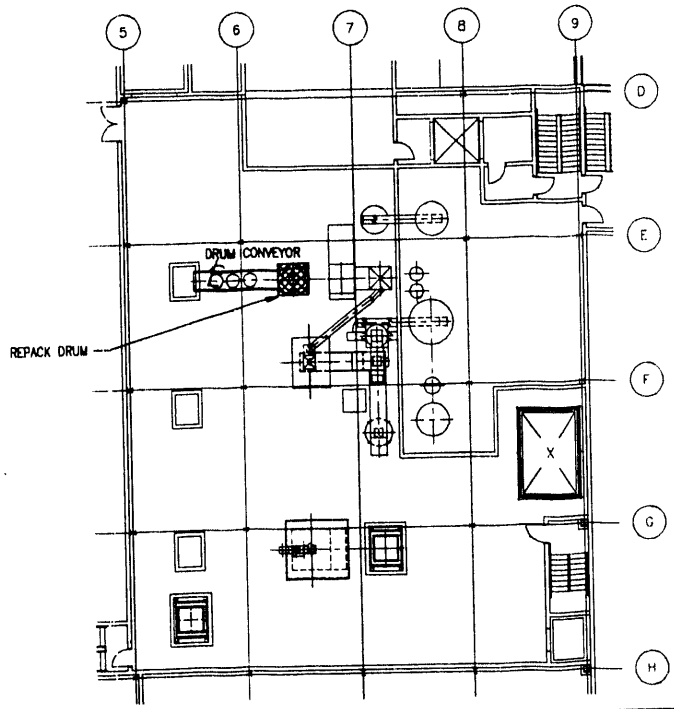




PLAN

UPPER LEVEL – OPERATING FLOOR



PLAN

MEZZANINE LEVEL – EQUIPMENT FLOOR

NOTES

1. GENERAL ARRANGEMENT (GA) LAYOUT IS NOT FINALIZED, BUT REPRESENTS PROCESS AREAS.

INDICATES PROBABLE AREAS OF DESIGN WHICH WILL REQUIRE ELECTRICAL HAZARDOUS CLASSIFICATION. (CLASS I, DIV 1 OR 2, GROUP D)

United Engineers & Constructors
A Raytheon Company

Western Operations

	BY	DATE
DESIGNED	C. PATCHIN	01-06-93
DRAWN	A. CALLENDER	01-07-94
CHECKED	G. CHAMBERS	01-07-94
LEAD ENGR		
ENG. MGR		
PROJ. MGR		
Q.A.		
OTHER		

APPROVED FOR DETAILED DESIGN
BY
FOR DATE

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
WESTINGHOUSE HANFORD COMPANY

WRAP 2A
ELECTRICAL–HAZARDOUS LOCATION AREA PLAN

SIZE	BLDG NO.	INDEX NO.	DRAWING NUMBER	REV
D	2337-W	8001	SK-E1	A

SCALE: 1/16"=1'-0" PROJECT NO. 6237.008 SHEET 1 OF 1

REV NO	DESCRIPTION	REV BY/DATE	CHK BY/DATE	APPROVALS/DATE
A	ACDR 90% ISSUE			

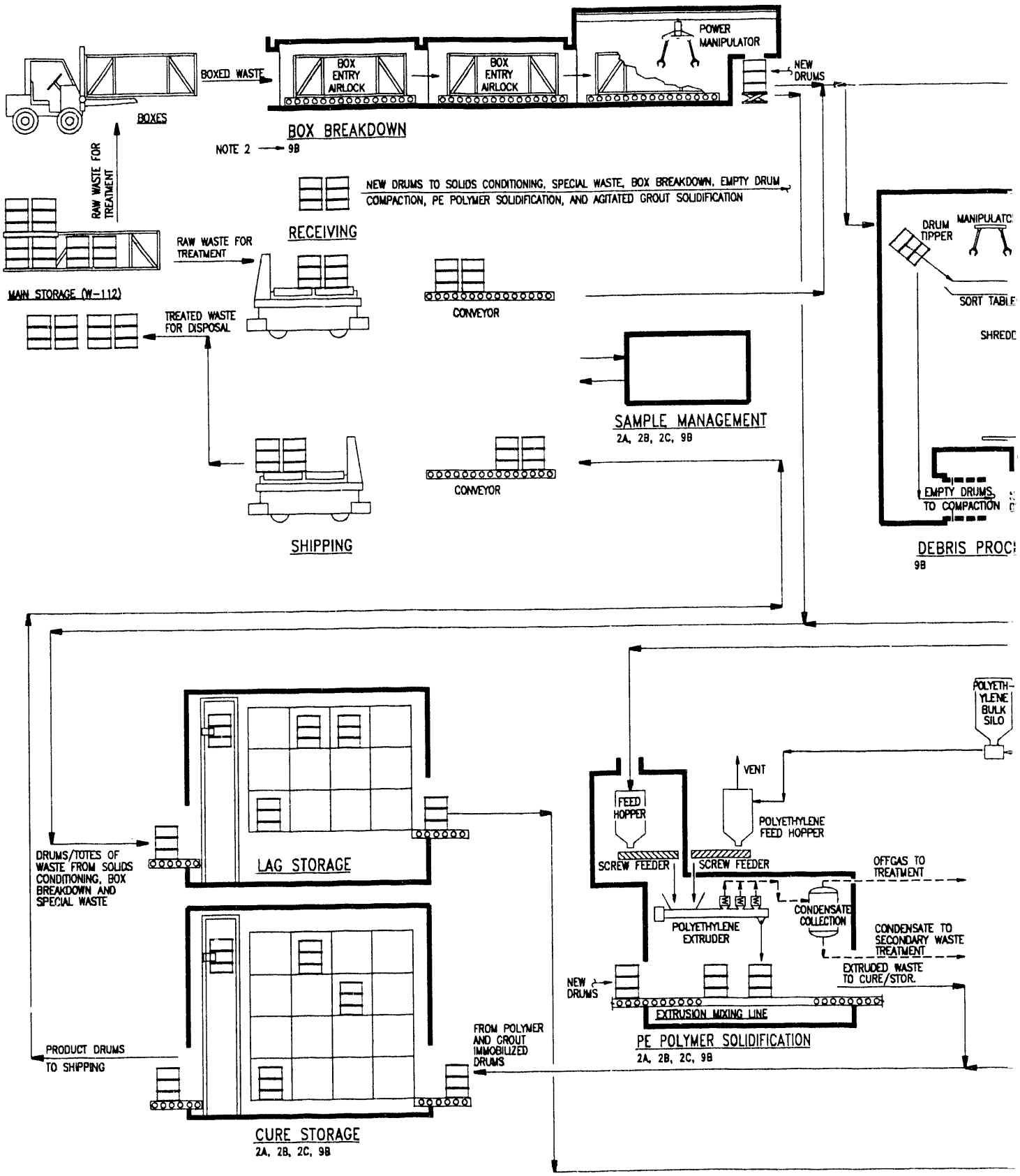
REVISIONS

FERENCE DRAWINGS
ONE

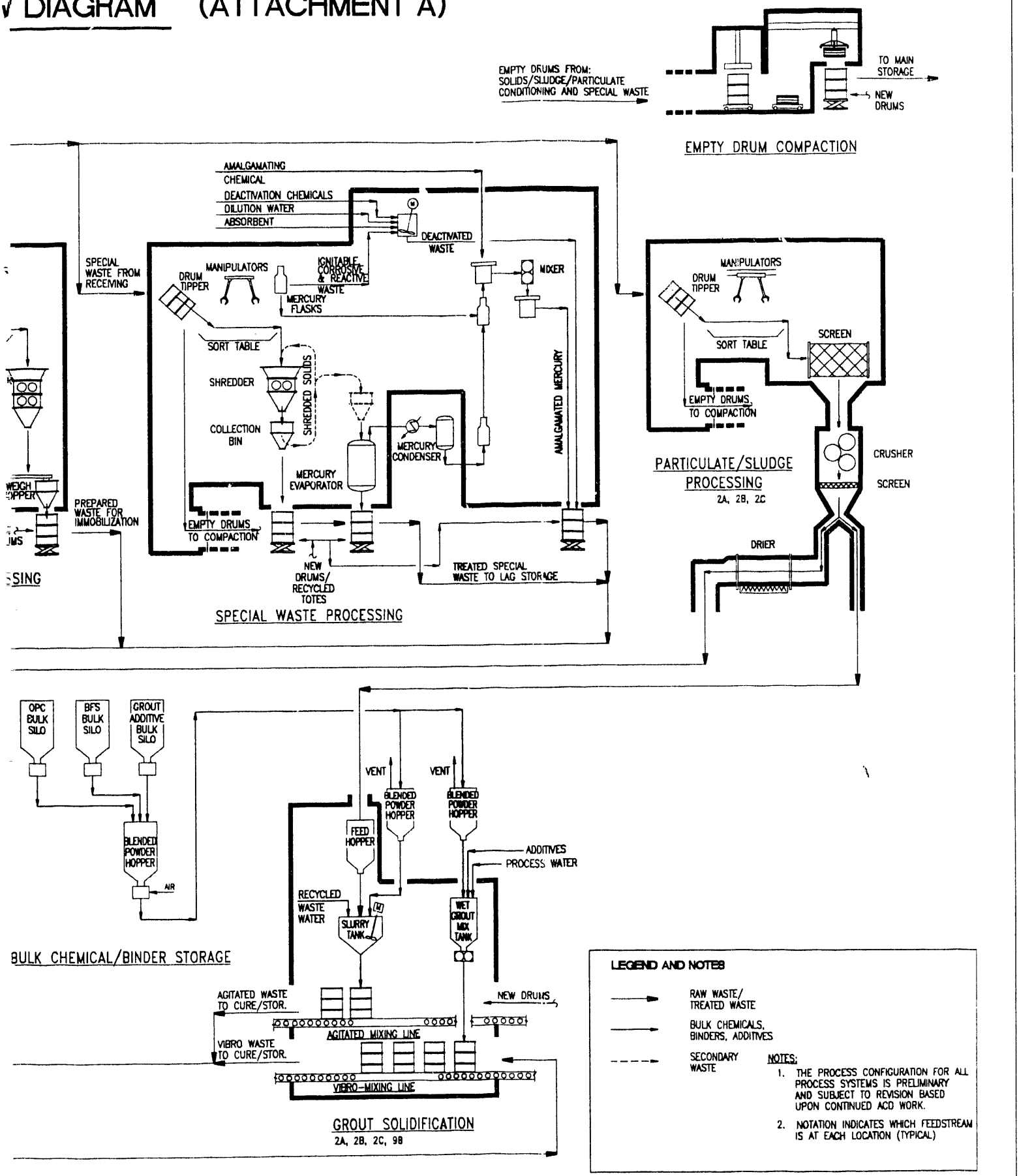
CADFILE: W2SKE1 CADCODE: 2C:IBM:ACD2:11:NN

COMPUTER GENERATED: NO MANUAL CHANGES ALLOWED

WRAP 2A PROCESS FLO



√ DIAGRAM (ATTACHMENT A)



WASTE RECEIVING AND PROCESSING FACILITY

TITLE: PRELIMINARY HVAC CONFINEMENT ASSESSMENT

Rev. 0

Submitted to:

UNITED STATES
DEPARTMENT OF ENERGY
Richland, Washington

Prepared by:

UNITED ENGINEERS
& CONSTRUCTORS
A **Raytheon** Company
Western Operations

PRELIMINARY HVAC CONFINEMENT ASSESSMENT

Prepared by: _____ Date: 1/10/94
HVAC Engineer

Reviewed by: _____ Date: 1/10/94
Senior Engineer

Approved by: _____ Date: 1/10/94
Engineering Manager

Approved by: _____ Date: 1/10/94
Project Manager

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1.0 OBJECTIVE

1.1 Background

1. The Waste Receiving and Processing (WRAP) Facility Module 2A will receive, process, package, certify and ship contact-handled low-level radioactive mixed waste, for permanent burial at the Hanford site disposal facilities. To ensure the safe processing of the waste materials, process operations will be accomplished in confinement systems, (i.e. enclosures with associated ventilation systems).

2. The Conceptual Design Report (CDR) (Reference 1) included the Preliminary Safety Evaluation (PSE) which classified the facility as "Low Hazard" and as Safety Class 3.

3. The scope of this Assessment is to:

   a. Define the confinement system design criteria

   b. Select an optimum arrangement that meets the criteria and good engineering judgement at the least cost to the DOE

   c. Present the selected arrangement in enough detail so that interfacing disciplines can use it to begin Title I design

1.2 Purpose and Need

1. The objective of this Assessment is to recommend a primary and secondary confinement system that complies with all requirements and results in a cost effective system.

2. The purpose and need for the Assessment is to provide an advanced conceptual design so that project wide concurrence can be obtained prior to beginning the Title I design.

2.0 SUMMARY

1. This study has defined the confinement system design criteria by reviewing and summarizing applicable requirements from the various design requirement documents. Excerpted criteria are tabulated in **Table I**.

2. The confinement system recommended provides a safe and reliable system and includes two confinement zones while the waste is confined inside the enclosures.

3.0 CONCLUSION AND RECOMMENDATIONS

1. Based on the design requirement documents provided, it is concluded that a safe and reliable confinement system design using Safety Class 3 equipment and two confinement zones will meet the applicable design criteria.

2. The recommended Confinement Zone Plans (H-2-140733 and H-2-140734) are included in Volume IV of this report.

3. The recommended arrangement should be used as the starting point for Title I design (i.e. interfacing disciplines should use this arrangement as the reference design, and the HVAC discipline should continue development in Title I design).

4.0 DESCRIPTION OF INVESTIGATION AND SOLUTIONS

4.1 Criteria

1. To help identify the many references in DOE 6430.1A (Reference 3) that provide requirements for the ventilation confinement systems, a computer word search was performed on DOE 6430.1A. The words "CONFINEMENT" and "ENCLOSURE" were used. Any statements not relating to the confinement system were eliminated (e.g. references to electrical enclosures). In addition, some statements that refer to confinement or enclosure, but neither word was specifically used were also added.

2. The FDC, Rev. 2 (Reference 4), and the SDRD, Rev. A (Reference 5) were reviewed and the criteria were added to the list. Finally, WHC-CM-4-9, Section 4.0 (Reference 6) was reviewed and any new criteria were added. The result of this research is presented in **Table I**.

3. **Table I** consolidates confinement system criteria as quoted from the requirement documents. It is recognized that some of these statements are taken out of context and do not apply because the statement is intended for higher Safety Class equipment only. This is considered in the study.

4.2 Assumptions

Assumptions made as part of this study are:

1. The facility has no Safety Class requirement greater than Safety Class 3.

2. The design requirement documents for this study are:

   a. DOE Order 6430.1A (Reference 3)

   b. FDC (Reference 4)

   c. SDRD (Reference 5)

   d. WHC-CM-4-9, Section 4 (Reference 6)

4.3 Confinement System Description

1. Description

a. Primary and secondary confinement zones:

Area	Zone	Press. *
Process Enclosures	I (Primary)	(in. wg) (-) 0.7 to 1.0
Process Areas and HEPA Filters Room(s)	II (Secondary)	(-) 0.1 to 0.25

* Pressure with respect to next higher confinement zone.

b. All other areas are considered to be non-confinement zones.

c. HVAC Zone Plans, Drawings H-2-140733 Rev.C and H-2-140734 Rev.C show the zone requirements superimposed on the building layout.

d. The primary confinement system consists of the process cells and enclosures and Zone I ventilation system. Zone I is maintained at a negative pressure with respect to the surrounding Zone II areas. Air is drawn into the Zone I enclosure through an inlet HEPA filter from the Zone II space. HEPA filters are provided at the Zone I outlets to minimize contamination of the exhaust ducts. Redundant filter trains and exhaust fans with two stages of testable HEPA filters will be provided. A parallel Zone I system similar to the above system with the addition of two stages of carbon bed absorbers will be used to extract air from the vicinity of releases of VOCs or toxic vapors that can be removed by carbon absorbers. (Other hazardous vapors or fumes (off-gas) generated in the process requiring scrubbers, etc., shall be treated within the process before entering the Zone I exhaust stream.)

e. The secondary confinement systems consist of the building structure forming the operating areas surrounding the process cells and enclosures and the Zone II ventilation system. Zone II is maintained at a negative pressure with respect to the atmosphere and the non-confinement zone areas of the building. A once-through ventilation system is used for Zone II. Outside air is heated, cooled or humidified as required and passes through 90 - 95% efficient filters before reaching the Zone II space. The air exhausted from Zone II passes through two stages of HEPA filters prior to being discharged to the atmosphere. Redundant Zone II supply and exhaust systems are provided. The supply air volume into Zone II areas will be controlled at a lower flow rate than the combined flow rates of the Zones I and II exhaust rates to maintain the Zone II pressure relationship.

f. Other confinement system factors:

- Only the exhaust ductwork, ductwork supports, and HEPA filter housing will be designed to withstand the Safety Class 3 DBE

- The exhaust fan(s) are not required to operate after the DBE

- Requires entry into Zone II through airlocks
- Is designed not to maintain negative pressure during the DBF
- Has stack monitoring UPS power to maintain monitoring capability during power outage
- Has a design to minimize potential inhalation of radioactive materials during normal operations
- HEPA filter assemblies to ASME N509, with in-place testing to ASME N510

5.0 REFERENCES

1. Conceptual Design Report, Waste Receiving and Processing Facility Module 2A.
2. Hazard Classification and Preliminary Safety Evaluation for Waste Receiving and Processing Facility Module 2A, WHC-SD-W100-PSE-002, Draft, dated July 1992.
3. DOE Order 6430.1A, dated April 6, 1989.
4. Functional Design Criteria, Waste Receiving and Processing Facility, Module 2A, SD-W100-FDC-001, Rev. 2.
5. Supplemental Design Requirements Document for Project W100, Waste Receiving and Processing (WRAP) Module 2A, WHC-SD-W100-SDRD-001, Rev. A (DRAFT).
6. Radiological Design, WHC-CM-4-9, Section 4, Rev. 0, undated draft.
7. SDC-4.1, Standard Arch-Civil Design Criteria, Design Loads for Facilities, Rev. 11, 9/6/89.
8. SDC-5.1, Standard Design Criteria for Heating, Ventilating and Air Conditioning, Rev. 6, 2/28/79.

TABLE I
CONFINEMENT CRITERIA

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
1	(1) 0110-6.4	The design of hazardous areas shall facilitate access by emergency personnel from the exterior and, at the same time, shall maintain any required CONFINEMENT or containment using air locks or other features.
2	(1) 0110-12.4	Building envelope air leakage through walls, windows, and doors shall comply with ASHRAE Standard 90.
3	(1) 0110-99.0.3	Particular care shall be taken to identify the use requirements of such large energy consumers as secondary CONFINEMENT ventilation systems and other high volume air-using equipment to ensure that such equipment is properly designed.
4	(1) 0110-99.0.3	Operating control features shall allow reduced equipment air flows during periods of nonuse, if personnel health and safety and environmental protection will not be adversely affected.
5	(1) 0110-99.0.4	In those areas where an accidental breach of a primary CONFINEMENT system could expose personnel to radioactive material, a distance of 75 feet as measured by the method in the NFPA 101 shall be the maximum travel distance to ensure that personnel can exit through the next CONFINEMENT barrier.
6	(1) 0110-99.0.6	The structural shell surrounding the critical areas and their supporting members shall remain standing and continue to act as a CONFINEMENT structure during the DBF under conditions of failure of any fire suppression system not designed as a safety class item.
7	(1) 0111-99.0.1	The design of structures, including their supports, that are CONFINEMENT system barriers shall ensure satisfaction of the functional requirements for the specific CONFINEMENT system they are a part of.
8	(1) 0111-99.0.1	In no case shall the total combustible loading located in a fire area exceed the fire resistance rating of the area ENCLOSURE.
9	(1) 1161-1	ENCLOSUREs as used here are physical barriers (e.g., cubicles, gloveboxes, fume hoods, conveyor tunnels) that, together with their ventilation and operating systems, prevent the release of radioactive or other hazardous material to the work space or the environment. Accordingly, their structural and CONFINEMENT integrity shall be primary design consideration.
10	(1) 1161-1	Unless more specific design guidance is provided to the design professional from DOE project manager, the primary reference source shall be the ACGIH Industrial Ventilation Manual.
11	(1) 1161-1	The design objective shall be to prevent exposure of the plant personnel to airborne contamination and shall implement ALARA concepts as practical to minimize operator exposures.
		* (1) 6430.1A, (2) FDC Rev. 2, (3) SDRD Rev. A (Draft), (4) WHC-CM-4-9, Section 4.0 (Draft)

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
12	(1) 1161-1	The **ENCLOSURE** system, including its internal and external support structures, shall be designed to withstand the effects of normal operating conditions and the environment.
13	(1) 1161-1	Also, DBAs such as fire, explosion, criticality, and natural phenomena shall be considered in the design of the **ENCLOSURE**.
14	(1) 1161-1	**ENCLOSURE** stability during a seismic event shall be based on the seismic parameters described in Section 0111-99.0.4, Earthquakes.
15	(1) 1161-1	All equipment that must be located within the **ENCLOSURE** shall be designed to allow for in-place maintenance and/or replacement.
16	(1) 1161-1	The design and operation of support and protection systems, such as fire protection, shall not promote the failure of the **ENCLOSURE** system integrity or the loss of **CONFINEMENT**.
17	(1) 1161-2	Noncombustible or fire-resistant and corrosion-resistant materials shall be used for **ENCLOSURE**s and, to the maximum extent practicable, for any required radiation shielding.
18	(1) 1161-2	**ENCLOSURE**s (except open-face hoods) shall be designed with the objective of being leak-tight.
19	(1) 1161-2	In conjunction with their ventilation systems, all **ENCLOSURE**s shall be capable of maintaining **CONFINEMENT** (i.e., negative pressure with respect to the surrounding operating area).
20	(1) 1161-2	To reduce migration of contamination, closure devices or permanent seals shall be provided on entrances and exits of piping, ducts, or conduits penetrating **CONFINEMENT** barriers. Such closures or seals shall have an integrity equal to or greater than the barrier itself.
21	(1) 1161-2	Where pertinent to safety, the **ENCLOSURE** design shall consider the heat generation in the **ENCLOSURE**.
22	(1) 1161-2	Generally, the fire barriers within and between **ENCLOSURE**s will be normally closed. Where operations require that the fire barrier be in the open position, it shall automatically close on activation of the fire detection system or by release of a fusible device. Design of the **ENCLOSURE** system shall allow automatic closure of the fire barrier without loss of **CONFINEMENT**, without degradation of the **ENCLOSURE** system's integrity, and without injury to personnel. The fire barrier shall be capable of being opened or closed manually from the exterior and interior of the **ENCLOSURE**.

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
23	(1) 1161-4	A ventilation system shall be installed on all **ENCLOSURE** systems to maintain a minimum negative pressure differential of 0.3 in. of water inside the **ENCLOSURE** (except open-face hoods) with respect to the operating area.
24	(1) 1161-4	HEPA filters shall be provided at the interface of the **ENCLOSURE** outlet and the ventilation system to minimize the contamination of ductwork and at the **ENCLOSURE** inlet to prevent movement of contamination within the **ENCLOSURE** to the operating area in the event of a flow reversal.A roughing filter should be installed to reduce HEPA filter loading.
25	(1) 1161-4	The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the **ENCLOSURE** system. Minimum inward air velocity shall be 125 plus or minus 25 linear ft/min or as determined from guidance provided in the ACGIH Industrial Ventilation Manual.
26	(1) 1161-4	The design of the **ENCLOSURE** ventilation flow pattern shall minimize the spread of fire, and fire screens shall be provided where necessary.
27	(1) 1161-4	For **ENCLOSURE**s where over pressurization is possible, a system shall be provided to ensure that **CONFINEMENT** is not breached.
28	(1) 1161-4	Small **ENCLOSURE** systems with positive-pressure supplied gases shall have positive-acting, pressure-relief devices (connected into the exhaust system) to prevent pressurization of the **ENCLOSURE**.
29	(1) 1300-1.3	The design of new or modification of existing special facilities shall address the health hazards represented by all hazardous materials in **ENCLOSURE**s, general work areas, and non-contaminated areas.
30	(1) 1300-1.3	In addition, to the extent practical, such releases shall be maintained ALARA.
31	(1) 1300-1.4.2	Releases of hazardous materials postulated to occur as a result of DBAs shall be limited by designing facilities such that at least one **CONFINEMENT** system remains fully functional following any credible DBA (i.e., unfiltered/unmitigated releases of hazardous levels of such materials shall not be allowed following such accidents).
32	(1) 1300-1.4.2	For facilities whose hazard potential is determined to be extremely low, deviations from the criteria of this section may be considered in accordance with Section 0101-2, Criteria Deviations.
32A	(1) 1300-1.4.2	To the extent practical, ALARA concepts shall be applied when designing special facilities to mitigate post-DBA releases of hazardous materials.
33	(1) 1300-1.4.4	Releases shall be monitored in accordance with the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series.

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
33A	(1) 1300-6.1	Special facilities shall be designed to minimize personnel exposures to external and internal radiological hazards, provide adequate radiation monitoring and alarm systems, and provide adequate space for health physics activities. Primary radiation protection shall be provided by the use of engineered controls (e.g., confinement, ventilation, remote handling, equipment layout, and shielding); secondary radiation protection shall be provided by administrative control.
34	(1) 1300-6.1	ALARA concepts shall be applied to minimize exposures where cost- effective.
35	(1) 1300-6.4	In addition, to the extent practical, the concept of ALARA shall be used when designing **CONFINEMENT** and ventilation systems to limit airborne contamination levels. The design shall ensure that respirators are not required to meet the dose limits for normal operations.
36	(1) 1300-6.4	Engineered controls and features shall also be provided to minimize potential inhalation of radioactive and other hazardous materials under all conditions.
37	(1) 1300-6.8	The change room exhaust air shall be HEPA filtered if dispersible radionuclides are handled in the process areas it serves.
38	(1) 1300-7.1	**CONFINEMENT** systems shall accomplish the following: ■ Minimize the spread of radioactive and other hazardous materials within the unoccupied process areas ■ Prevent, if possible, or else minimize the spread of radioactive and other hazardous materials to occupied areas ■ Minimize the release of radioactive and other hazardous materials in facility effluents during normal operation and anticipated operational occurrences ■ Limit the release of radioactive and other hazardous materials resulting from DBAs including severe natural phenomena and man- made events in compliance with the guidelines contained in Section 1300-1.4.2, Accidental Releases.
39	(1) 1300-7.2	**CONFINEMENT** capabilities, including **CONFINEMENT** barriers and associated ventilation systems, shall maintain a controlled, continuous airflow pattern from the environment into the **CONFINEMENT** building, and then from non-contaminated areas of the building to potentially contaminated areas, and then to normally contaminated areas.
40	1) 1300-7.2	For a specific nuclear facility, the number and arrangement of **CONFINEMENT** barriers and their required design features and characteristics shall be determined on a case-by-case basis.
41	1) 1300-7.2	Typical factors that affect **CONFINEMENT** system design are the type, quantity, form, and conditions for dispersing the hazardous material, including the type and severity of DBAs.

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
42	1) 1300-7.2	In addition, alternative process and facility designs may reduce the potential hazards and the requirements for **CONFINEMENT** system design.
43	1) 1300-7.2	Engineering evaluations, trade-offs, and experience shall be used to develop a practical design that achieves **CONFINEMENT** system objectives.
44	1) 1300-7.2	The number of **CONFINEMENT** systems required in different locations of a facility may vary depending on the potential consequences from hazards during normal operation, anticipated operational occurrences, and DBAs.
45	1) 1300-7.2	Although individual **CONFINEMENT** systems are not required to withstand the effects of every accident, they shall effectively perform their required functions for the DBAs they are required to withstand.
46	1) 1300-7.2	Sufficient redundancy shall be provided in the unlikely event of a **CONFINEMENT** system failure.
47	1) 1300-7.2	At least one of the **CONFINEMENT** systems shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events (see Section 0111-99.0, Nonreactor Nuclear Facilities General), including the postulated DBAs and DBF initiated by these events, and remain functional to the extent that the guidelines of Section 1300-1.4.2, Accidental Releases, are not violated.
48	(1) 1300-7.2	The adequacy of the design of these **CONFINEMENT** systems to effectively perform their required functions shall be demonstrated by the safety analysis.
49	(1) 1300-7.2	To the extent practical, the ALARA concept shall be applied to the design of all **CONFINEMENT** systems to minimize exposures to hazardous materials.
50	(1) 1300-7.3	Special features (e.g., air locks, enclosed vestibules) shall be considered for access through **CONFINEMENT** barriers to minimize the impact of facility access requirements on the ventilation system and to prevent the release of radioactive airborne materials.
51	(1) 1300-8.1	Waste handling areas shall comply with the standards of **CONFINEMENT** and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled.
52	(1) 1300-8.1	Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A.
53	(1) 1300-9	Emphasis shall be placed on reducing effluents released to the environment to ALARA levels using the best technology economically available at the time of design.
54	(1) 1300-11.1	Design of the areas in a facility that may become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions shall incorporate measures to simplify future decontamination. Such items as service piping, conduits, and ductwork shall be kept to a minimum in these areas and shall be arranged to facilitate decontamination.
55	(1) 1300-11.1	Filters shall be positioned in ventilation systems in locations that minimize contamination of ductwork.
56	(1) 1300-11.2	Use modular, separable **CONFINEMENT**s for radioactive and other hazardous materials to preclude contamination of fixed portions of the structure.
57	(1) 1300-11.2	Locate exhaust filtration components of the ventilation systems at or near individual **ENCLOSURE**s so as to minimize long runs of internally contaminated ductwork.
58	(1) 1300-11.2	Equipment, including effluent decontamination equipment, that precludes, to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas including curves and turns in piping and ductwork.

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
59	(1) 1324-5.1	Instrumentation and control systems shall be required at a RSWF to provide monitoring and control capabilities associated with CONFINEMENT, nuclear criticality safety, and radiation protection.
60	(1) 1324-5.1	The degree of CONFINEMENT required in a radioactive solid waste facility is both storage-specific and process- specific, but in either case shall suit the most restrictive case anticipated.
61	(1) 1324-5.1	In general, the primary contamination CONFINEMENT shall be the radioactive solid waste process systems equipment and associated off-gas or vent systems during the treatment stage of processing.
62	(1) 1324-5.1	In special cases, such as radioactive solid waste facilities where the processes or storage include corrosive or noxious materials, the radioactive solid waste process or storage system shall be totally enclosed and provided with its own ventilation system and off-gas cleanup system. In such cases, the radioactive solid waste process or storage system shall be treated as the primary CONFINEMENT system.
63	(1) 1324-6.1	Secondary CONFINEMENT for radioactive solid waste during treatment shall be a process cell or building and its ventilation system, while for such waste during interim storage, a storage building or structure shall be used.
64	(1) 1324-6.1	Tertiary CONFINEMENTs are not required in most cases for radioactive solid waste during the treatment or interim storage phase of the radioactive solid waste management process.
65	(1) 1324-6.1	In addition to these principal CONFINEMENT systems, features such as change rooms and special access ways shall be used to minimize the spread of radioactive contamination within the facility.
66	(1) 1324-6.2	The primary CONFINEMENT system consists of process systems equipment and its associated ventilation and off-gas system, storage containers, or other waste and site-specific engineered barriers.
67	(1) 1324-6.2	Systems, components, and structures that compose the process system and/or storage containers shall be designed to ensure their integrity for normal operations, anticipated operational occurrences, and for the DBAs they are required to withstand. The primary CONFINEMENT system consists of process systems equipment and its associated ventilation and off-gas system, storage containers, or other waste and site-specific engineered barriers.
68	(1) 1324-6.2	As a minimum, portions of the process system and/or storage containers whose failure would result in an unacceptable risk and whose functions are necessary to facilitate a safe shutdown condition shall be designed to remain functional following a DBE. High-level enriched uranium, uranium-233, and transuranic solid waste processes and/or storage containers shall meet these requirements.
69	(1) 1324-6.3	The secondary CONFINEMENT system consists of the process cell barriers and the ventilation systems associated with the cells or building, or a storage building or structure.
70	(1) 1324-6.3	The process cell and/or building CONFINEMENT barriers and associated ventilation systems shall be capable of performing their necessary functions following a DBE.
71	(1) 1324-6.3	Other secondary CONFINEMENTs shall be considered to determine the need to meet these requirements commensurate with the hazards associated with the radioactive solid waste to be confined.

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
72	(1) 1324-6.3	The secondary CONFINEMENT shall be designed to ensure that it can withstand the effects of severe natural phenomena and man- made events, including the DBAs and DBF initiated by these events, and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.
73	(1) 1324-6.3	All penetrations of the secondary CONFINEMENT shall have positive seals to prevent the migration of contamination out of the secondary CONFINEMENT area.
74	(1) 1324-6.3	Process cells shall be supplied with ventilation air from the building ventilation system, and shall be provided exhaust ventilation with sufficient capacity to ensure an adequate controlled ventilation flow as required in the event of a credible breach in the secondary CONFINEMENT barrier.
75	(1) 1324-6.3	Pressure in the compartments shall be negative with respect to the building ventilation system.
76	(1) 1324-6.3	Special features (e.g., air locks or enclosed vestibules) shall be considered for access through secondary and tertiary CONFINEMENT barriers.
77	(1) 1324-7.3.1	Exhaust outlets that may contain transuranics or fission products shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.
78	(1) 1530-99.0	Wherever practical, special facilities shall be designed and constructed using building components of fire-resistant and noncombustible material, particularly in locations vital to the functioning of CONFINEMENT systems.
79	(1) 1530-99.0	To the extent practicable, combustible materials shall not be used in the construction of process system CONFINEMENT barriers.
80	(1) 1530-99.0	CONFINEMENT systems, particularly the building structural shell and its associated ventilation system, shall be designed with the capability of retaining the CONFINEMENT function during the DBF.
81	(1) 1550-2.5.5	Air filters shall be located on the suction side of fans and coils and in other special locations as required for air treatment.
82	(1) 1550-2.5.5	Air-filter pressure drop gauges of the diaphragm-actuated, dial- type (preferred) or the inclined manometer type shall be located on all filter assemblies.
83	(1) 1550-2.5.5	HEPA filter assemblies shall comply with ASME N509.
84	(1) 1550-2.5.5	The design professional shall design for a location that facilitates in-place testing of HEPA filters, with particular attention given to plenum hardware provisions that allow for testing of the HEPA filter bank without requiring the testing personnel to enter the plenum. Utility services shall be extended to the plenum location (e.g., electrical receptacles and compressed air) to facilitate testing work. In-place testing design requirements shall meet all the recommendations of UL 586, ASME N510, and ERDA 76-21.
85	(1) 1550-2.5.5	HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life.The design professional may eliminate the installation of pre- filters if an analysis of filtration requirements and consideration of the filter assembly justifies omission.

TABLE I: CONFINEMENT CRITERIA

No.	* Reference	Criteria
86	(1) 1550-2.5.5	In providing fire protection for the HEPA filters, the design shall separate prefilters or fire screens equipped with water spray sufficiently from the HEPA filters to restrict impingement of moisture on the HEPA filters. Under conditions of limited separation, moisture eliminators or other means of reducing entrained moisture shall be provided. Moisture eliminators may be omitted where system design provides sufficient filter redundancy to ensure continued effluent filtration in the event of fire within any portion of the system.
87	(1) 1550-2.5.5	The HEPA filter fire protection system shall be activated in a manner consistent with the fire protection system in the room or building in which the filters are located and as directed by the cognizant DOE fire protection authority.
88	(1) 1550-2.5.6	Fire dampers shall not be used on exhaust system ducting if it is required to maintain CONFINEMENT of hazardous materials during and after a fire event.
89	(1) 1550-2.5.6	Such penetrations more than 96 square inches in area and more than 6 inches in minimum dimension shall provide a penetration delay equal to that required for the security barrier.
90	(1) 1589-2	At a minimum, facility CONFINEMENT systems, including filters and ventilation systems, shall comply with the "improved risk" criteria defined in DOE 5480.7 and shall preclude offsite release of greater than TLV amounts of toxic materials during the maximum credible fire loss conditions.
91	(1) 1595-6.5	All air handling systems shall be provided with the smoke and fire protection controls required by NFPA 101.
92	(1) 1595-6.5	All supply, return, relief, and exhaust air ventilation systems shall have interlock controls that interface with fire and smoke detection system controls and either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire throughout the building.
93	(1) 1595-6.5	Special exhaust systems shall be designed to include fire and smoke safety controls as required by NFPA 91.
94	(2) 2.1.2	The release of radioactive and hazardous materials during routine operations shall not exceed the administrative control limits in WHC-CM-7-5, *Environmental Compliance Manual.*
95	(2) 2.1.3, (3) 3.2.1.3.3	HVAC system shall assure safe operation and maintain airflow from non-contaminated areas to areas of progressively higher potential contamination.
96	(2) 2.1.3, (3) 3.2.1.3.3.a	Maintain airflow between different areas through the establishment of differential pressure zones for ventilation and contamination control.
97	(2) 2.1.3	Provide representative effluent record sampling and continuous online monitoring.
98	(2) 2.1.3, (3) 3.2.1.3.3.b	Permit in-place testing of HEPA filters.
99	(2) 2.1.3, (3) 3.2.1.3.3.c	Provide parallel HEPA filter systems.
100	(2) 2.1.3, (3) 3.2.1.3.1.a	Provide adequate heating and cooling as described in DOE 6430.1A, Section 1550.
101	(2) 2.1.3, (3) 3.2.1.3.3.d	In ventilation Zones I, 2, and 3, the airflow shall be directed downward, away from the worker's breathing zone.

TABLE I: CONFINEMENT CRITERIA		
No.	* Reference	Criteria
102	(2) 2.1.3, (3) 3.2.1.3.3.e	Utilize welded joints on ductwork carrying potentially contaminated materials.
103	(2) 2.1.3, (3) 3.2.1.3.3.g	Provide changeable prefilters upstream of the first HEPA filters.
104	(2) 2.1.3, (3) 3.2.1.3.3.h	Use bagout or self-contained filters and other features for changing highly contaminated components, wherever possible.
105	(2) 2.1.3, (3) 3.2.1.3.1.b	The HVAC system shall be controlled by a distributed control system with monitoring, alarm reporting and reset capability, through a central process control system.
106	(2) 2.1.3, (3) 3.2.1.3.1.a	Provide air conditioning as required for all sensitive equipment.
107	(2) 2.1.3, (3) 3.2.1.3.3.f	Minimize the ability of radioactive materials to accumulate in the ductwork and provide means to detect buildup.
108	(2) 2.1.3, (3) 3.2.1.3.1	Provide moisture separators or heaters to minimize moisture loadings on filters.
109	(2) 2.1.3	Remove flammable vapors from air streams upstream of heaters.
110	(2) 2.1.4	UPS shall be provided for the Effluent Monitoring and Sampling Systems.
111	(2) 2.1.6, (3) 3.2.1.3.1.a	The HVAC Systems shall be designed to meet the conditions described in SDC-5.1, Section C.
112	(2) 2.2.5	The PMS shall provide control and surveillance of building HVAC systems.
113	(3) 3.2.1.3.2	All HVAC systems that serve a space containing radioactive waste (including non-confinement systems used for storage) shall be isolated from other non-confinement systems.
114	(3) 3.2.1.3.3.c	The HVAC Systems shall maintain pressure relationships between zones in accordance with WHC-CM-4-9.
115	(3) 3.2.1.3.3.c	There shall be no loss of confinement as a consequence of any credible system/component failure resulting from any normal or DBA situation.
116	(3) 3.2.1.3.3.c	Air flowing through the maximum credible breach into the zone 1 enclosure shall be sufficient to provide a face velocity of 125 ± 25 feet per minute. The maximum credible breach of a zone 1 barrier shall be determined by analysis of the Title 1 glovebox design. At a minimum this will be a single gloveport.
117	(3) 3.2.1.3.3.c	Change rooms used for donning/doffing of SWP clothing shall be served by the Zone II ventilation system. (6430.1a, 1300-6.8)
118	(3) 3.2.1.3.3.c	An atmospheric pressure reference header shall be provided and used as the reference point for control of zone pressures.
119	(3) 3.2.1.3.3.c	The post Design Basis Accident (DBA) configuration of the HVAC systems shall be total system shutdown. Zone integrity (including exhaust ducting) shall be maintained up to the Zone II boundary. The exhaust system shall fail open. Backflow prevention for confinement supply systems shall be provided by HEPA filtration of the supply per DOE 6430.1A, 1305-5.1 (paragraph 7). The supply system shall fail open.
120	(3) 3.2.1.3.3.c	Confinement system supply and exhaust fans will be capable of operation with either of their Air Handlers and Filter Trains respectively.
121	(4) page 2	Primary Confinement Zone--Confinement features must prevent the spread of contamination, including the DBA for the facility.
122	(4) 2.2.4	Volumetric airflow rate in secondary confinement shall be between 4 and 8 AC/hr.
123	(4) 2.3.1	The design shall provide the capability of isolating Zone I from Zone II and/or isolating portions of Zone I from the remainder of the Zone.

TABLE I: CONFINEMENT CRITERIA		
No.	*** Reference**	**Criteria**
124	(4) 3.2.4	Supply system connections to Zone I shall be equipped with HEPA filtration and isolation dampers.
125	(4) 4.1.4	Ducts serving Zone I should not connect with ducts serving other areas unless the Zone I air stream has passed through at least one testable stage of HEPA filtration.
126	(4) 4.1.5	The facility exhaust fans shall be located downstream of final HEPA filter banks and provide sufficient redundancy to maintain the total exhaust flow rate during normal operation, maintenance, and single point failure.
127	(4) 4.1.7	The design shall provide redundant exhaust fans and filter systems to facilitate maintenance and filter changes without system performance degradation.
128	(4) 4.1.8	Zone I and Zone II exhaust ductwork passing through fire walls shall be constructed to resist the effects of a fire and contain no fire dampers.
129	(4) 4.1.14	The exhaust from Zone I may join the facility exhaust upstream of the final stage(s) of HEPA filtration.
130	(4) 4.1.17	The capacity of the exhaust fan(s) shall be sufficient to maintain design flow rates throughout the range of dust loading on the filters to a maximum of 4 in. wg.
131	(4) 4.6.7	The first testable stage of HEPA filters for Zone I shall be located close to the exhaust inlet to prevent airborne radioactive materials from entering a major portion of the ventilation ductwork.
132	(4) 5.2.2	Return air streams to be recirculated from Zone II shall be filtered with two testable stages of HEPA filters and continuously monitored. The system shall automatically switch to a once through mode of operation whenever the radiation monitor detects contamination downstream of the first HEPA filter stage. A manual override shall be provided.
133	(4) 5.2.3	Sampling capability shall be provided between the two stages of HEPA filters to aid in detecting airborne radionuclides passing the first stage filter.
134	(4) 5.2.4	For a recirculating system, the CAM instruments shall be equipped with alarms and controls which automatically change the ventilation system to supply clean air to the work areas and HEPA filter the contaminated exhaust air.
135	(4) 6.1	The ventilation system shall be designed to adequately confine and restrict release of radioactive materials, assuming failure of a single component of the system.
136	(4) 6.3	Emergency, standby, or uninterruptible power shall be provided, as determined by the SAR, to the exhaust ventilation system.

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