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# TEST PLAN:

# WIPP BIN-SCALE CH TRU WASTE TESTS

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1.0 SIGNATURE SHEET

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## 3.0 TEST PROGRAMMATIC INFORMATION

### 3.1 TEST TITLE: WIPP BIN-SCALE CH TRU WASTE TESTS

### 3.2 DOCUMENT DATE - January 1990

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### 3.5 FOREWORD

This WIPP Bin-Scale CH TRU Waste Test program described herein will provide relevant composition and kinetic rate data on gas generation and consumption resulting from TRU waste degradation, as impacted by synergistic interactions due to multiple degradation modes, waste form preparation, long-term repository environmental effects, engineered barrier materials, and, possibly, engineered modifications to be developed. Similar data on waste-brine leachate compositions and potentially hazardous volatile organic compounds released by the wastes will also be provided. The quantitative data output from these tests and associated technical expertise are required by the WIPP Performance Assessment (PA) program studies, and for the scientific benefit of the overall WIPP project.

This Test Plan describes the necessary scientific and technical aspects, justifications, and rationale for successfully initiating and conducting the WIPP Bin-Scale CH TRU Waste Test program. This Test Plan is the controlling scientific design definition and overall requirements document for this WIPP in situ test, as defined by Sandia National Laboratories (SNL), scientific advisor to the U.S. Department of Energy, WIPP Project Office (DOE/WPO).

Many site engineering, operational, and safety requirements are also defined, as needed to support the conduct of this overall test program. There will be other parallel and supporting engineering design requirements and specifications, engineering work packages, standard operating procedures, safety procedures, waste handling and retrieval plans, and other necessary documentation, etc. Such services and documentation (not in this Test Plan) will be provided by the Westinghouse Waste Isolation Division (WID), the WIPP management and operating contractor. All of these documents and plans provide necessary support to the successful conduct of the scientific program as defined in this Test Plan. All such supporting commitments are summarized in Section 13.3. The program will be conducted as a joint cooperative and interactive effort between SNL and WID. The overall test program will be directed by Sandia National Laboratories. The Test Plan clearly lays out the respective areas of test responsibility for both SNL and WID. The entire test program is being performed under the auspices of, and for the DOE/WPO.

Considerable engineering detail and scientific background information is included herein to provide an adequate, overall description of the complete test program. An interested reader will not, therefore, have to search in multiple documents for necessary, supplemental information. This Test Plan is not, however, intended to be a treatise on the topics of waste degradation and the overall impacts of resultant gas generation on the long-term performance and safety of the WIPP facility. Interpretations of test data not yet obtained will not be attempted in this document. The data from this bin-scale test program, and the subsequent interpretations thereof, are input information to the WIPP PA studies. Evaluations of test results and their potential impacts on the WIPP facility are specific objectives of the WIPP PA program. This topic will addressed in more detail in Section 5.

This test program is specifically included and described briefly in the US DOE Draft Final Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment, DOE/WIPP 89-011 [US DOE, 1989a]. This in situ test program must be regarded as a separate entity from the operational demonstrations program previously defined and planned at the WIPP [US DOE, 1989d].

Much of the preliminary, introductory narrative (Section 5), objectives (Section 4), and conceptual test design and summary (Section 6) of this Test Plan were originally contained elsewhere, in Appendix A, in the Plan for the Disposal-System Characterization and Long-Term Performance Evaluation of the Waste Isolation Pilot Plant, SAND89-0178 [Bertram-Howery and Hunter, 1989]. This "Appendix A" was also included in DOE/WIPP 89-011 [US DOE, 1989a]. The Test Plan includes many technical and schedule updates to the annotated descriptions in the DOE Plan.

The procedures, designs, and materials used in this test are necessary to provide the required data. They are not intended to set precedents for future WIPP site operations without further detailed technical evaluations.

Specific details provided in this Test Plan are believed to be accurate as of the date of publication. Authorized changes in experimental details and supporting engineering designs, as described herein, will occur as the test program progresses and is installed and performed in situ. Changes in technical detail are expected, and are based on: forthcoming scientific and engineering test developments at the WIPP site and at waste generating facility sites; early test data and their interpretations; new knowledge and developments, plus associated or perceived programmatic impacts and needs; and, any other problems that may arise and need resolution. Minor test detail changes will be documented and incorporated into the updatable Appendices of this Test Plan, Section 18.0. Future major test changes, modifications, and additions, such as Phase 3 of this program, to be briefly described in Section 8.2, will be documented in a separate Test Plan Addendum. All future changes to this Test Plan will attempt to incorporate new knowledge, insights, and inputs of all personnel and organizations involved.

The success and schedule of these WIPP Bin-Scale CH TRU Waste Tests are closely tied to the effective and cooperative interaction between the scientific (Sandia National Laboratories) and engineering (Westinghouse WID) participants in this program. Test and schedule success are also dependent on other DOE/WPO efforts: TRUPACT-II licensing and scheduling; the WIPP Supplemental Environmental Impact Statement (SEIS); the WIPP Safety Analysis Report (SAR); WIPP land withdrawal legislation; interpretations of Environmental Protection Agency (EPA) hazardous waste regulations -- and associated impacts on WIPP operations, from 40 CFR 191, Subpart B, the Resource Conservation and Recovery Act, RCRA, 40 CFR 268, and the potential granting of a no-migration variance by the EPA to the WIPP. These concerns are addressed separately in both DOE/WPO [US DOE, 1989a] and SNL [Bertram-Howery and Hunter, 1989] documentation; they are not addressed specifically in this Test Plan.

Tentative schedules in this Test Plan, Section 13, are based on current but evolving DOE/WPO schedules and related information, as impacted by first waste receipt schedules and the DOE/WPO efforts described above, as well as by other parallel concerns, documentation, or complicating factors. The schedules are based on the assumption that CH TRU wastes will be available for shipment to the WIPP for test emplacement in FY90. Schedules are also dependent on the completion of certain commitments by test participants, as listed in Section 13.3. Schedules may, by necessity, be modified at a later date.

## 3.6 TEST PLAN REVIEW

### 3.6.1 Formal Peer Review

As required by WIPP quality-assurance procedures, a formal peer review of the Test Plan: WIPP Bin-Scale CH TRU Waste Tests (Rough Draft, dated May 1989) was conducted. Written comments were received and a review meeting held on August 23-24, 1989, at the WIPP site. The comments, suggestions, criticisms, etc., were documented and commented on separately, and can be found in the SNL-WIPP quality assurance files for this test program. Most of the peer review comments, as well as those comments received from all other reviewers, have been incorporated into this latest and final edition of the Test Plan.

The formal peer review panel members are listed below.

James Butler, Harvard University
James K. Channell, Environmental Evaluation Group
Thomas L. Clements (& K. Guay), Idaho National Engineering Laboratory
Eric D'Amico, Rocky Flats Plant
Martha A. Ebra (& N. Bibler), Savannah River Site
A. J. Francis, Brookhaven National Laboratory
Anthony F. Gallegos, Environmental Evaluation Group
Stanley Kosiewicz, Los Alamos National Laboratory

(Plus other personnel at the above named sites who may have assisted the panel members.)

Half of these formal reviewers were selected based on their knowledge of nuclear waste preparations, handling, and testing activities at U.S. DOE waste generating facilities. The other half were specifically selected because they were not associated with waste generating facilities. These later individuals all have specific expertise in the areas of microbiology, environmental sciences, radiological safety, etc., that are applicable to the topic of safe nuclear waste management.

Note: During the course of the peer review meeting, and at the suggestion and encouragement of Sandia management, the members of the external peer review panel, or their designated representatives, agreed tentatively to meet on a periodic basis, about every 6 months, to help review new developments relative to (all of) the WIPP CH TRU waste tests. They will also help contribute their expertise to assist in the evaluation and interpretation of test data and results from the WIPP tests, as available.

Details, WIPP programmatic impacts, and schedules of the bin-scale test program have also been presented to other review groups over the period of June to December 1989. These review and other associated organizations included the WIPP Panel of the National Academy of Sciences, the Environmental Evaluation Group based in New Mexico, the U.S. Environmental Protection Agency, and various U.S. DOE offices and review panels. The purposes of these multiple presentations have been to disseminate up to date test concepts and objectives, to receive technical and other inputs, to maximize the planned informational output to organizations that will use the test data, and to minimize any potential negative impacts on the overall WIPP program. Feedback comments, suggestions, and criticisms from these review meetings have also been incorporated into this Test Plan as appropriate.

### 3.6.2 Informal and In-House Peer Review and Contributors

Recognition is given to the following WIPP project personnel for reviewing and providing constructive comments and additions to the ROUGH DRAFT Test Plan: WIPP Bin-Scale CH TRU Waste Tests, dated May 8, 1989.

Sandia National Laboratories: L. H. Brush, P. A. Cahill, P. L. Jones, J. L. Krumhansl, J. T. McIlmoyle, S. Y. Pickering, G. E. Tucker, M. M. Warrant, and W. D. Weart.

Westinghouse WID: M. Bali, R. F. Cook, W. D. Greenlee, M. J. Leroch, and D. J. Moak.

IT Corporation: D. Deal and P. Drez.

Tech Reps, Inc.: R. L. Jones

Acknowledgments must also be given to all other, unnamed participants (Sandia National Laboratories, Westinghouse WID, DOE, and others) who helped in the preliminary formulation, scientific and engineering design, and other aspects of this test program.

## 4.0 TEST OVERVIEW

### 4.1 EXECUTIVE SUMMARY

This WIPP Bin-Scale CH TRU Waste Test is a multi-phase experimental plan intended to provide relevant composition and kinetic rate data on gas generation and consumption resulting from TRU waste degradation under WIPP repository relevant conditions. Actual CH TRU wastes being tested include both radioactive and hazardous-mixed wastes representative of the current (and planned near-future) output of various U.S. DOE waste generating facilities. Waste degradation and consequent gas production will be impacted by, and tested as a function of many variables: synergistic interactions due to multiple degradation modes; waste form types and processing procedures; long-term repository environmental effects; intrusion of different types and quantities of brines; different repository periods from the operational phase to the longer-term, post-closure period; engineered barrier materials in contact with the wastes such as salt, backfill and getter materials, perhaps grouts; and, possibly, engineered modifications or fixes (to be developed) that can reduce the quantities of gases to be generated or released. Gas samples will be obtained periodically from each test bin and quantitatively analyzed for gases generated by multiple waste degradation mechanisms and released as a function of time. Gases to be quantified also include potentially hazardous volatile organic compounds released by the wastes, of environmental safety and EPA RCRA (hazardous waste) concerns.

Test samples of waste-brine leachate solutions will also be periodically obtained from the bins and analyzed for radionuclide source-term concentrations, hazardous organic components and toxic metal concentrations, and for any impacts on migration due to organic or inorganic complexing agents mixed with the wastes. Solution data, as well as the gas data and results will be inputted directly to the WIPP PA modeling studies and also evaluated for EPA RCRA (hazardous waste) characterization impacts and concerns.

The WIPP bin-scale test program as currently defined involves the testing of about 600 drum-volumes of actual CH TRU wastes contained within about 124 separate test bins. A test bin is a specifically designed metal container to hold the wastes safely and allow for the periodic sampling of released gases and waste leachant liquids. It is not intended to be a transportation or waste disposal container. The test program also specifically includes an expansion capability (Phase 3) so that more bins can be added as required and tested in the next several years. This expansion capability is needed to accommodate (1) additional waste types (more than those currently shippable to the WIPP), (2) future processed waste types, engineered barriers or modifications than can significantly reduce the amount of gas to be generated, (3) tests that can incorporate and help resolve further desired characterizations for EPA RCRA or other regulatory and/or programmatic concerns, and (4) additional tests to reduce any unacceptably large, experimental uncertainties potentially indicated by initial results.

Bin-scale test data will be linked by geochemical modeling and predictive calculations with related data from the parallel laboratory and WIPP in situ alcove CH TRU waste test programs. The combined data from all three related test programs, laboratory, bin-scale, and in situ alcove tests, are required by the WIPP PA study. Full test details on waste types and engineered and other components to be used in this bin-scale test program are described in this document.

The quantitative data, results, and interpretations from these tests are required by the WIPP PA program. The performance of this bin-scale test program has been planned solely to obtain necessary data on radioactive and hazardous gas and leachate components potentially released, and their impacts on both the short-term and long-term safe operation and containment capability of the WIPP facility.

4.2 TEST OBJECTIVES

The overall objectives of this WIPP bin-scale CH TRU waste test program are to:

1. Quantify with a high degree of control gas generation- and depletion-rates, and compositions from actual TRU wastes, as a function of waste type, time, and interactions with brines and other repository natural and engineered barrier materials. Experimental conditions will represent, primarily, the longer-term, post-operational phase of the repository as well as the operational-phase. With the exception of VOCs, these tests will not quantify total gas generation potentials (quantities).

2. Provide a larger-scale evaluation and extension of the laboratory-scale test results, using actual TRU wastes under repository relevant, expected conditions. The use of accelerative, overtest conditions could bias interpretations and will not be permitted.

3. Evaluate the synergistic impacts of microbial action, varying degrees of brine saturation, waste compaction, degradation-product contamination, etc., on the gas-generation capacity and geochemical environment of TRU waste.

4. Incorporate representative long-term impacts of room closure and waste compaction on gas generation by including supercompacted wastes.

5. Evaluate effectiveness for minimizing overall gas generation by incorporating getter materials, waste form modifications, and/or engineered fixes into the CH TRU waste test system.

6. Measure solution-leachate, source-term radiochemistry and hazardous-constituent (i.e., organics, toxic metals) chemistry of brine-saturated TRU wastes, as a function of many credible environmental variables.

7. Determine the amount of volatile organic compounds and other hazardous gases released from the TRU wastes under realistic repository conditions, to quantify how EPA hazardous waste regulations will impact the WIPP.

8. Conduct detailed pretest and posttest waste characterizations of all wastes used in this program to quantify radioactive species, hazardous waste constituents, and overall waste matrix components. These characterizations are necessary to demonstrate both to what extent test wastes are representative of the behavior of all CH TRU wastes and to provide information needed in test data interpretations. Posttest waste characterizations will specifically quantify the total VOC source-term available in the tested waste materials.

9. Specifically determine to what extent the test wastes are "representative" of, and/or bracket, the RCRA constituent concentrations of the CH TRU wastes in storage at DOE waste generator sites that are to be isolated at WIPP. Wastes to be considered for WIPP emplacement and tested in this program must meet specifications of both the WIPP waste acceptance criteria and applicable transportation requirements.

10. Provide necessary gas-generation and -depletion data and source-term information in direct support of WIPP PA analyses, predictive modeling, and related evaluations, as well as for related EPA RCRA characterizations.

11. Help establish an acceptable level of confidence in the WIPP PA calculations. Help evaluate the validity of pertinent assumptions used in modeling. Help eliminate most "what if" questions and concerns.

## 5.0 INTRODUCTION

This Test Plan has been prepared at this time because of the special interest of the U.S. Department of Energy (DOE), National Academy of Sciences (NAS), the U.S. Environmental Protection Agency (EPA), and the Environmental Evaluation Group (EEG) based in New Mexico in those components of the planned WIPP Test Phase: Performance Assessment/5-Year Plan [US DOE, 1989a; Bertram-Howery and Hunter, 1989] experiments that will use actual, radioactive CH TRU wastes at the WIPP or at a DOE waste-generating or storage facility before they are shipped to the WIPP site. The interpreted test results will reduce uncertainties in the performance assessment by evaluating predictions of gas generation and of possible interactions of hazardous components of WIPP waste with other elements of the WIPP repository.

The Test Plan details why and how the experimental program measurements will be conducted and provides the technical justifications. It describes necessary procedures, techniques, and operations for the acquisition of data on TRU waste gas quantities, compositions, generation and consumption rates, and waste material-brine-leachate radiochemical measurements. Extensive variations are expected resulting from various modes of waste degradation, including brine and other engineered barrier interactions or modifications with the wastes.

Repository relevant data will be acquired from individual test bins, specific to respective waste types, as affected by combinations of various environmental variables and/or materials. The overall test design and test bin replication will allow the effects of almost all variables on gas production to be unfolded from that of other specific variables. These data are necessary for supporting the needs of performance assessment modeling- and predictive-calculations, specifically the WIPP PA repository room model dealing with gas generation [Bertram-Howery and Hunter, 1989].

Test data are also necessary and will be acquired for quantifying hazardous constituents potentially released from the actual TRU wastes during conditions of repository storage. These hazardous constituents include primarily volatile organic component gases, VOCs, such as carbon tetrachloride, other halogenated hydrocarbons, and similar organic solvents; they also include toxic (heavy) metals, e.g., lead, cadmium, mercury, etc., that could be leached from the waste materials in the long-term. The hazardous component VOC gases and toxic metals will be quantified in this test program and interpreted in relation to U.S. Environmental Protection Agency (EPA) hazardous waste regulations, i.e., 40 CFR 268, as applicable to the WIPP and the wastes permitted within. The test characterization process includes both pretest and posttest quantification of VOC concentrations in the test bin wastes.

## 5.1 BACKGROUND

Containers of transuranic wastes to be disposed of at the WIPP are a mixture of standard 210-liter (55-gallon) drums and a lesser number of TRU Standard Waste Boxes (SWB). These containers are filled with wastes from chemical and engineering research, development, and production facilities for the U.S. defense programs. The wastes are composed of: (1) laboratory hardware such as glassware, ring stands, piping, and other metal structures; (2) cellulosic materials such as towels, tissues, and wiping cloths; (3) protective gloves and clothing; (4) chemicals and inorganic process sludges, many of which are stabilized with cement; (5) various plastics, rubbers, and resins; (6) residual organic solvents, resulting in possible releases of VOCs; and, (7) worn out or contaminated engineering equipment and tools.

Generally, as soon as waste materials are placed in drums and boxes, they will begin to release gases. In the short-term, these gases are generated predominantly from radiolytic degradation of the wastes, and include hydrogen, oxygen (rapidly depleted in most cases), carbon oxides, and low-molecular-weight organic compounds [Zerwekh, 1979; Kosiewicz, 1979, 1981; Molecke, 1979]. Radiolysis of water and potentially intruding brines could also generate appreciable quantities of hydrogen (and oxygen) in the post-operational and long-term time periods, particularly from high-moisture content process sludges [Clements and Kudera, 1985]. Microbial degradation mechanisms are expected to be of potential major concern in both the short- and long-term time periods [Caldwell et al., 1987; Molecke, 1979]. Microbially generated gases include carbon dioxide or methane, [Caldwell et al., 1987; Molecke, 1979] potentially nitrogen from denitrification of nitrates (i.e., from the nitrates contained in inorganic process sludges), and hydrogen sulfide from sulfate-reducing bacteria [Brush and Anderson, 1988a]. Anaerobic (anoxic) metal corrosion in the post-operational and long-term periods could also generate significant quantities of hydrogen [Brush and Anderson, 1988a; Molecke, 1979]. No radioactive gases are generated, with the possible exception of radon from the decay of transuranic isotopes in the wastes. Note: Since hydrogen gas can be generated by several mechanisms, its source (mechanism) will not be readily apparent from the bin gas analyses. Bin data comparisons with laboratory test [Brush, 1989] results will be necessary to decouple effects and obtain a more thorough mechanistic interpretation.

Current, available data on gas generation rates from TRU-contaminated waste materials and simulants are summarized in Table 5.1, and are based on previous, WIPP-specific laboratory testing [Molecke, 1979; Caldwell, et al., 1987]. These measured values are presented for background, comparative information only. They were obtained in many cases from highly accelerated over-tests, conducted over relatively short time periods, i.e., 6 months or less, and have relatively large estimated uncertainties. As such, these laboratory data are not considered entirely appropriate for WIPP PA analyses; the database must be increased in size and the uncertainties greatly reduced. Further details and information concerning these laboratory results are found elsewhere [Molecke, 1979]. The gas generation data to be obtained in this WIPP bin-scale test program will be for realistic, repository-relevant environmental conditions, and will be obtained over periods of 5 years or more.

These intermediate- or bin-scale tests will use actual CH TRU wastes from various waste generator facilities that have been specially prepared, modified, and repackaged into special metal boxes or "bins" that have been specially designed for testing and gas and brine leachate sampling purposes. The specially prepared wastes contain additives to study the synergistic interactions between individual waste types, backfill and getter materials, metal corrodants, injected brines, and, as developed, modified waste forms and engineered fixes to minimize gas generation. These tests, to be conducted under closely controlled experimental conditions, will provide both repository relevant gas and brine-leachate radiochemical data. The bin-scale results will be both compared with and used to extend similar past [Zerwekh, 1979; Kosiewicz, 1979, 1980, 1981; Caldwell et al., 1987; Molecke, 1979] and current laboratory-scale [Brush, 1989] measurements (made on simulated waste materials), thereby reducing uncertainties in the data base, simplifying both analyses and interpretations of the data.

Table 5.1 Simulated TRU Waste Comparative Gas Generation Rates [data from Molecke, 1979 and #-Caldwell, et al., 1987]

| Mechanism | Waste Material/Matrix | Gas Production Limits (moles gas/year/drum) |
|---|---|---|
| MICROBIAL: | Organic Composite, aerobic | 0-(0.9-5.5)-12** |
| | Organic Composite, anaerobic | 0-(1.2-4.2)-32 |
| | Plywood Box,* aerobic | 0-(0.44-2.2)-3.0 |
| | Plywood Box,* anaerobic | 0-(1.1-3.7)-4.1 |
| | (Plywood Box, aerobic, 3.2 $m^3$) | 0-(2.8-14)-19 |
| | (Plywood Box, anaerobic, 3.2 $m^3$) | 0-(6.8-23)-26 |
| | Asphalt, aerobic | 0-(0.1-2.6)-8.4 |
| | Asphalt, anaerobic | 0-(0-1.9)-4.8 |
| | #Composite, aerobic, 1% water, 25°C | 1.3 |
| | #Composite, aerobic, 91% water, 25°C | 1.6 |
| | #Composite, aerobic, 91% brine, 25°C | --- |
| | #Composite, aerobic, 91% brine, 40°C | 5.2 |
| | #Composite, anaerobic, 1% water, 25°C | 2.4 |
| | #Composite, anaerobic, 91% water, 25°C | 4.2 |
| | #Composite, anaerobic, 91% brine, 25°C | 3.2 |
| RADIOLYSIS: | Cellulosics (0.039 Ci***) | 0.002-(0.005-0.011)-0.012 |
| | Polyethylene (0.039 Ci) | 0.003-(0.007)-0.008 |
| | PVC (0.039 Ci) | 0.01-(0.03-0.042)-0.08 |
| | Process Sludges (7.7 Ci) | 0.76 |
| | Organic Composite (0.039 Ci) | 0.002-(0.005)-0.006 |
| | Asphalt (7.7 Ci) | 0.1-(0.15-0.76)-1.0 |
| | Concrete-TRU Ash (poured, 15 Ci) | 0.03-(0.045-0.93)-1.0 |
| | Concrete-TRU Ash (heated, 15 Ci) | 0.0002-(0.0005-0.035)-0.05 |
| | Alpha Decay, He generation (15 Ci) | 0.000015 |
| CORROSION: | Mild Steel Drum*, anaerobic | 0-2.0 |
| | Mild Steel Drum*, aerobic | 0 |
| THERMAL | Organic Composite (25°C) | 0 |
| | Organic Composite (40°C) | 0-(0.02-0.2)-0.4 |
| | Paper (70°C) | 0.5-(1.3)-2 |
| OVERALL AVERAGE: | Existing INEL TRU Wastes, Aerobic | 0.0005-(0.3-1.4)-2.8 |

* drum volume = 0.21 $m^3$

** lower limit - (most probable range) - upper limit, with estimated uncertainties

*** 0.039 Ci = 0.5 g $^{wg}Pu$, 15.4 Ci = 200 g $^{wg}Pu$ (max./drum)

If the WIPP is approved for permanent waste disposal after the planned DOE 5-year test phase program [US DOE, 1989a], the standard WIPP operation will include several steps. Waste containers shipped to the WIPP will be placed in one of seven rooms in one of eight panels, and the rooms will be backfilled with appropriate materials. After all seven rooms in a panel are filled with drums or boxes of waste and backfilled, the panel will be sealed off from the rest of the repository with a fluid- and gas-tight seal. Any gas generated by the waste after a panel is sealed must be considered in the assessment of repository performance over the period of time required by the standards governing the disposal of radioactive waste. If test results warrant, consideration could be given to the venting of generated gases until final sealing of the repository, or to the use of other engineered fixes or modifications. The overall performance of the repository includes not only the room responses, but also the individual and coupled responses of panel seals, mine drifts, shaft seals, disturbed rock (fractured) zones around the shaft seals, and potential radionuclide transport through the upper aquifers to the accessible environment.

## 5.2 JUSTIFICATION

A major concern raised by gas released from the TRU wastes stored in the WIPP is the possible pressurization of the disposal room during room closure and terminal isolation of the waste. The total quantity of gases to be generated, and their rates of generation must be quantified, not assumed from possibly inappropriate data. WIPP PA must be able to adequately predict or evaluate the following concerns, including:

(1) Will the gas pressure be high enough to retard repository room closure?
(2) Will the gas pressure be sufficiently high to fracture the Salado formation?
(3) Will internal gas pressurization affect repository seal performance?
(4) Is there a realistic potential for interactions between released VOCs and either backfill material or the seal system?
(5) Will sufficient gas be generated to provide a pressurized environment that could release radioactivity during potential repository post-closure intrusion?

The gases released by stored radioactive wastes and their rates of generation as a function of repository time may significantly affect the assessment of radioactivity releases from the repository by human intrusion. For the confident evaluation of the effect of the gases on potential release scenarios, a relevant database that defines the appropriate chemical and microbial reactions and the amounts, compositions, and rates of gases generated is required. Similarly, data are also needed on hazardous components (gaseous VOCs, dissolved toxic metals) released from the wastes under repository conditions, in order to quantify impacts of EPA's hazardous waste (RCRA) regulations, 40 CFR 268, on the WIPP.

The present form of the EPA Standard for radioactive waste disposal, 40 CFR 191, requires that repository performance be predicted for 1,000 years for individual protection and for 10,000 years for containment. For these very long times, experimental testing in real time cannot be used to demonstrate performance. The Standard suggests that a probabilistic, predictive, mathematical approach be used, in which models or model segments are used to simulate, over time, the important processes identified by field exploratory research [Zerwekh, 1979; Clements and Kudera, 1985b]. Data also must be acquired for input to the probabilistic predictive models. When scenarios for the release of waste from the repository to the accessible environment have been identified and the appropriate probabilistic analysis completed for each scenario, a complementary cumulative distribution function (CCDF) will be constructed to show whether the repository, as designed, can be demonstrated to meet the EPA Standard.

Several kinds of data on the potential in situ behavior of CH TRU wastes are needed for WIPP PA modeling and analyses:

(1) Gas quantities, speciation, plus generation and depletion rates as a function of time, including the impacts of several other waste-condition parameters;
(2) Source term definition of leached or mobilized chemical, radiochemical, or dissolved toxic species, as affected by both the bin-internal gaseous atmosphere and potential chelating or complexing agents in leachate brines, either initially present in the actual wastes or formed by various degradation mechanisms; and,

(3) Systems interactions and synergisms occurring between all materials and mechanisms within the TRU waste container, etc.

The impacts of radiolytic, microbial, and chemical-corrosion degradation mechanisms on gas generation can be adequately analyzed and evaluated under known, controllable conditions in these planned bin-scale, radioactive TRU waste tests. Their extrapolation to full repository pressure and fluid-flow behavior will, however, continue to require numerical extrapolation of experimental results.

The analyzed brine leachate samples from individual bins may not provide "definitive" source term (thermodynamic) solubilities, but will provide realistic (not assumed) TRU species' (kinetic) concentrations as a function of time. These solubilities can be impacted by actual waste materials/TRU interactions with leached organic ligands or chelates and other gas atmosphere and chemical components, which could appreciably change solution pH and Eh. Fewer assumptions will, therefore, have to be made concerning species solubilities or solubility limits in subsequent PA calculations.

## 5.3 RATIONALE

The gas and water contents of TRU-waste disposal rooms could affect long-term performance, especially in the event of human intrusion. Current estimates of the rates of gas production by TRU waste are based on laboratory studies of processes such as radiolysis, microbial activity, corrosion, and thermal degradation [Zerwekh, 1979; Kosiewicz, 1979, 1980, 1981; Caldwell et al., 1987; Molecke, 1979], and field studies of head-space gases in drums conducted by Clements and Kudera [1985]. The extreme heterogeneity of CH TRU wastes resulting from the variety of waste streams exacerbates the difficulty of getting gas production data representative of the total waste mix. To do so requires large numbers of experiments, on multiple types of actual TRU wastes, conducted under closely controlled conditions.

In the past, gas generation did not seem critical to considerations of long-term performance of the WIPP. Calculations of the diffusive transport of gas out of the repository and into the surrounding Salado Formation [US DOE, 1980; SNL, 1979, pp. 3-43 - 3-64] implied that even if the high gas-production rates estimated by Molecke [Molecke, 1979] as upper limits were applicable, the gas permeability of the surrounding rock would be high enough to allow gas to escape without a significant increase in repository pressure. Recent, more definitive, far-field gas permeability measurements [Tyler et al., 1988, pp. 142-160], however, imply that high gas-production rates may significantly pressurize the repository. Thus, it has become necessary to resolve the differences between estimates of gas-production rates, to establish a realistic range of gas-production rates in the WIPP environment.

Recently, Brush and Anderson [1988a] calculated that processes such as drum corrosion, microbial decomposition of cellulosic materials, and reactions between drum-corrosion products and microbially generated gases could, in addition to affecting the gas budget of the repository, consume or produce quantities of water similar to recent predictions of brine influx from the Salado Formation.

Thus, it has become evident during the last year that a more complete, repository relevant database on gas evolution rates is critical to understanding and addressing the behavior and ultimate state of the repository; this is critical to many of the other scenarios. The TRU waste experiments described herein will provide a large segment of the database required to develop and enhance the understanding and confidence in comparisons to the EPA Standard.

## 5.4 APPROACH

The assessment of gas issues must consider three elements: (1) gas production, (2) gas consumption, and (3) gas transport. Gas is produced by radiolytic, chemical, and biological reactions between the waste, waste containers, engineered backfill, brine, and salt. Gas consumption, normally controlled by radiolysis, microbial degradation, and chemical/corrosion processes, can presumably be increased by including gas getter materials in the backfill component. Gas transport depends on the ability of the formation to accept the gas and allow it to disperse. At the WIPP, waste will be emplaced in a layered sequence of Salado evaporites consisting of pure to impure halite, including numerous marker beds of anhydrite, clay, and polyhalitic halite. The primary parameter controlling gas transport, both in the disturbed rock zone and in the region outside that affected by the repository, is gas permeability of the geologic formation. Gas permeability differs for various gases in different stratigraphic units and as a function of relative saturation of gas and brine. The issue of gas transport and the response of the WIPP to elevated internal gas pressures can be and is being addressed without waste, but gas production and consumption are strong functions of the waste itself.

Laboratory experiments [Brush, 1989] will provide detailed kinetic data on individual mechanisms of concern and will provide a major focus for numerical extrapolation of experimental results. However, to accurately measure net gas production and consumption under realistic condition, actual radioactive wastes must be used. Thus, data needed for the performance assessment models can only be obtained from the combination of laboratory tests (small-scale, simulated waste), [Brush, 1989; Zerwekh, 1979; Kosiewicz, 1979, 1980, 1981; Caldwell et al., 1987; Molecke, 1979] intermediate, bin-scale tests (described herein), and large, alcove (field) tests [Molecke,1989b; Bertram-Howery and Hunter, 1989]. Resultant data from all of these experimental programs, when coupled with model development, will be used to assess the importance of gas in the repository. The strong interrelationships between the three types of experimental programs, and the perceived benefits and disadvantages of each program are summarized below.

The on-going laboratory-scale tests, [Brush, 1989] in combination with earlier lab test results, [Zerwekh, 1979; Kosiewicz, 1979, 1980, 1981; Caldwell et al., 1987; Molecke, 1979] will provide a large proportion of the early data. These tests will provide detailed information on each degradation mode of gas generation and on the efficacy for minimizing gas production for various getter materials, waste form modifications, and/or other engineering fixes to be developed.

Laboratory tests have the following distinct <u>advantages</u>:

1. They are easier than field tests to set-up and control experimentally.
2. They can incorporate the effects of more test variables, and analyze the impacts of each variable separately on gas production.
3. They can be safely conducted at high-pressures, similar to repository lithostatic pressures, about 15 MPa or higher. Because of test safety concerns and constraints on the bin-scale and alcove test programs, only

the laboratory testing program can provide the gas high-pressure results needed.

4. They can evaluate speciation and solubilities of Pu, Am, U, and Th as a function of Eh and pH, including the effects of individual getter materials on Eh and pH.
5. They can specifically address the biodegradation of VOCs, of concern in EPA 40 CFR 268.

Laboratory tests also have the following significant <u>disadvantages</u>, however:

1. They use simulated, not actual TRU wastes.
2. They do not contain unknown materials that will be present in the WIPP waste inventory, e.g., organic compounds and solvents, chelating agents, etc.
3. They are performed on a very small-scale relative to a repository, making scaling-factor effects a significant unknown.
4. They don't contain the same microbial inoculants as found in actual TRU wastes.
5. The impacts of radiolytic production on the anaerobic (anoxic) corrosion of steels cannot be addressed.
6. Total synergistic reactions and interactions of all real-waste components are not present.
7. The laboratory test system is too simplistic and may not adequately represent the repository for a thoroughly credible PA analyses.

The bin-scale tests described herein are similar in scope to the laboratory tests, examine most of the parameters of the laboratory tests, provide data on gas generation and getter effectiveness, and help evaluate and extend the results of the lab tests to more complex geometries and environments. The bin-scale tests may be viewed as larger-scale laboratory experiments, except that they have the following distinct <u>advantages</u>:

1. They incorporate actual radioactive and hazardous-mixed TRU wastes, including minor chemical components, organic compounds and solvents, and microbial contaminants that could have a very significant impact on overall gas generation and source-term radiochemistry.
2. There are few test simulations or required assumptions.

3. All test components, waste forms, contaminants, and possibly engineered fix materials (applied to the waste and/or backfill materials, to reduce gas production) are all interacting in a synergistic, repository relevant environment, in which various modes of gas generation occur simultaneously, as opposed to the more simplistic laboratory studies.
4. The larger scale of the test bins, incorporating about 6 drum-volumes of wastes each, help smooth out the known nonhomogeneities among supposedly similar waste types.
5. The total test matrix can be expanded as necessary, to incorporate new waste forms, backfill and getter materials, and engineered modifications, as they are developed and are ready for testing, or simply to improve experimental statistics, should early results prove more heterogeneous than expected. All wastes to be tested must, by definition, meet the requirements of both transportation and WIPP waste acceptance criteria.
6. These tests can provide data rapidly compared to the alcove tests, consistent with present WIPP PA schedules.

The bin-scale test program has the following significant disadvantages:

1. Tests cannot be conducted at high gas pressures.
2. Not all repository environmental effects can be fully incorporated, as they can be in the alcove tests.
3. The performance of bin-scale tests at the WIPP is linked to first receipt of waste.
4. Tests can only examine limited interactions between waste types.

The WIPP in situ alcove CH TRU waste tests, [Molecke, 1989] will be conducted under credible, expected-case repository conditions, relevant to both the operational phase and longer-term, post-operational phase. The major advantages of the alcove tests follow:

1. Tests will provide "real-world" data, with the fewest simulations or restraints of any of the test programs that could potentially bias the end results.
2. Only alcove tests incorporate the environmental, possibly synergistic effects of the repository itself, e.g., gases and fluids released from the host rock salt, salt mine geochemistry and biochemistry, etc., on waste degradation rates and modes.

3. Assessments will determine the gas generation rates for the times of interest, and incorporate how the gases will either be consumed or transported from the disposal room through the geology or fractures therein.
4. There are no significant scaling effects due to the size of the test alcoves, (approximately 1/4 full scale).
5. Many waste forms are mixed together in the same test alcove, as would be the case in an operating repository.

The major <u>disadvantages</u> of the alcove tests follow:

1. The inability to test at high gas pressures because of underground facility safety concerns.
2. The number of test alcoves available is small, significantly limiting the number of test variables and test replicates that can be incorporated.
3. The combination of many waste types within each test alcove makes interpretations of the effects from each type or degradation mechanism almost impossible -- without comparison to other test program data.
4. The large volume of each test alcove, plus the initial trapped gas (air or nitrogen), decreases the analytical sensitivity for gases of interest being produced -- small changes in the quantity of produced gases may be masked.
5. The expected rates of production for individual gases, and changes in those rates, may not be clearly evident for an appreciable period of time, particularly when compared to gases generated and analyzed in the smaller test bins.
6. There is no human access to the alcoves after test initiation. Potential, future engineering modifications cannot be added after the test begins.

The added degrees of experimental control, assumed increased sensitivity and selectivity for gas analyses, and the increased number of test conditions or variables to be used in the bin-scale tests, relative to the alcove tests, allows the interpretation of obtained data to be simpler and more straightforward than that from the alcove tests. As such, the bin-scale tests provide a technically more satisfying and rapid means of obtaining data.

Collecting test data from any of these tests must not be simply a monitoring or confirmatory activity. Data must be used for both analytical and predictive performance assessment modeling calculations and for comparison with smaller-scale laboratory data on simulated wastes. It must be emphasized that it is the combined suite of CH TRU waste test programs, laboratory, bin-scale, and alcove, that is required to provide the full spectrum of information and expertise needed for the WIPP PA program. The three experimental programs must be linked with both geochemical modeling and studies of the response of the WIPP to elevated gas pressures, should these be generated. Each test program has its own significant advantages and disadvantages. None of the three test programs alone can credibly produce the required information.

The laboratory tests [Brush, 1989; Bertram-Howery and Hunter, 1989] were initiated in FY 89 and will be conducted in parallel with the WIPP bin-scale and in situ alcove [Molecke, 1989b] tests, both of which will begin in FY 90. These parallel test programs will proceed concurrently and will be sequenced to permit the early laboratory results to have some impact on the configuration of the bin-scale tests, and vice versa. For example, backfill getter additives to be evaluated in laboratory tests for gas and brine sorption capability would be selected and evaluated by the end of FY 90 [Lappin, 1989a], then subsequently evaluated for in situ efficacy in Phases 2 and 3 of the bin-scale tests (to be described later). Also, preliminary brine-leachate results from the bin-scale tests could be used to help "focus" laboratory evaluations of radionuclide chemistry into specific ranges of test conditions as quickly as possible [Lappin, 1989a]. Initial results from both the laboratory and bin-scale tests could be used to help redefine the starting test parameters of the alcove tests on an alcove by alcove basis, assuming that the wastes and other test materials had not already been loaded, the alcove sealed (from access), and testing in that specific alcove initiated. Results from the alcove tests are not currently anticipated to have much feedback to the laboratory and bin-scale tests because of their later schedule sequencing and emplacement -- with the possible exception of later contingency additions to Phase 3 of the bin-scale tests.

### 5.5 OPTIONS ON BIN-SCALE TEST LOCATION

It is not mandatory on a scientific basis that these bin-scale tests be conducted at the WIPP. The waste-filled test bins do not directly experience the impacts of the repository environment on waste degradation, as do the parallel in situ alcove CH TRU waste tests [Molecke, 1989]. It is mandatory, however, that these tests provide most of the required data to the WIPP Performance Assessment modeling effort in the necessary time frame, before the end of FY92 [Bertram-Howery and Hunter, 1989]. Due to uncertainties in current WIPP opening and waste availability schedules, options for conducting these bin-scale tests at other U.S. DOE sites, e.g., the Rocky Flats Plant, the Idaho National Engineering Facility, and possibly others have been investigated. The merits, technical relevance, schedule feasibility, and expenses for the other site options are still being evaluated. The following possibilities are also being evaluated: (a) conducting portions of the bin-scale test program at alternate sites, then moving them to the WIPP as appropriate, or (b) conducting bin tests at alternate sites for waste forms that are not currently transportable to the WIPP, e.g., high-activity wastes from the Savannah River Site.

Conducting the bin-scale tests underground at WIPP is by far the best choice or option based on the deciding factors listed in Table 5.2. The WIPP site and other sites are compared in this Table; deciding factors are listed in approximate descending order of importance.

Table 5.2 Deciding Factors and Options For Bin-Scale Test Location

| Favored Site | Deciding Factors: |
|---|---|
| W (= WIPP) | 1. Time Availability to Meet WIPP PA Needs |
| W | 2. Test Set-up and Instrumentation Time |
| W | 3. Isolation from the Accessible Environment |
| W | 4. In Situ Temperature Control (2$^{\circ}$C range) |
| W | 5. Availabilities of Test Facilities, Buildings |
| W | 6. Minimization of Overall Test Expenses |
| W | 7. Programmatic Concerns, Site Relevance |
| W provided | 8. SNL-WIPP PI and Instrumentation Control |
| W provided | 9. Data Acquisition and Control Systems |
| W | 10. Minimization of Travel, Key Personnel |
| W, O (= Other) | 11. Test Radiological Safety and Control |
| W, O | 12. Technical Personnel, Training & Availability |
| W, O | 13. Analytical Instrumentation and Availability |
| O, W | 14. Legislation and Permitting Uncertainties |
| O | 15. Waste Transportation Concerns |

## 6.0 BIN-SCALE TEST TECHNICAL SUMMARY

The primary purpose of this WIPP Bin-Scale CH TRU Waste Test program is to provide relevant data and technical support to the WIPP Performance Assessment program for both predictive modeling studies and for the assessment of hazardous component release, and consequent impacts on the WIPP, in relation to EPA concerns and regulations, i.e. 40 CFR 191 and 40 CFR 268. Specific data to be obtained include the quantities, compositions, and kinetic rate data on gas production and consumption resulting from various CH TRU waste degradation mechanisms. Similar data on potentially hazardous volatile organic compounds released by the wastes will also be provided. Concentrations of radioactive species (source-term radiochemistry), toxic metals, and dissolved organic compounds in the waste-brine leachate (in a limited population of bins) will also be quantified as a function of time. Actual radioactive and hazardous-mixed CH TRU wastes will be used in these tests. Further information on test objectives, rationale, and justifications can be found in Sections 4 and 5.

Net gas quantities and generation rates are expected to be significantly impacted by, and will be measured as a function of:

1. Several representative classifications and types of CH TRU wastes. All wastes to be used in this test program must meet the specifications of both transportation requirements and the WIPP waste acceptance criteria.
2. Time (periodically, over several years).
3. Impacts of several types and quantities of intruding brines.
4. Impacts of waste interactions with salt, container metals, backfill materials, and, possibly, grouts.
5. Aerobic and anaerobic environment conditions representative of the operational-phase and longer-term, post-operational-phase of the repository, respectively.
6. Impacts of potential gas getter materials or other engineered alterations and modifications, particularly on gas production or consumption.

The waste gas production results will also include synergisms between the various degradation modes, radiolysis, microbial, and chemical, including corrosion. Different test conditions are tailored so that the effects of individual environmental variables on gas production can be separated from the effects of other variables.

Periodically collected gas samples from each test bin will be analyzed using an on-site, gas chromatograph-mass spectrometer (GC-MS) instrument to determine major and minor gas concentrations (including VOCs), and changes in those compositions as a function of time. The GC-MS analyses of all gases released at a concentration level above 1 ppm allows the calculation of their rates of generation and/or depletion to be made. Evaluating the changes in gas compositions helps to determine the relative importance and kinetics of individual degradation mechanisms over time, and of the subsequent impacts of degradation by-products on further gas production. The gas analysis system will be described in some detail in Section 11.2 The important major gases to be analyzed, based on earlier, WIPP-specific laboratory testing, [Zerwekh, 1979; Kosiewicz, 1979, 1980, 1981; Caldwell et al., 1987; Molecke, 1979] include: hydrogen, carbon dioxide, carbon monoxide, methane, oxygen, water vapor, nitrogen, and specific-injected tracer gases. Minor gases to be quantified potentially include: volatile organic compounds (VOCs, e.g., carbon tetrachloride, methylene chloride, xylenes, freons, and other organic solvents used at DOE waste generating facilities), radon, ammonia, hydrogen sulfide, nitrogen oxides, hydrogen chloride, and possibly others, as detectable. The major gases are primarily those generated or consumed by various waste degradation mechanisms occurring within the test bin, or simply those remaining from the initial air atmosphere. Other, minor gases may be sorbed in or on the wastes and eventually can be volatilized, or can be generated by multiple minor chemical and microbial waste degradation mechanisms.

Gas data collection will be initiated as soon as each test bin is emplaced, prepared, and sealed. Data and analyses from ongoing tests will be incorporated into the WIPP PA calculations as available, on a near-continuous basis. These tests are expected to start providing significant data within weeks to months after test emplacement. Bin-scale testing will continue for a minimum of about 5 years, or until the data acquired are sufficient to provide confidence in the reliability of the information being obtained. It is presently assumed that these tests must continue until the experimental results lead to interpretations reliable to about the 95 % level of confidence. It is recognized, however, that: (a) this objective may not be reasonable in all instances, and (b) this high level of confidence may not be required by WIPP

PA under all test conditions. At specific periods within the testing program, data will be analyzed and evaluated for input to ongoing PA studies. At appropriate test intervals, approximately annually, data will be fully evaluated and documented in topical reports.

Brine-waste leachate samples from some of the test bins will also be periodically collected and will be analyzed for solubilized species of interest as a function of time including: concentrations of transuranic radionuclides, both dissolved and in colloidal form; total activity; dissolved toxic metals of concern to EPA hazardous waste regulations, e.g., Pb, Hg, Cd, Cr, As, Se, Ba; chelated radioactive species; brine pH; etc. Brine leachate analyses will be conducted off-site. Further details on the brine leachate, analyses, and associated topics, are found in Section 11.3.

This bin-scale TRU waste program involves testing in multiple, large, instrumented metal "bins" with specially prepared TRU wastes and appropriate material additives. Each WIPP test bin will be specially prepared and filled with TRU wastes at various U.S. DOE waste generator sites, then will be shipped to the WIPP for in situ testing. Each bin will function as a nominally independent, isolated, and controlled test system. All test bins are planned to be isolated at WIPP within one underground test room, Room 1 of Panel 1. The possibility exists that Room 2 of Panel 1 may be required for later, anticipated portions of the test program, Phase 3, to be described. Therefore, Room 2 must be reserved for this purpose now.

The following bin-scale test conditions must also be incorporated:

1. The scope and scale of the test must be adequately large to obtain the quantities and types of data needed. Test wastes must be statistically representative of the entire DOE waste inventory that will be shipped to, and isolated at the WIPP. Therefore: (a) waste characterizations must eventually be extended to all significant TRU waste types (in storage or generated at DOE facilities), and (b) any significant waste types not initially included (e.g., high-activity wastes from Savannah River) must be incorporated in the test program (Phase 3) as they become available, if they meet the appropriate regulations.
2. All TRU wastes emplaced in the WIPP during this test program must be in a retrievable mode. At the conclusion of the testing, all bin-scale wastes

will be, or will be modified as necessary, to be retrieved. Options for posttest waste disposal are discussed in Section 14.2.

3. Pretest (Section 8.3.1) and posttest (Section 14.1) waste quantification of VOCs and other hazardous or toxic components will be conducted to help provide baseline levels, for comparing with and evaluating concentrations measured during the course of testing.
4. Facility operations and procedures must be realistically utilized.
5. Conduct of the test must be controlled so that personnel and radiological safety are maintained.

The "specially prepared" wastes to be incorporated in this test include up to about six drum (55-gallon) volume-equivalents of specific types of actual CH TRU wastes. Four representative waste types have been selected for testing in the initial phases of this program:

1. HONG, high-organic/newly generated wastes, both noncompacted and supercompacted (from the Rocky Flats Plant).
2. LONG, low-organic/newly generated wastes, both noncompacted and supercompacted (from the Rocky Flats Plant).
3. HOOW, high-organic/old wastes.
4. PS, inorganic process sludges.

Further waste details, specifications, and assumptions will be presented in Section 8.1. Details on the required pretest waste characterization procedures for all wastes used in this test program are described in Section 8.3.1.

The advantage of testing the in situ degradation behavior of supercompacted wastes is that such wastes are expected to be very similar to regular, noncompacted wastes that have been crushed/compacted in situ by long-term salt-creep closure of repository rooms. Although these tests will simulate the geometric effects of long-term compaction, they may not adequately simulate the time-dependent relation between corrosion and compaction or between microbial degradation and compaction. Impacts on gas generation caused by compaction can thus be realistically evaluated during the course of these tests, then factored into the performance assessment calculations. Most high-organic ("soft") and low-organic ("hard," primarily metals and glasses) newly generated wastes at the Rocky Flats Plant will be supercompacted starting in 1990, and continuing thereafter. As such, these wastes will constitute a major fraction of TRU wastes to be shipped to the WIPP in the future. Other representative wastes, e.g., high-activity, organic sludges, specially processed -- as developed by the waste generators, waste types not currently shippable, waste types requiring further hazardous-waste (RCRA) characterizations, etc., may be defined and tested in a planned Phase 3 of this test program. These waste types will incorporated on an "as available" basis, if their inventory and characterization indicate a chance for them to have a statistically significant impact on WIPP repository behavior.

Bin-scale test moistness conditions are defined as:

1. "Dry." This is the expected case in the short-term, i.e., before the wastes come to equilibrium with the surrounding Salado formation.
2. "Moistened" with Salado brine, about 1% by volume of waste. This is the expected case within several years, and for a long period of time.
3. "Saturated" with Salado brine. This is a probable case in the long-term. Experimental restraints limit "saturation" to be about 10% added brine by volume. This amount should suffice to provide free brine (leachate) available for periodic sampling and analyses (Section 11.3).
4. "Saturated" with Castile brine. This is a possible occurrence in the long-term, assuming human intrusion into a sealed repository.

The potential implications of these moistness conditions on both the short- and long-term periods of repository isolation on (a) waste degradation, (b) gas production, and (c) brine intrusion are described further in Section 10.3

All brines will be injected into the test bins at the WIPP facility. Further details on the brines are found in Section 10.3. All excess brines will be removed from the bins as part of the posttest waste characterization, as part of the test termination procedures (Section 14.2).

Various backfill and gas getter materials have been selected for testing, to evaluate their impacts on gas production and consumption and for impacts on waste-brine-leachate solution radiochemistry and possibly hazardous-component chemistry. Backfill combinations and emplacement geometry are to be representative of the post-operational phase, when CH TRU waste containers are no longer expected to be intact, when the wastes and container materials will be layered with the salt and backfill materials. Selected backfill and getter materials are: (1) none, (2) WIPP rock salt, (3) rock salt and bentonite clay (70%/30%), (4) salt/bentonite and gas and/or radionuclide getter additives, to be specified later, and (5) salt/others, e.g., grouts, to be defined later. The definition of getter materials and other backfill materials is dependent on ongoing laboratory [Brush, 1989] testing and development. When available, these materials will be added to the bin-scale test matrix. Refer to Section 10.1 for further details.

The internal atmosphere of each test bin is initially controlled and is to be representative of TRU wastes in both the short-term, post-emplacement period (aerobic), and later, time periods, assumed anaerobic (anoxic). Initial bin atmospheres can be modified with a combination of argon gas flushing and the use of an oxygen-gettering reactant system. Atmosphere control techniques are described in Section 11.1. ALL test waste bins will also be injected with inert, nonradioactive tracer gases. These tracer gases help facilitate analysis and interpretation of the data by allowing a gas mass/volume balance to be conducted. Potential gas leakage outflow or inflow can thus be compensated for.

The study of potential anaerobic corrosion of metals within the wastes, as impacted by other ongoing degradation mechanisms, is one of the significant objectives of this test. As such, the initial internal atmosphere within most of the test bins will be made anaerobic; thereafter, production of gases from various degradation mechanisms will control whether each bin stays anaerobic. The results of tests in which the oxygen concentration/oxidation potential are allowed to find their own "equilibrium" level are extremely important. The present estimates of total gas production assume that anaerobic corrosion of metals in the waste (and their containers) will produce more than 50 % (~ 900 moles gas/drum) of the expected gas-generation potential within the WIPP (~ 1500 moles/drum). The corrosion of steels and other metals under aerobic or inadequate anaerobic conditions, in contrast, does not generate any gas.

CH TRU HONG wastes will generate their own anaerobic $H_2$ and $CO_2$ atmosphere by means of radiolysis, primarily. However, there is some uncertainty that the bin internal atmosphere will become anaerobic during the available time interval of this program. Therefore, most HONG waste bins will be purged and made anaerobic at the start of the test. CH TRU HOOW and LONG wastes will also be purged initially with argon gas until anaerobic. During repackaging of HOOW wastes into test bins, the (assumed) previously established anaerobic environment is replaced by air. Purging these test bins establishes an anaerobic atmosphere similar to the original environment, as presumably generated by both microbial and radiolytic degradation mechanisms. No initial gas flushing for the inorganic PS wastes will be conducted. The radiolytic depletion or production of oxygen from the PS wastes will be quantified along with other released gases.

Most plastic bags encapsulating CH TRU wastes within test bins will be "pre-breached," that is, multiply-punctured and/or sliced during the packaging procedures (refer to Section 8.3.2). Pre-breaching procedures will be conducted at the generator/preparer facilities. The waste "pre-breaching" permits both the release of gases and contact between and interactions of the wastes with injected brines, resident colonies of halophilic, halotolerant, and/or nonhalophilic bacteria, internal humidity, and the other added material components within the bin. The "pre-breaching" operation is beneficial for both testing and transportation purposes.

There will also be a limited number of test bins where no waste pre-breaching will be conducted. These test bins, with "as received" wastes, will have no added brine nor other added components. They will be conducted with an initial, internal air (aerobic) environment. These bins are intended to provide gas release data applicable solely to the short-term, operational phase of the WIPP repository, in comparison to most of the other test bins, initially made anaerobic, that provide gas production data specific to the post-operational phase. The "as received" bins are directly parallel to similar WIPP alcove tests, [Molecke, 1989b] also with "as-received" wastes, in test alcove TA2. Other pertinent details on all CH TRU waste packaging in bins, special preparations, any added materials, etc. are discussed in Section 8.3.

The leak-tight bins will have a closely controlled and sealed test environment, similar to an isolated, waste-filled repository room. Each bin is equipped with redundant gas sampling and injection ports, redundant brine injection and sampling ports. Each bin is also equipped with integral, non-gas-sorbing particulate filters, so as to not impact the quantification of

VOCs. As such, any gases sampled or released will not contain particulate radioactive contamination. Further details on the gas sampling and brine sampling details are found in Sections 11.2 and 11.3, respectively. Associated test bin instrumentation includes remote-reading: thermocouples, pressure gages, pressure-relief valves, gas flow/volume monitors, and oxygen-specific detectors; these instruments are discussed in Section 12.1. Each test bin and associated instruments are periodically and closely controlled and monitored by a computerized data acquisition system; this is discussed in detail in Section 12.2.

The "test bins" are specifically designed to fit within a TRU Standard Waste Box, SWB, for both transportation to the WIPP and eventual posttest disposal. The SWBs, with test bins inside them, are transported within a TRU-PACT-II shipping cask. The test bin is NOT to be regarded as a transportation or terminal disposal container, it is to be used for testing purposes only. Further details on the test bins are found in Section 9.

This bin-scale test program is planned to take place in three phases. Phase 1 can be initiated at WIPP in FY90 and will incorporate test bins where all components can be presently defined. The backfill materials will be: none, salt, or salt/bentonite. Approximately 48 waste-filled bins of different waste compositions and backfills, including replicates, will be included in Phase 1. There will also be 8 other, empty, Phase 1 test bins used for both pressure and gas baseline-reference purposes during the course of the test program. These 8 non-waste containing bins will be emplaced and hooked up in the WIPP in an early time frame, prior to first waste receipt. They will also be used to initiate, checkout, and debug the test program, i.e., instrumentation, gas sampling, routine operations, etc., before test bins with actual TRU wastes are emplaced. The eight baseline-reference bins will be kept in test operation, with periodic gas sampling, during the entire course of this test program.

Phase 2 tests will incorporate another 68 waste-containing bins, with more moisture conditions, with gas getter materials, and with the supercompacted high-organic and low-organic wastes. Initiation of much of Phase 2 is dependent on supporting laboratory data, [Brush, 1989], particularly as to the composition of gas getters or other backfill material components; it is also dependent on the availability of supercompacted wastes. Phase 2 tests are not anticipated to start sooner than about early FY 91.

Phase 1 and 2 of the WIPP bin-scale CH TRU test program incorporate an anticipated total of 124 test bins, including about 608 drum-volume equivalents of actual CH TRU wastes. Of these 124 test bins, 28 are basically dedicated to acquiring gas production data applicable to the short-term, operational phase of the WIPP repository and 88 are applicable to the longer-term, post-operational phase. A complete summary of all Phase 1 and 2 test bins, added components, and other specifics, are listed in Table 8.3.

A Phase 3 of the test program is also defined but cannot be described or quantified in detail at this time. Phase 3 test bins are required to accommodate all potential test contingencies. They will include any other processed waste forms, backfill materials, and/or getter materials that may be defined and developed in the future. If any engineered modifications or fixes (to the wastes and/or the backfill materials) to reduce gas production are similarly defined in the future, they will also be tested for efficacy with actual TRU wastes in this program. Future needs for additional test bins and drum-volumes of actual CH TRU wastes will be based on: upcoming developments, preliminary test results, perceived data needs, and/or possible WIPP project decisions. Details of Phase 3 tests will be incorporated into future, separate addenda to this Test Plan.

It must be clearly recognized, however, that there may be some potential overlap between initiation of the various phases of this test program. Individual waste types of interest, e.g. incinerated wastes, grouted wastes, high -activity wastes, etc., (originally planned for Phase 3 testing) may be added to the test program as soon as they are certified for transportation and also meet the WIPP waste acceptance criteria. A fundamental objective of this test program is to generate statistically reliable data and results from inherently nonhomogeneous wastes. Therefore, the numbers of test bins specified in this Test Plan are probably minimum values. Again, all future changes to the details contained in this Test Plan will be documented in separate addenda.

Detailed test planning for the bin-scale tests continued through late 1989, followed by procurement actions. Site preparation, including any necessary test preparation and installation also began during 1989 and will continue for about one year. First data acquisition for these tests is anticipated to start during FY90.

Further descriptions and technical details of these WIPP bin-scale CH TRU waste tests will be provided in the following Sections of this Test Plan. Other information, including engineering designs, work packages, and details that may be updated frequently, even after the test program has started, will be described or included in the Appendices to this Test Plan, Section 18. Updatable segments of the Appendices will be included with the SNL QA records documentation for this WIPP test program, not bound together with the main body of the Test Plan.

## 7.0 PHYSICAL PLAN OF TEST ROOM

All in situ test activities for these bin-scale CH TRU waste tests, Phase 1 and Phase 2, will take place in Room 1 of Panel 1 of the WIPP waste storage area. This room has as-mined dimensions of 4.0 m-high by 10 m-wide by 91.4 m-long (13 ft x H 33 ft x 300 ft). The location of Room 1 of Panel 1 is illustrated in Figure 7-1. This test room will contain all Phase 1 and Phase 2 test bins, auxiliary hardware, and the supporting data acquisition and control instrumentation shed (DAS). Approximately 120 test bins can be stacked and tested in Room 1.

Phase 3 of this test program, when initiated, will require additional space for additional test bins. This required additional space necessitates that all of Room 2 Panel 1 also be allocated for the Phase 3 tests. This Room 2 location, also illustrated in Figure 7-1, will permit necessary instrumentation cabling from the Phase 3 bins to the DAS shed in Room 1 to be kept to an absolute minimum length. Instrumentation requirements for individual Phase 3 bins are expected to be the same as those for Phase 1 and 2 bins. Should individual Phase 3 bins become available early in the test program, they will simply be added to, or intermingled with the ongoing tests in Room 1 of Panel 1.

The test bins, to be described in Section 9.1, will be located about 3 to 4 ft from the salt ribs, on approximate 8-foot centers and stacked two levels high, in specially designed support fixtures or stands (refer to Section 9.2). A major feature of this bin stacking arrangement is that it will allow easy forklift access to individual bins, down the wide center access path, should it become necessary to retrieve individual bins during the course of the test. This general layout of the bins and the instrument shed is illustrated in Figure 7-2.

Other bin stacking arrangements have been suggested, such as stacking two rows of bins down the center of the test room(s). This arrangement was proposed in order to avoid all degree of floor fracturing known to occur near the room ribs as a function of time. The center arrangement, however, limits access to the bins to two relatively narrow paths adjacent to the room ribs. A radiological and safety assessment evaluation is currently being conducted

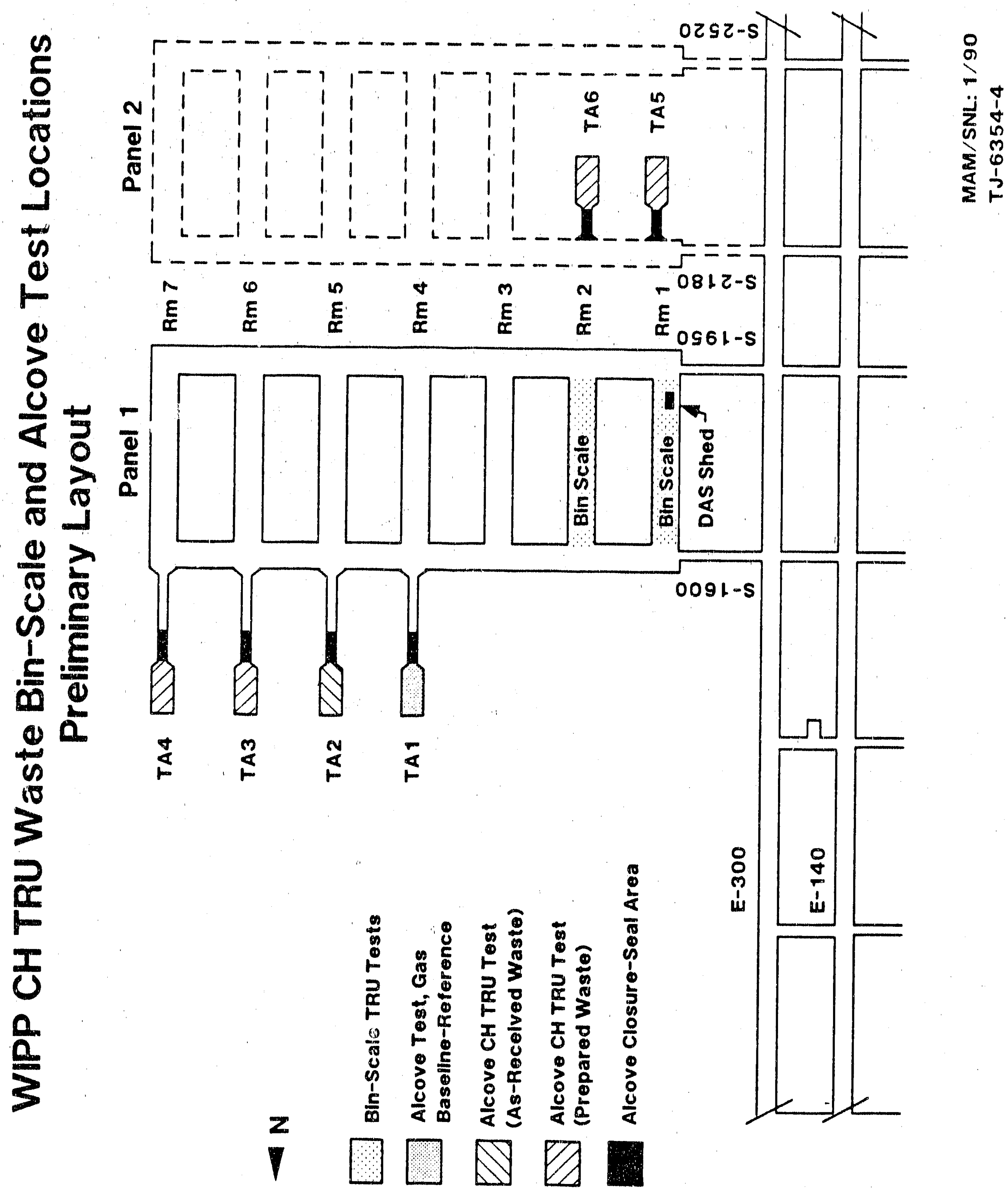


Figure 7-1 Location of Bin-Scale Test Room, Plan View

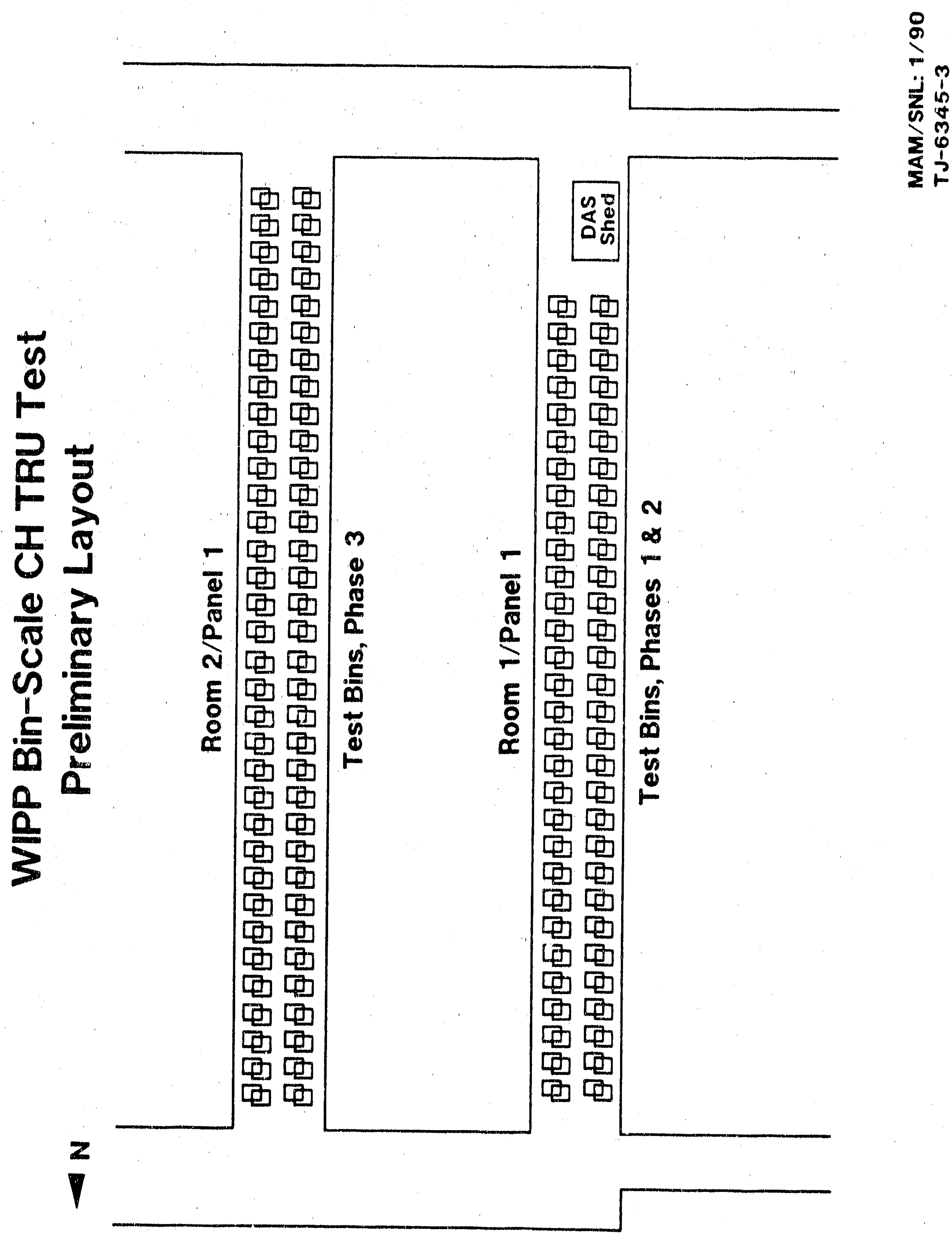


Figure 7-2 WIPP Bin-Scale Test Room, Plan View

to determine the relative safety merits of both proposed bin layouts. The final (optimized) stacking layout will be determined on the basis of the safety evaluations. Until such safety assessments are completed, the bin layout, and illustrations thereof in this Test Plan will not be altered.

The DAS instrumentation shed, 13.5 ft-wide by 31.7 ft-long, will be located in the southwestern corner of Room 1. The shed will be aligned along the long-axis of the room, standing about 3 to 4 ft away from the west rib, and about 10 ft north of the bottom end of the room. In this location, the shed will be out of the main travel path for forklift (or other) vehicles carrying waste bins into the test room. Installation of the shed requires a level, compacted salt foundation pad, and an adequate source of electric power. Purposes and contents of the DAS shed will be described in Section 12.2.1.

Rooms 1 and 2 of Panel 1 have already been mined. Room preparation and outfitting requirements, to be provided by WID, follow:

1. Adequate test room ventilation. This consists of standard mine ventilation flow-through air and exhaust air ducts to collect and channel gases released from the test bins to the mine exhaust system. The exhaust air ducts must have appropriate connections to the test bins; a WID EWP will be required for this ductwork system.

2. Radiological safety and control. There will be continuous air, particulate radioactivity, monitors (CAM), for personnel safety; refer to Section 16.2. The room is located within the WIPP Radioactive Materials Area, RMA. There will be administrative controls as far as personnel access and monitoring procedures, based on current WIPP standard operating procedures. Again, refer to Section 16.2.

3. Adequate test room lighting and electrical support. Installed lighting must provide adequate illumination to the test rooms; all fixtures must be spark and explosion proof for safety. Electrical support includes providing power outlets throughout the test area. A WIPP system grounding bus must also be provided for safety purposes. All test bins will be electrically grounded by attachment to this grounding bus, with the use of grounding clamps or other devices.

4. Rock-bolting. The roof, or back, of this test room area has already been rock bolted for stability and safety during the WIPP pilot-phase period.

5. Floor and rib preparation. The floor of the test rooms shall be adequately firm and level, to allow transport of machinery (e.g., forklift trucks) and the stable emplacement of bin stands, bins, and the DAS instrumentation shed. No other special floor preparations are required. Since all emplaced bins and the DAS shed are located about 3 to 4 ft. from the salt ribs, no special rib requirements are needed. The current condition of the ribs in Room 1 and Room 2, Panel 1, is satisfactory.

# 8.0 CH TRU WASTES

## 8.1 TYPES AND QUANTITIES OF TEST CH TRU WASTES

The CH TRU wastes tested in this bin-scale program must be representative of the major fraction of CH TRU wastes to be isolated eventually at the WIPP facility during normal operating procedures, i.e., those expected after the initial 5-year test phase period [US DOE, 1989a], regardless of the sources of these wastes. Actual CH TRU test wastes to be emplaced must, on an overall basis, include:

1. A representative quantity and mixture (distribution) of waste types/classifications, as produced at U.S. DOE waste generating facilities. Refer to Tables 8.1 and 8.2. Statistical evaluations of both waste characteristics and gas-generation and brine-leachate behavior must be adequate to support the estimation of the (assumed similar) behavior of all significant waste streams from the DOE waste generating facilities.

2. A representative blend of transuranic and hazardous waste types, including both hazardous-mixed and non-mixed TRU wastes as defined by EPA RCRA regulations. Specifically selected, nonhazardous "innocuous" mixtures of wastes are not allowable; the scientific credibility of this test program must be maintained.

3. Representative waste Curie loadings.

Descriptions or specifications on CH TRU waste types, their pretest and posttest characterizations in regard to radionuclide content and hazardous waste regulations, applicable caveats, relationship to transportation requirements, etc., are more fully addressed below and in Section 8.2.

The CH TRU waste types to be emplaced and tested at WIPP, in Phases 1 and 2 of this program, will include:

1. HONG, high-organic/newly generated wastes, both standard and supercompacted.
2. HOOW, high-organic/old wastes, standard noncompacted.

3. LONG, low-organic/newly generated wastes, both standard and supercompacted.

4. PS, inorganic process sludge wastes, usually dewatered and cemented.

The wastes include both standard, noncompacted wastes (from several waste generators) and supercompacted wastes, as will be produced at the Rocky Flats Plant, RFP. Supercompacted TRU wastes include both "soft" high-organic wastes and "hard" low-organic wastes, primarily glasses and metals. For purposes of this test program, "newly generated" is defined to include wastes generated and packaged within 2 years of their shipment to the WIPP. The majority of such newly generated wastes are expected to originate at RFP. "Old wastes" are defined to be those generated 5 years or more before shipment to WIPP, and are retrievably stored. The majority of such old wastes are expected to originate, or be stored, at the Idaho National Engineering Laboratory, INEL. "New" and "old" wastes are specifically defined and separated in this test program for the express purpose of evaluating radiolytic degradation and gas production differences among the organic-matrix wastes. Other technical caveats on these age specifications are described in Section 8.2.1. Other appropriate details, differences, and availabilities of "newly-generated and old wastes" are described in Section 8.2.

All TRU wastes shipped to the WIPP must meet the criteria and limitations specified in the WIPP Waste Acceptance Criteria (document) [US DOE, 1989c]. At the conclusion of the test phase, test wastes must also be brought into compliance with the WIPP Waste Acceptance Criteria, as required. Also, all test wastes (bins) must be transportable within, and be included in, the existing and planned TRUPACT-II certification limits, as licensed by the Nuclear Regulatory Commission. The TRUPACT-II shipping cask imposes certain limitations on the types of TRU wastes; only TRU waste content codes (categories) described in the TRUPACT-II Content Codes (TRUCON) document, [US DOE, 1989b] are shippable at present. The broad CH TRU waste types specified above, HONG, HOOW, LONG, and PS wastes, require some cross-categorization with the TRUCON codes. Table 8.1 gives the desired types of wastes to be included in this test in terms of TRUCON waste types and codes [US DOE, 1989b]. Mixed PS/HONG wastes described in Section 8.2, will be included as Type III, category 127 mixed wastes [Drez, 1989]. All wastes to be loaded into an individual test bin, and replicates of that test bin, must be of essentially the same waste type -- have the same TRUCON category number.

## Table 8.1

### WIPP CH TRU Test Wastes: TRUCON Codes Cross-listing

| WIPP Test Type | TRUCON Designation: Waste Type | Content Codes (description) |
|---|---|---|
| HONG | III (solidified organics, newly generated) | 116A (combustible wastes)<br>119A (filters; mostly organic)<br>121A (organic solid waste)<br>123A (leaded rubber; gloves)<br>125A (combustible & noncombus.)<br>126A (cemented org. process solids)<br>127A (organic/mixed wastes) |
| HOOW | III (solidified organics, retrievably stored) | 216A (combustible wastes)<br>219A (filters; mostly organic)<br>221A (organic solid waste)<br>223A (leaded rubber; gloves)<br>225A (combustible & noncombus.)<br>226A (cemented org. process solids)<br>227A (organic/mixed wastes) |
| LONG | II (solid inorganics, newly gen. & [old]) | 115A [215A] (graphite waste; equipment)<br>117A [217A] (metal waste)<br>118A [218A] (glass waste)<br>122A [222A] (inorganic solid waste)<br>124A [224A] (pyrochemical salt waste) |
| PS | I (solidified aqueous or homogeneous inorganic, new and [old]) | 111A [211A] (cemented/dewatered sludges)<br>114A [214A] (cement.inorg. particulates) |

Most existing TRUCON content codes will be included in this bin-scale test program. TRUCON waste content codes not listed in Table 8.1 are currently excluded because they (a) are of a low percentage compared to other waste types, (b) are expected (based on previous laboratory test [Molecke, 1979] results) to have a minimal gas-generation potential, in both the short- and long-term, or (c) are not presently shippable. The small percentage waste types, therefore, need not be tested in an in situ test at this time; laboratory testing appears more appropriate.

Other representative waste types do exist or may be proposed, e.g., high-activity wastes (primarily from the Savannah River Site), organic sludges, specially processed -- as developed by the waste generators or proposed by others, waste types not currently shippable, waste types requiring further hazardous-waste (RCRA) characterizations, etc. If, however, any of these or other waste forms become significant, transportable, and viable for future waste isolation at the WIPP, they will be added and tested in Phase 3 of this test program on an "as available" basis, as mentioned earlier.

Based on a preliminary analysis [Batchelder, 1989] of wastes existing at both RFP and INEL, and extrapolated to exist through the year 2013, a percentage distribution of waste types was calculated and is listed in Table 8.2. Percentages are based on drum-volume (55 gallon) equivalents.

Table 8.2 Available CH TRU Waste Type Distributions

| | | |
|---|---|---|
| High-Organic, Newly Generated | | 32.6 % |
| High-Organic, Old Waste | | 12.7 % |
| (High-Organic, Total = | | 45.3 %) |
| Low-Organic Wastes | (New + Old) | 39.2 % |
| Process Sludges | (New + Old) | 15.5 % |
| TOTAL = | | 100.0 % |

All of the CH TRU wastes to be tested will be either "as-received" or "specially prepared." The "as-received" wastes consist of several types of either newly generated (unpackaged) or repackaged wastes that are emplaced into the test bins in unbreached plastic bags, with no added brine nor other added components; no intentional punctures in the plastic bags will be allowed. They will be conducted with an initial, internal air (aerobic) environment, with the exception of "as-received" HOOW bins that have an argon atmosphere (inside the bin, but outside the individual waste bags). For the most part, these bins are intended to provide gas release data applicable solely to the short-term, operational phase of the WIPP repository, in comparison to most of the other test bins, initially made anaerobic, that will provide gas production data specific to the post-operational phase. These "as received" test bins are directly parallel to similar WIPP alcove tests [Molecke, 1989a] also with "as-received" wastes, in test alcove TA2. The "as-received" test bins are listed and summarized in Table 8.3.

The "specially prepared" wastes are, for the most part, representative of the longer-term, post-operational phase conditions of the WIPP repository, when waste containers have become breached (corroded or crushed open), and mixed/layered with surrounding salt, backfill and other materials, remains of corroded container materials, and also moistened with intruding brines. All of the "specially prepared" wastes are repackaged into WIPP test bins (Section 9.0). In order to be representative of these expected, longer-term conditions, waste "preparation" includes: (a) pre-breaching (multiply puncturing and/or slicing) internal, individual waste packaging bags for most waste types; (b) adding backfill and getter materials; (c) adding metal corrodants approximately equal in surface area to the drums originally containing the wastes, instead of the original drums; (d) injecting different types and amount of brine; and, (e) appropriately preparing the initial, bin internal gas atmosphere. All these "preparation" details are described in Section 8.3, materials to be added will be described in detail in Section 10, and internal bin atmosphere modifications are described in Section 11.1. The "specially prepared" test bins are also listed and summarized in Table 8.3.

As stated earlier, the scope and scale of this bin-scale test program must be adequately large to collect the types and quantities of data needed for the WIPP PA program calculations and evaluations. Data needs must be tempered somewhat in that all combinations of waste types, backfill materials, getter materials, brine types and quantities, and gas atmospheres cannot be realistically tested in situ. There are limitations on test needs

Table 8.3a Summary of WIPP Test Bin Specifications

Phase 1:

| Bin # | Waste Type | Brine Type | Brine Volume | Backfill, Getter, Other Materials | | Initial Atmosphere |
|---|---|---|---|---|---|---|
| TB001 | Empty | None | --- | None | | Air |
| TB002 | Empty | None | --- | None | Pressure | Air |
| TB003 | Empty | None | --- | None | Baseline- | Argon |
| TB004 | Empty | None | --- | None | Reference | Argon |
| TB005 | Empty | None | --- | None | | Air |
| TB006 | Empty | None | --- | None | Gas | Air |
| TB007 | Empty | None | --- | None | Baseline- | Argon |
| TB008 | Empty | None | --- | None | Reference | Argon |
| TB009 | HONG | Dry | --- | None | Operatnl.- | Air |
| TB010 | HONG | Dry | --- | None | Phase | Air |
| TB011 | HONG | Dry | --- | None | Reference- | Argon |
| TB012 | HONG | Dry | --- | None | Case | Argon |
| TB013 | HONG, | As-Received | --- | None | Short- | Air |
| TB014 | HONG, | As-Received | --- | None | Term | Air |
| TB015 | HONG, | As-Received | --- | None | Reference- | Air |
| TB016 | HONG, | As-Received | --- | None | Case | Air |
| TB017 | LONG, | As-Received | --- | None | Short-Term | Air |
| TB018 | LONG, | As-Received | --- | None | Reference | Air |
| TB019 | LONG | Dry | --- | None | Operatnl.- | Argon |
| TB020 | LONG | Dry | --- | None | Phase | Argon |
| TB021 | LONG | Dry | --- | None | Reference- | Argon |
| TB022 | LONG | Dry | --- | None | Case | Argon |
| TB023 | PS, | As-Received | --- | None | Short-Term | Air |
| TB024 | PS, | As-Received | --- | None | Reference | Air |
| TB025 | PS | Dry | --- | None | Operatnl.- | Air |
| TB026 | PS | Dry | --- | None | Phase | Air |
| TB027 | PS | Dry | --- | None | Reference- | Air |
| TB028 | PS | Dry | --- | None | Case | Air |
| TB029 | HONG | Dry | --- | Salt | | Argon |
| TB030 | HONG | Dry | --- | Salt | | Argon |
| TB031 | HONG | Salado | 12 L | Salt | | Argon |
| TB032 | HONG | Salado | 12 L | Salt | | Argon |
| TB033 | HONG | Salado | 120 L * | Salt | | Argon |
| TB034 | HONG | Salado | 120 L * | Salt | | Argon |
| TB035 | HONG | Castile | 120 L * | Salt | | Argon |
| TB036 | HONG | Castile | 120 L * | Salt | | Argon |
| TB037 | HONG | Dry | --- | Salt/Bentonite | | Argon |
| TB038 | HONG | Dry | --- | Salt/Bentonite | | Argon |
| TB039 | HONG | Salado | 12 L | Salt/Bentonite | | Argon |
| TB040 | HONG | Salado | 12 L | Salt/Bentonite | | Argon |
| TB041 | HONG | Salado | 120 L * | Salt/Bentonite | | Argon |
| TB042 | HONG | Salado | 120 L * | Salt/Bentonite | | Argon |
| TB043 | HONG | Castile | 120 L * | Salt/Bentonite | | Argon |
| TB044 | HONG | Castile | 120 L * | Salt/Bentonite | | Argon |
| TB045 | LONG | Dry | --- | Salt/Bentonite | | Argon |
| TB046 | LONG | Dry | --- | Salt/Bentonite | | Argon |
| TB047 | LONG | Salado | 12 L | Salt/Bentonite | | Argon |
| TB048 | LONG | Salado | 12 L | Salt/Bentonite | | Argon |
| TB049 | LONG | Salado | 120 L * | Salt/Bentonite | | Argon |
| TB050 | LONG | Salado | 120 L * | Salt/Bentonite | | Argon |

(continued) [* = leachant sampling]

Table 8.3b Summary of WIPP Test Bin Specifications (continued)

| Bin # | Waste Type | Brine Type | Brine Volume | Backfill, Getter, Other Materials | | Initial Atmosphere |
|---|---|---|---|---|---|---|
| | | | Phase 1 (continued): | | | |
| TB051 | PS | Dry | -- | Salt/Bentonite | | Air |
| TB052 | PS | Dry | -- | Salt/Bentonite | | Air |
| TB053 | PS | Salado | 40 L | Salt/Bentonite | | Air |
| TB054 | PS | Salado | 40 L | Salt/Bentonite | | Air |
| TB055 | PS | Castile | 40 L | Salt/Bentonite | | Air |
| TB056 | PS | Castile | 40 L | Salt/Bentonite | | Air |
| | | | Phase 2: | | | |
| TB057 | HOOW, As-Received | | -- | None | Short- | Argon |
| TB058 | HOOW, As-Received | | -- | None | Term | Argon |
| TB059 | HOOW, As-Received | | -- | None | Reference- | Argon |
| TB060 | HOOW, As-Received | | -- | None | Case | Argon |
| TB061 | HOOW | Dry | -- | None | Operatnl.- | Argon |
| TB062 | HOOW | Dry | -- | None | Phase | Argon |
| TB063 | HOOW | Dry | -- | None | Reference- | Argon |
| TB064 | HOOW | Dry | -- | None | Case | Argon |
| TB065 | HOOW | Dry | -- | Salt/Bentonite | | Argon |
| TB066 | HOOW | Dry | -- | Salt/Bentonite | | Argon |
| TB067 | HOOW | Salado | 12 L | Salt/Bentonite | | Argon |
| TB068 | HOOW | Salado | 12 L | Salt/Bentonite | | Argon |
| TB069 | HOOW | Salado | 120 L * | Salt/Bentonite | | Argon |
| TB070 | HOOW | Salado | 120 L * | Salt/Bentonite | | Argon |
| TB071 | HOOW | Castile | 120 L * | Salt/Bentonite | | Argon |
| TB072 | HOOW | Castile | 120 L * | Salt/Bentonite | | Argon |
| TB073 | HONG | Dry | -- | Salt/Bent/Getter | | Argon |
| TB074 | HONG | Dry | -- | Salt/Bent/Getter | | Argon |
| TB075 | HONG | Salado | 12 L | Salt/Bent/Getter | | Argon |
| TB076 | HONG | Salado | 12 L | Salt/Bent/Getter | | Argon |
| TB077 | HONG | Salado | 120 L * | Salt/Bent/Getter | | Argon |
| TB078 | HONG | Salado | 120 L * | Salt/Bent/Getter | | Argon |
| TB079 | HONG | Castile | 120 L * | Salt/Bent/Getter | | Argon |
| TB080 | HONG | Castile | 120 L * | Salt/Bent/Getter | | Argon |
| TB081 | HOOW | Dry | -- | Salt/Bent/Getter | | Argon |
| TB082 | HOOW | Dry | -- | Salt/Bent/Getter | | Argon |
| TB083 | HOOW | Salado | 12 L | Salt/Bent/Getter | | Argon |
| TB084 | HOOW | Salado | 12 L | Salt/Bent/Getter | | Argon |
| TB085 | HOOW | Salado | 120 L * | Salt/Bent/Getter | | Argon |
| TB086 | HOOW | Salado | 120 L * | Salt/Bent/Getter | | Argon |
| TB087 | HOOW | Castile | 120 L * | Salt/Bent/Getter | | Argon |
| TB088 | HOOW | Castile | 120 L * | Salt/Bent/Getter | | Argon |
| TB089 | PS | Dry | -- | Salt/Bent/Getter | | Air |
| TB090 | PS | Dry | -- | Salt/Bent/Getter | | Air |
| TB091 | PS | Salado | 8 L | Salt/Bent/Getter | | Air |
| TB092 | PS | Salado | 8 L | Salt/Bent/Getter | | Air |
| TB093 | PS | Castile | 8 L | Salt/Bent/Getter | | Air |
| TB094 | PS | Castile | 8 L | Salt/Bent/Getter | | Air |

(continued) [* = leachant sampling]

Table 8.3c Summary of WIPP Test Bin Specifications (continued)

| Bin # | Waste Type | Brine Type | Brine Volume | Backfill, Getter, Other Materials | Initial Atmosphere | |
|---|---|---|---|---|---|---|
| | | | Phase 2 (continued): | | | |
| TB095 | HONG-SC | Dry | -- | Salt/Bentonite | Argon | |
| TB096 | HONG-SC | Dry | -- | Salt/Bentonite | Argon | (SC = |
| TB097 | HONG-SC | Salado | 8 L | Salt/Bentonite | Argon | Super |
| TB098 | HONG-SC | Salado | 8 L | Salt/Bentonite | Argon | Compacted |
| TB099 | HONG-SC | Salado | 40 L | Salt/Bentonite | Argon | Wastes) |
| TB100 | HONG-SC | Salado | 40 L | Salt/Bentonite | Argon | |
| TB101 | HONG-SC | Castile | 40 L | Salt/Bentonite | Argon | |
| TB102 | HONG-SC | Castile | 40 L | Salt/Bentonite | Argon | |
| TB103 | HONG-SC | Dry | -- | Salt/Bent/Getter | Argon | |
| TB104 | HONG-SC | Dry | -- | Salt/Bent/Getter | Argon | (SC = |
| TB105 | HONG-SC | Salado | 8 L | Salt/Bent/Getter | Argon | Super |
| TB106 | HONG-SC | Salado | 8 L | Salt/Bent/Getter | Argon | Compacted |
| TB107 | HONG-SC | Salado | 40 L | Salt/Bent/Getter | Argon | Wastes) |
| TB108 | HONG-SC | Salado | 40 L | Salt/Bent/Getter | Argon | |
| TB109 | HONG-SC | Castile | 40 L | Salt/Bent/Getter | Argon | |
| TB110 | HONG-SC | Castile | 40 L | Salt/Bent/Getter | Argon | |
| TB111 | LONG-SC | Dry | -- | Salt/Bentonite | Argon | |
| TB112 | LONG-SC | Dry | -- | Salt/Bentonite | Argon | |
| TB113 | LONG-SC | Salado | 8 L | Salt/Bentonite | Argon | |
| TB114 | LONG-SC | Salado | 8 L | Salt/Bentonite | Argon | |
| TB115 | LONG-SC | Salado | 40 L | Salt/Bentonite | Argon | |
| TB116 | LONG-SC | Salado | 40 L | Salt/Bentonite | Argon | |
| TB117 | PS/HONG | Dry | -- | Salt/Bentonite | Argon | |
| TB118 | PS/HONG | Dry | -- | Salt/Bentonite | Argon | |
| TB119 | PS/HONG | Salado | 10 L | Salt/Bentonite | Argon | |
| TB120 | PS/HONG | Salado | 10 L | Salt/Bentonite | Argon | |
| TB121 | PS/HONG | Salado | 10+60 L* | Salt/Bentonite | Argon | |
| TB122 | PS/HONG | Salado | 10+60 L* | Salt/Bentonite | Argon | |
| TB123 | PS/HONG | Castile | 10+60 L* | Salt/Bentonite | Argon | |
| TB124 | PS/HONG | Castile | 10+60 L* | Salt/Bentonite | Argon | |
| | | | [* = leachate sampling] | | | |
| | | | Phase 3 (To Be Defined): | | | |
| TB125 | ....... | | | ....... | | |
| TB126 | ....... | | | ....... | | |
| ⋮ | Alternate Wastes | | | Other Backfill Materials, TBD | | |
| ⋮ | Processed Wastes | | | Other Getter Materials, TBD | | |
| ⋮ | Other Wastes, TBD | | | Engineered Modifications, TBD | | |
| ⋮ | Additional Wastes for Statistical Purposes, Etc. | | | | | |
| TB??? | ....... | | | ....... | | |

versus realities of limits on manpower, funding, operations, etc. There is also the desire to limit the quantities of CH TRU wastes to be emplaced and tested in this program to a reasonable minimum, consistent with the statistical reliability of the test results. Only those wastes required to provide an adequate data base on gas generation and brine-leachate radiochemistry will be used. Test wastes types selected do not identically match the (expected repository loading) percentages shown in Table 8.2; waste types and test conditions have been chosen to evaluate the situations where the most gases are expected to be generated, based on past test experience (Section 5.1). The selected overall, limited test matrix of waste types, materials, brines, and other conditions is presented in Figures 8-1, 8-2, 8-3, and 8-4, for HONG, LONG, HOOW, and PS waste types, respectively, and summarized in Table 8.3. The bin number-designations in Table 8.3 are for reference only; it is not implied that the bins must be emplaced in this specific order.

Blank columns and rows are retained in the matrices in Figures 8-1, 8-2, 8-3, and 8-4 to illustrate some of the limitations/deletions as described below, conducted to minimize the total number of required test bins.

1. In almost all cases, it has been assumed that duplicate, rather than triplicate or quadruplicate, testing under each specific set of conditions will be adequate. Therefore, the numbers of test bins specified in this Test Plan are probably minimum values. As stated previously, if any test additions or changes are proposed in the future, again, they will be both justified and documented in separate Test Plan addenda.

2. All entries in the "moist Castile" rows were eliminated because the "saturated Castile" condition is considered much more likely in the event of potential human intrusion of the repository. Differences in gas generation due to brine moistness and brine "saturation" will be obtained with the Salado brine conditions.

3. All brine moistness conditions were eliminated in the "none" backfill column. In the short-term, operational phase of the repository, before waste containers become breached, the waste materials will remain essentially dry and not in contact with any backfill or salt materials.

4. There are both "salt" and "salt/bentonite" backfill columns, so that differences in gas generation caused by the bentonite component can be readily distinguished. With the exception of the HONG waste test matrix, however, all entries in the "salt" backfill column have been deleted, to minimize the number of bins.

5. Most "moist brine" condition columns were eliminated for the PS waste test matrix. PS wastes can contain 50% or more of sorbed (not free) water. Addition of relatively small amounts of brine can increase the total moisture content to essentially "saturated" conditions.

This bin-scale test program is planned to take place in three phases. Phase 1 tests can be initiated in FY 90 and will incorporate test bins where all components can be presently defined. Approximately 48 waste-filled bins of different waste compositions and backfills, including replicates, will be included in Phase 1. There will also be 8 other, empty Phase 1 test bins used for both pressure and gas baseline-reference purposes.

## WIPP CH TRU Waste Bin-Scale Test Matrix

### High-Organic/Newly Generated (HONG)

Argon Purged/Anaerobic
*Non-Purged/Aerobic

| Moisture Condition | None (Operational Phase) | Salt (Longer-Term Phase) | Salt/Bent. | Salt/Bent. & Getter | Salt/Bent. (SuperCompacted) | Salt/Bent. & Getter (SuperCompacted) | |
|---|---|---|---|---|---|---|---|
| | First Phase | | | Second Phase | | | |
| Dry | 4* As-received: 2* / 2 | 2 | 2 (possible) (long-term) | 2 | 2 | 2 | expected case, short-term |
| Moist Castile | 0 | 0 | 0 | 0 | 0 | 0 | not expected (test in lab only) |
| Moist Salado | 0 | 2 | 2 | 2 | 2 | 2 | expected |
| Saturated Salado | 0 | 2 | 2 | 2 | 2 | 2 | probable |
| Saturated Castile | 0 | 2 | 2 | 2 | 2 | 2 | possible, human intrusion |

Backfills

| HONG Bin Totals | |
|---|---|
| 1st Phase | 24 |
| 2nd Phase | 24 |
| | 48 |

MAM/SNL: 10/89

Figure 8-1 WIPP Bin-Scale HONG Test Waste Matrix

## WIPP CH TRU Waste Bin-Scale Test Matrix

### Low-Organic/Newly Generated (LONG)

| Moisture Condition | First Phase: None | First Phase: Salt | First Phase: Salt/Bent. | Second Phase: Salt/Bent. & Getter | Super-Compacted: Salt/Bent. |
|---|---|---|---|---|---|
| Dry | 2* As-Received<br>4 | 0 | 2 | 0 | 2 |
| Moist Castile | 0 | 0 | 0 | 0 | 0 |
| Moist Salado | 0 | 0 | 2 | 0 | 2 |
| Saturated Salado | 0 | 0 | 2 | 0 | 2 |
| Saturated Castile | 0 | 0 | 0 | 0 | 0 |

Backfills

Argon Purged/Anaerobic

*Non-Purged/Aerobic

| LONG Bin Totals | |
|---|---|
| 1st Phase | 12 |
| 2nd Phase | 6 |
| | 18 |

MAM/SNL: 10/89

Figure 8-2 WIPP Bin-Scale LONG Test Waste Matrix

## WIPP CH TRU Waste Bin-Scale Test Matrix

### High-Organic/Old Waste (HOOW)

**Second Phase**

**Argon Purged/Anaerobic**

(to minimize impacts of repackaging on internal atmosphere)

| Moisture Condition | None | Salt | Salt/Bent. | Salt/Bent. & Getter |
|---|---|---|---|---|
| Dry | 4 As-received<br>4 | 0 | 2 | 2 |
| Moist Castile | 0 | 0 | 0 | 0 |
| Moist Salado | 0 | 0 | 2 | 2 |
| Saturated Salado | 0 | 0 | 2 | 2 |
| Saturated Castile | 0 | 0 | 2 | 2 |

Backfills

— Reference Case (Dry row)

| HOOW Bin Totals | |
|---|---|
| 1st Phase | 0 |
| 2nd Phase | 24 |
| | 24 |

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Figure 8-3 WIPP Bin-Scale HOOW Test Waste Matrix

## WIPP CH TRU Waste Bin-Scale Test Matrix

### Processed Sludge (PS)

Waste is PS 40%/ HONG 60% (side-by-side) — applies to Second Phase

| Moisture Condition | None (First Phase) | Salt (First Phase) | Salt/Bent. (First Phase) | Salt/Bent. & Getter (Second Phase) | Salt/Bent. (Second Phase) |
|---|---|---|---|---|---|
| Dry | 2 As-received<br>4 | 0 | 2 | 2 | 2 |
| Moist Castile | 0 | 0 | 0 | 0 | 0 |
| Moist Salado | 0 | 0 | 0 | 0 | 2 |
| Saturated Salado | 0 | 0 | 2 | 2 | 2 |
| Saturated Castile | 0 | 0 | 2 | 2 | 2 |

Backfills

"Dry As Received" is MOIST

Non-Purged

Moist Castile and Moist Salado: delete, in favor of saturated cases

| PS Bin Totals | |
|---|---|
| 1st Phase | 12 |
| 2nd Phase | 14 |
| | 26 |

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Figure 8-4 WIPP Bin-Scale PS Waste Test Matrix

Phase 2 tests will incorporate another 68 waste-filled bins, with more moisture conditions, with gas getter materials, and with supercompacted high-organic and low-organic wastes. It was assumed that older, stored TRU (HOOW) wastes may require more repackaging and transportation concern than newly generated wastes. As such, all HOOW wastes are scheduled to be packaged, emplaced, and tested at WIPP in Phase 2 of this test program. Initiation of much of Phase 2 will be dependent on supporting laboratory schedules and data [Brush, 1989], particularly as to the composition and quantities of gas getters or other backfill material components and the availability of supercompacted wastes. Phase 2 tests would not be anticipated to start sooner than about early FY 91.

The Phase 1 and 2 designations for each test bin are also illustrated in Figures 8-1 through 8-4. The bin totals included in each phase are summarized in Table 8.4 (revised). There are a total of 28 of the 124 test bins dedicated to the operational-phase of the repository. These bins do not contain any added brine or backfill materials. They are listed in in the first column of Figures 8-1 through 8-4 and are summarized in Table 8.3 (as "short-term reference" or "operational-phase" tests). Conversely, there are a total of 88 of the 124 bins dedicated to the longer-term of the repository lifetime, when brine, backfills, getter materials, and an anaerobic environment must be assumed to be in contact with the TRU wastes.

Eight of the 124 test bins contain no TRU wastes, they are used to obtain baseline-reference data, for background comparison to the waste-filled bins. Four of these bins are for pressure baseline-reference purposes; two are filled with air, two are filled with argon gas, with all at an initial, positive pressure of 0.25 psi differential (Sections 11.1.3, 12.1.2). The other four of these bins are for gas baseline-reference purposes, to monitor any potential air/oxygen permeation or leakage into the bins or depletion of of any gases, primarily oxygen, due to reaction with test hardware or simply leakage outflow. Two of the gas baseline-reference bins are filled with air, two are filled with argon gas, with all at 0.25 psi differential.

These 8 non-waste containing bins are to be emplaced and hooked up in the WIPP in the Spring of 1990 (see Table 13.1) to start the performance of the bin-scale test program, prior to first waste receipt at WIPP. They will also be used to specifically initiate, checkout, and debug the test system, i.e.,

Table 8.4 WIPP Bin-Scale CH TRU Waste Test Quantities

| | Phase 1 | | Phase 2 | | |
|---|---|---|---|---|---|
| HONG: High-Organic (Newly Generated) | 24 | | 24 | | |
| LONG: Low-Organic (Newly Generated) | 12 | | 6 | | |
| PS: Inorganic Process Sludges | 12 | | 14 | | |
| HOOW: High-Organic (Old Waste) | 0 | | 24 | | |
| Empty/Pressure-Reference Bins | 4 | | 0 | | |
| Empty/Gas-Reference Bins | 4 | | 0 | | |
| Phase 1 and 2 GRAND TOTALS: | 56 | + | 68 | = | 124 BINS |
| Phase 3 Tests: | (TBD) | | | | ?? BINS |

Table 8.5 WIPP Bin-Scale Test Required Drum-Volumes of Wastes

| | Phase 1 & 2 Bin Totals | Drum-Volumes | Phase 3 (TBD) |
|---|---|---|---|
| HONG: Noncompacted | 32 | 216 | |
| HONG: Supercompacted | 16 | 64 | |
| LONG: Noncompacted | 12 | 72 | |
| LONG: Supercompacted | 6 | 24 | |
| HOOW: | 24 | 144 | |
| PS: | 26 | 88 | |
| Empty/Pressure-Ref.: | 4 | 0 | |
| Empty/Gas-Reference: | 4 | 0 | |
| TOTALS: | 124 BINS | 608 DRUMS | |
| Phase 3 Tests: | ?? BINS | (TBD) | |

instrumentation, gas sampling, routine operations, etc., before test bins with actual TRU wastes are emplaced.

Table 8.5 lists the approximate total drum-volume equivalents of each category of CH TRU wastes used in Phases 1 and 2 of this test. These numbers are based on assuming about 6 drum-volumes of noncompacted (HONG, HOOW, and LONG) wastes per bin, and 4 drum-volumes of process sludge or supercompacted wastes per bin. There are also about 3 HONG and 2 PS drum-volumes per bin for each of the PS/HONG mixed bins listed in Figure 8-4. There is, therefore, a grand total of about 608 drum-volumes of CH TRU wastes used in the first two phases of this program.

A Phase 3 of the test program is also defined but cannot be described or quantified in detail at this time. Phase 3 test bins are defined and required to accommodate all potential test contingencies. They will include any other alternate or processed waste forms, backfill materials, and/or getter materials that may be defined and developed in the future. Some additional bin testing may also be required if early experimental results indicate more heterogeneous behavior, i.e., significantly large variations in gas results between replicate bins, than is presently expected. As any engineered modifications or fixes to reduce gas production are similarly defined in the future, they will also be tested for efficacy with actual TRU wastes in this program phase. Future needs for additional test bins and drum-volumes of CH TRU wastes will be based on: (a) upcoming developments, (b) preliminary test results, (c) perceived data needs, and/or (d) possible WIPP project decisions. It is expected that some flexibility will be maintained to add individual Phase 3 bins to the existing test program as these bins become available. Details of Phase 3 tests will be incorporated into a future, separate Test Plan addendum.

## 8.2 WASTE SPECIFICATIONS AND ASSUMPTIONS

The CH TRU wastes to be tested in this bin-scale program will potentially be obtained from several waste generator sources, predominantly the Rocky Flats Plant and Idaho National Engineering Laboratory, but possibly also originating from other sites. Most of these wastes are currently being generated or are in temporary storage facilities at these and other DOE-operated generator sites. These wastes can be shipped to the WIPP for test emplacement pending the availability of TRUPACT-II shipping casks. As such, the test wastes must be included within the existing (and planned) TRUPACT-II certification limits, as licensed by the Nuclear Regulatory Commission. Fortunately, this appears to be the case [Drez,1989]. The initial TRUPACT-II certification will allow the transport of approximately 80 to 90% of the CH TRU wastes existing (and being generated) at both the RFP and INEL facilities [Warrant, 1989; Drez, 1989]. Refer again to Table 8.1.

### 8.2.1 Waste and Waste Degradation Caveats

Several clarifications will also be made on the differences of various degradation mechanisms on or between waste types (HONG and HOOW wastes; LONG and PS wastes). To the extent that they are described by current "process knowledge," HONG and HOOW waste types or matrices are essentially identical, except for the age specifications described earlier. However, the impacts of radiolytic degradation and consequent gas generation are expected to be significantly greater for HONG wastes than those for HOOW. It is well known [Zerwekh, 1979; Kosiewicz, 1981; Molecke, 1979] that radiolytic degradation of organic TRU waste matrix materials decreases as a function of time. Assessments of the degradation of HONG wastes (as evaluated by periodic gas sampling and composition analyses, Section 11.2) are largely directed at obtaining further data relevant to the operational-phase of the WIPP repository, when radiolysis is still of significance. Degradation evaluations of HOOW are more focused on the long-term, post-operational phase of the repository, when it is assumed that radiolysis is of lesser impact and importance compared to microbial degradation. The initial WIPP inventory will, however, contain an appreciable component of HOOW; refer to Table 8.2. Evaluations of gas generation from HOOW, conducted with the long-term, expected anaerobic environment of a repository, can concentrate more closely on microbial and other modes of degradation during the course of this in situ test program. It must be acknowledged that in the long-term, there is no anticipated difference between HONG and HOOW wastes, but both are used in this test program to obtain necessary information for a complete database.

HOOW and HONG wastes probably have the highest initial concentration of VOCs, compared to the other waste types, because of their sorptive properties and associated uses in chemical processes used at U.S. DOE waste generation facilities. A major objective of this test program is to quantify changes in VOC concentrations in the bins as a function of time. The initial VOC concentrations could either increase due to further volatilization, or decrease due to microbial degradation or metabolism processes. A further test objective, to be met by posttest waste characterizations (refer to Section 14.1), is to determine a reliable RCRA source-term for VOCs (remaining in the wastes). This posttest, residual VOC source-term will be used for comparison with VOC estimates based solely on process knowledge.

Similar to HONG and HOOW, there is no appreciable long-term difference between newly generated or "old" low-organic wastes or between newly generated or "old" PS. However, it is assumed that the older, stored TRU wastes will be subject to more repackaging and transportation concerns than newly generated wastes. As such, there may be a longer delay regarding when these older wastes could be received at the WIPP for testing. Therefore, only newly generated PS and low-organic (LONG) wastes have been initially requested or specified. However, if older PS and low-organic wastes are made available on an acceptable schedule, they may be interchanged for newly-generated PS and LONG wastes. The less than 2-year, and more than 5-year age specification for these waste categories is not critical. Therefore, the content codes for both newly generated and retrievably stored [old] PS and LONG wastes are listed in Table 8.1.

The study of degradation and gas generation of (all) inorganic PS wastes is focused on the expected major mode of degradation, radiolysis of the contained sorbed or chemically bound water. Radiolysis of PS wastes yields both hydrogen and a significant amount or buildup of oxygen gas [Clements and Kudera, 1985], unlike most other waste forms. With the sludges, radiolysis could continue for a long period of time before the bound water would become depleted. Long-term brine intrusion into the repository environment could, conceivably, replenish the water necessary for radiolytic production of gases. Inorganic PS wastes also contain an appreciable amount of sorbed nitrates. These nitrates could be the nutrient source for microbial denitrification reactions, yielding nitrogen gas -- if either the wastes themselves contain significant (microbial) nutrients or the PS wastes are sufficiently close to cellulosic matrix wastes, to allow interactions.

Because of PS waste packaging constraints within the bins, described in Section 8.2.2, no brine-leachate data will be obtained. Brines will still be added to the PS wastes (Section 8.4), but they will not be sampled.

The major focus of interest for the degradation of low-organic/LONG waste is the anaerobic corrosion of steel (and other metals), with the potential for releasing large quantities of hydrogen gas. The actual extent of corrosion will be measured in an (initially set) anaerobic environment, while the metals are simultaneously being impacted by radiolysis and, possibly, microbial action. The radiolysis of any water present (or intruding, in the long-term) in the LONG wastes could potentially generate sufficient oxygen, and possibly some hydrogen peroxide, to change corrosion (reactions) to semi-oxic modes, in which no hydrogen would be generated. Conducting such tests on actual CH TRU LONG wastes could provide the necessary data required for the WIPP PA program predictive calculations.

### 8.2.2 RFP Noncompacted Wastes

Rocky Flats Plant could potentially supply a significant proportion of both newly generated and existing (to be repackaged) specially prepared, noncompacted wastes [D'Amico, 1989]. Based on preliminary waste acceptance schedules at the WIPP, RFP [D'Amico, 1989] might be willing to specially prepare an appreciable quantity (up to ~2000 drum-volumes) of such noncompacted wastes, store such specially prepared wastes at RFP for a short time, and then ship such wastes to the WIPP for test emplacement. The potential also exists for RFP [D'Amico, 1989] to repackage and specially prepare HOOW wastes that were originally generated at RFP and are currently stored at the INEL facility. Facilities exist at RFP [D'Amico, 1989; Barthel, 1988] where necessary repackaging activities could be accomplished. [Discussions to accomplish this special preparation of HOOW at RFP have been initiated between the participants; details are being finalized between DOE WPO and RFP to formalize this agreement.]

Inorganic PS produced at RFP cannot [D'Amico, 1989] be filled directly into test bins because of already installed process-line sludge equipment and associated hardware. PS wastes will be filled into polyethylene drum-liners, without the metal 55-gallon drum. A plastic bag within the liner will totally surround the sludge and be sealed shut; there may also be another plastic bag on the outside of the drum-liner. Four of these sludge-filled drum-liners without lids will then emplaced into each test bin. The use of slightly shorter polyethylene drum-liners, and/or of similar liners with reinforced top rims for remote handling strength and safety, may be necessary for purposes of the bin-scale test program [D'Amico, 1989]. If such special drum liners are required, they will be provided by the WIPP project to RFP. Further design details or purchase specifications for these special drum liners will be provided by WID [Bali]. A special spacer-form may be needed within the test bin, to keep the four PS waste-filled liners from possibly sliding around during bin transport. These spacer-forms will be provided by the WIPP project to RFP; further design details or purchase specifications for these will be provided by WID [Caviness].

Note: There is no readily apparent or acceptable means to puncture the polyethylene drum liners before or during the sludge-filling operation at the generator facility due to radiological-safety, particulate contamination concerns. There is, similarly, no easy engineering procedure available to puncture the 90 mil-thick polyethylene liners within the test bins after closure. Any brines added to the top of the PS wastes in the bins will not, therefore, be able to be sampled for leachate analyses.

Because of the potential for release of nitrogen gas resulting from the microbial denitrification of PS wastes in proximity to cellulosic waste materials, there are 8 test bins listed in Table 8.3 which specifically contain a mixture of both PS and HONG wastes. These mixed-waste drums are, essentially, 2 drum-volumes of PS layered over 3 drum-volumes of HONG wastes. This mixture (waste content code 127A or 227A, Table 8.1), requires special waste packaging procedures (Section 8.3.2). The pre-breached HONG wastes will be emplaced in the bottom of the the bin. Then, the contents of 2 drums of PS wastes, without packaging materials, will be manually emplaced over the top of the HONG wastes. This layering of waste types permits test evaluation of the potential microbial denitrification interactions of interest. Periodic sampling of brine leachates can also be conducted. This special packaging of mixed types of TRU wastes does not require modifications or other impacts to the bin design. Preliminary details of this special, mixed-waste packaging have been discussed with RFP [D'Amico, 1989].

8.2.3 RFP Supercompacted Wastes

Most high-organic ("soft") and low-organic ("hard," primarily metals and glasses) newly generated wastes will be supercompacted at RFP starting in 1990 and continuing thereafter. These wastes could constitute a major fraction of the TRU wastes to be shipped to the WIPP in the future. Because of anticipated new waste production rates, RFP does not currently plan to supercompact any "old wastes;" therefore, no requests for such wastes are made in this Test Plan.

The advantage of including supercompacted wastes in this test program is that the in situ degradation of supercompacted wastes may be quite similar to that of regular (noncompacted) wastes that have been crushed/compacted in situ by the expected long-term (salt creep) closure of repository rooms. However, it must be recognized that the supercompacted waste to long-term compaction comparison is not perfect. While supercompaction may simulate the geometric effects of long-term closure, it may not necessarily simulate the relation between compaction and brine saturation as a function of time, microbial degradation by-product contamination as a function of time, long-term anaerobic corrosion [Lappin, 1989a], etc. In addition, potential galvanic coupling of compacted metals within the wastes in the presence of intruding brines, potentially yielding some hydrochloric gas generation, could also cause an increase in the rate of generation of gas (hydrogen); this potential gas-generation impact will be evaluated in this test program.

Impacts on gas generation caused by compaction are expected to be greatest for radiolytic degradation/gas generation rates (over the short- to near-term time period) and for microbial degradation over the short- to long-term [Molecke, 1979]. Supercompaction of organic matrix TRU wastes should not significantly impact the maximum rate of gas generation from radiolytic degradation, the G value (the number of molecules of gas formed for each 100 eV of irradiation input energy) of the waste materials will not be [Molecke, 1989c] altered. The rate of such radiolytic gas generation could, however, remain almost constant for a long period of time for the supercompacted wastes. It was observed [Kosiewicz, 1981; Molecke, 1979] that the actual rate of radiolytic waste degradation gas production from non-supercompacted wastes decreased appreciably as a function of time. Supercompacted wastes could, however, generate a larger quantity of gas by radiolysis over a specified period of years than similar volumes of non-supercompacted wastes. This radiolytically generated gas volume must be put into proper perspective, however. Microbial degradation of organic wastes, in competition with radiolysis, has the experimentally measured potential [Molecke, 1979] to generate about two orders of magnitude more gas than does radiolysis; refer to Table 5.1. Consequences of gas generation from all mechanisms acting on supercompacted (and other) wastes, with possible positive or negative synergisms, can be realistically estimated or evaluated during the course of these tests and factored into the WIPP PA calculations.

It is planned to test both types of the supercompacted wastes, i.e., "soft" HONG and "hard" LONG, at WIPP with each type in separate bins. Some details on these wastes follow: RFP will be [D'Amico, 1989; Barthel, 1988] generating approximately 600 (standard 55 gallon) drums of supercompacted wastes per year, at a rate of 50 per month, including about 27 drums of "soft" wastes and 23 drums of "hard" wastes. The anticipated volume ratio for initial, noncompacted wastes processed is 3:1, soft:hard. The net, overall compaction ratio is 4.66:1; for soft wastes it is about 6.8:1, for hard wastes it is about 2.6:1. If it is assumed that there will be 4 (55 gallon) drum-volumes of supercompacted waste contained within a test bin, this would equate to about 10.4 (hard) to 18.6 (soft) equivalent drum-volumes of noncompacted, preprocessed TRU wastes per bin.

The RFP accomplishes the supercompaction [Barthel, 1988] by initially removing wastes from 55-gallon drums, repackaging the wastes with some precompaction into 35-gallon drums, then supercompacting these drums. The 35-gallon drums are punctured with 4 holes, 1/8 in.-diameter, before supercompaction, to allow release of air during the supercompaction step. The resultant crushed "pucks" are then repackaged into 55-gallon drums; there are planned to be 3 pucks of "soft" wastes per (final) 55-gallon drum, or 4 pucks of "hard" wastes. Other details are found elsewhere [Barthel, 1988].

The RFP cannot fill supercompacted wastes directly into bins [D'Amico, 1989] because of already established handling and packaging procedures. The supercompacted waste "pucks" will be prepared and packaged into 55-gallon drums; each 55-gallon drum has an internal fiberboard (similar to shoe-box cardboard) liner and a sealed plastic bag surrounding the supercompacted wastes. Four of these waste-filled drums will be emplaced into each test bin; no drum lid will be used on the 55-gallon drums. However, four standard 55-gallon drums will not physically fit within a bin. Special drums, slightly shorter and without side ridges, will be provided to RFP by the WIPP project for use in the bin-scale test program. Further details on these special drums, i.e., specifications and purchasing information, will be provided by WID [Bali].

In addition, to allow added brine in the bin-scale tests to partially penetrate through the top of the supercompacted waste "pucks," additional holes will be required on the top of the 35-gallon drum lids. Four, 1/2 in.-diameter holes, arranged in a square pattern are needed. These special 35-gallon drum-lids will also be provided by the WIPP project to RFP; further design details or purchase specifications for these will be provided by WID. Because of the supercompacted waste packaging constraints within the bins, the same as those described for PS wastes, there will be no brine sampling and no brine-leachate data will be obtained.

To prevent the four 55-gallon drums of supercompacted wastes from possibly sliding around during bin transport, a special spacer-form may be needed within the test bin. These spacer-forms will be provided by the WIPP project to RFP; further design details or purchase specifications for these will be provided by WID [Caviness].

## 8.3 TEST WASTE SPECIAL PREPARATIONS

The CH TRU wastes to be used in these bin-scale tests require some preliminary analyses and packaging and preparations at the waste generator/preparer facilities before they can be shipped and emplaced in the WIPP. Several assumptions described below have been made in regard to waste preparation techniques and details, based on discussions with RFP [D'Amico, 1989].

### 8.3.1 Bin-Scale Pretest Waste Characterizations

Detailed pretest waste characterizations of all wastes used in this program are required to quantify radioactive species, hazardous waste constituents, and overall waste matrix components. These characterizations are necessary to demonstrate both to what extent test wastes are representative of the behavior of all CH TRU wastes and to provide information needed in test data interpretations. Pretest characterizations will also specifically determine to what extent the test wastes are "representative" of, and/or bracket, the RCRA constituent concentrations of the CH TRU wastes in storage at DOE waste generator sites that are to be isolated at WIPP. Overall DOE programmatic requirements for the characterization of WIPP experimental wastes are described elsewhere [US DOE, 1989e]; the requirements described in this section, while themselves not definitive, are intended to be more specific.

The overall objectives of this test program (listed in Section 4.2) specifically include quantifying:

1. the compositions, concentrations, and rates of generation of gases produced by TRU waste degradation,
2. the volatile organic compounds (VOCs) released with other gases generated,
3. concentrations of radioactive species leached from the wastes by intruding brines, and
4. the types and amounts of hazardous toxic metals or organic components similarly leached.

To accomplish these objectives, there are to be several required pretest characterization procedures conducted on all initial (unopened) containers of wastes to be used in this test program including: (a) head-space gas sampling and analyses, (b) quantification of the radionuclide content, and (c) real-time radiography analysis. Similarly, there are also pretest waste characterizations required for all individual bags of wastes held within the initial containers. These procedures include: (d) removal and weighing of each individual bag of waste within the container, and (e) a visual, quantitative evaluation of the contents of each individual waste bag. These procedures are to be conducted by the waste generators/preparers prior to specially preparing and packaging the (characterized) wastes into the WIPP test bins. Each precharacterization procedure is described below.

The VOCs present within the head-space of each starting container of TRU waste to be emplaced into test bins must be quantified. This is to both ensure that such hazardous components are present and to provide a baseline concentration value for subsequent bin gas analyses. The pretest VOC quantification involves obtaining a head-space gas sample from each TRU (existing, prepackaged only) drum or SWB before the container is opened. Analyses of these samples will be conducted at the generator site or, possibly, at the WIPP, in the same manner, and for the same gases as described in Section 11.2. Such pretest WIPP VOC analyses will be in addition to any other gas analyses that may be conducted by the waste generator/shipper sites for possible transportation data requirements.

The initial VOC content within individual WIPP test bins (after arrival at WIPP) will also be analyzed as part of the test emplacement procedures, as described in Section 8.4, step 3. These initial VOC gas samples will be analyzed at the WIPP in the same manner, and for most of the same gases as all other test gas samples to be obtained; refer to Section 11.2. Refer also to Section 14.1 for posttest VOC analyses, required to determine the (residual) VOC source-term actually present in the wastes within each bin.

For pre- to posttest comparisons, there needs to be an initial quantification step for the the radionuclides (Pu, Am, U, and Th; possibly others) in each initial container of waste included within each test bin. This information will be used to help interpret the the composition and quantity of measured (generated) gases within the bin resulting from radiolytic degradation. Such quantification procedures will normally be conducted by the waste generator/preparer facilities for transportation requirements, before the initial containers of TRU wastes are packaged into the WIPP test bins. The radionuclide content within the starting wastes can be obtained by either non-destructive assay or radiochemical techniques, to be chosen by the generating facility. The types of waste data required for transportation purposes include total alpha activity curies; plutonium equivalent curies; radionuclide inventory for specific nuclides including $^{239}$Pu, $^{241}$Am, $^{235}$U, and others; total fissile mass; and, thermal wattage. Some of the procedures commonly used to obtain these data include passive-active neutron assay and segmented gamma scanning. Each technique has its inherent limitations or uncertainties. After technique selection by the generator facility, estimated uncertainties will be included in the statistical evaluation of waste properties and behavior. There are no other bin-scale radionuclide characterization/quantification data requirements in addition to the transportation data requirements.

A small sample of sludge (assumed homogenous throughout the drum) will be obtained (by the generator/preparer) from each starting drum of PS waste to be used in this test program. This pretest sludge sample will be quantified radiochemically; it will also be quantified for toxic metals and VOCs. Details on sample size and analyses procedures remain to be finalized with and by the generators. EPA analysis procedures and protocols will be evaluated for appropriateness for use with these sludges; EPA test protocols, or modifications thereof, may then be instituted. Details will be included in the Appendices, Section 18.8.3.1, when available.

All test containers will also undergo real-time radiography, RTR, to help evaluate for free liquids, metals, and other significant, discernible components.

Both the RTR and radionuclide quantification procedures are normally conducted by the waste generator/preparer facilities for transportation requirements before the (initial containers of) TRU wastes are packaged or repackaged for shipment to the WIPP. It must also be noted that while remote assays will quantify the content of radionuclides, understanding of the physical form of these nuclides can only come from generator "process knowledge."

Data and interpretations of the transportation radionuclide and RTR analyses conducted by the waste generator/shippers are to be shared with the WIPP project for purposes of bin-scale test data interpretations. Further discussions between the WIPP project and the generator/ shipper sites are required to formalize details of data sharing. Forthcoming details will be found in the Appendices of this Test Plan, Section 18.8.3.1.

The following waste-intrusive, pretest characterization procedures are specific to, and required for, bin-scale test wastes only. With the exception of PS wastes, these procedures will apply to all waste types, including wastes to be supercompacted. After the preceding pretest waste procedures have been conducted, the initial waste containers will be opened and each bag of waste within individually weighed. Each bag of waste (normally a clear plastic bag [Drez, 1989]) will then be visually examined for a quantitative evaluation of the contents of the bag. This examination can be videotaped for later, more thorough evaluations. The purpose of the weighing and visual examination procedures is to obtain a quantitative estimate on the weight and volume of specific items within in the waste bag, e.g., amounts of cellulosics, rubber gloves, plastics, wood, steel, aluminum, lead, other metals, glasses, ceramics, etc. This information is needed to interpret the probable source or component item responsible for the generation and compositions of gases measured; it greatly enhances the information obtained. The gas data does not have to be represented as coming from "waste classification ###," but from a more specific xx % of cellulosics, xx % plastic, etc. The measured gas data base can thus be interpreted in a broader manner, possibly interpolated to other waste classifications that are similar, but have different percentages of the same basic components.

These waste-intrusive procedures are to be conducted by the waste generators/preparers prior to the other special preparation procedures (Section 8.3.2) such as bag-slashing or puncturing. The weighed and visually examined (characterized) wastes can then be emplaced into the WIPP test bins, or into containers to be supercompacted and then used in this test program.

### 8.3.2 Test Bin Waste Filling

Most newly generated wastes can be packaged directly into the prepared WIPP test bins at the generator site(s); previously packaged wastes (drummed) can be emptied into these bins, without the original drums. Packaging of process sludges and supercompacted wastes has already been described. Two options exist for filling the wastes within the bins; the wastes will either be "as-received" or "specially prepared." Details on the "as-received" wastes were described in Section 8.1. Figure 8-5 shows a schematic of a test bin filled with "as-received" wastes. Details for the "specially prepared" CH TRU wastes follow.

Pre-Breaching: CH TRU wastes, initially contained within plastic bags, will be pre-breached (details below) then filled into the test bins. This will be accomplished within an appropriate alpha-contamination facility at the waste generator(s) site. One overall polyethylene or PVC bag within the test bin will enclose all the pre-breached wastes and other components (to be described). This overall test system encapsulates all "specially prepared" wastes and other interacting materials (with the exception of injected brine, refer to Section 8.4), and permits limited mixing, gas generation, brine

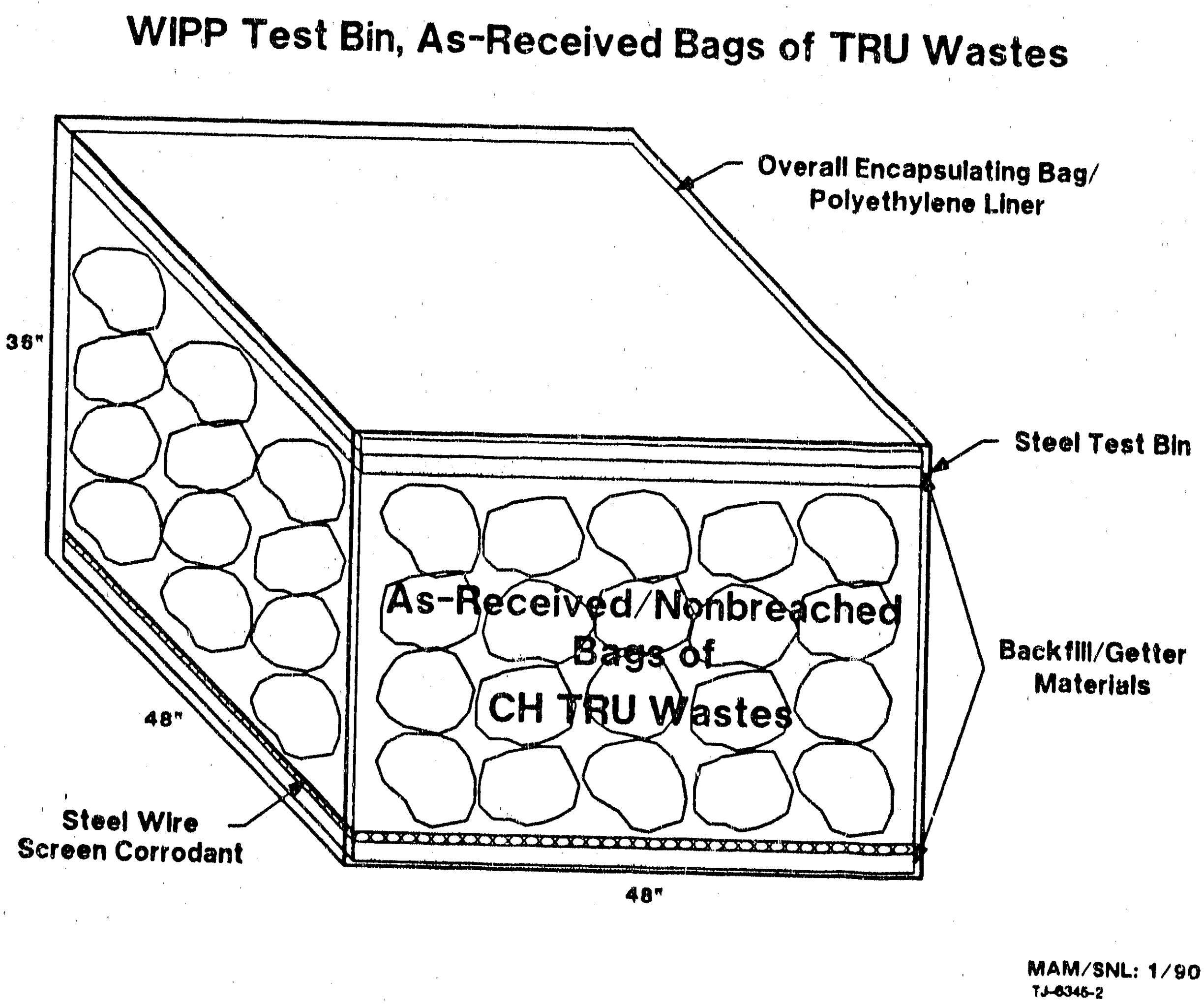



Figure 8-5 Schematic of WIPP Test Bin with "As-Received" Wastes

leaching, eventual release/sampling, and analyses. It also essentially minimizes the potential for release of particulates from the test bin.

The plastic-bag pre-breaching procedure can be accomplished while the wastes are being packaged, or before, at the option of the generator. Two separate types of waste pre-breaching will be required, bag puncturing and bag slashing; the type of pre-breaching depends on the amount of brine to be injected into the test bins (Table 8.2).

1. Pre-breaching/bag puncturing. Bag puncturing is the pre-breaching technique required for wastes to be emplaced in bins that will have a large amount (10% by volume) of brine injected. This pre-breaching step involves, nominally, puncturing the bottom and side of each plastic bag of waste material with a special "puncturing paddle." This "puncturing paddle" is a hand-held device with a active surface of about 1 $ft^2$ in area, having multiple puncturing points ("nails," about 0.25 in.-long and about 0.13 in.-diameter), in a 1 in. pattern. The bottom and side corner of the bag of waste can be tapped or rolled over the surface of the "puncturing paddle" until the bag contains multiple small holes. These punctured waste bags will then be set into the test bin with the holes facing (mostly) downward. The multiple purposes of pre-breaching/puncturing are to provide pathways for injected brine to wet the wastes, leach radionuclides and other chemical components from the wastes (particularly those sitting on the bottom of the bin, in direct contact with the standing layer/level of brine), and provide access pathways for the entrance or exit of gases and water vapor within the bin. The pre-breaching/bag slashing technique (below) may, alternately, be used for bags of wastes that will be located in the upper two-thirds (more than 1 ft. from the bottom) of these test bins. NOTE: The puncturing paddles will be designed by WID and will be provided to waste preparers by the WIPP project; refer to the Appendices, Section 18.8.3.2.

2. Pre-breaching/bag slashing. Bag slashing is the pre-breaching technique required for wastes to be emplaced in bins that will have either no injected brines or a small amount (1% volume). This bag slashing procedure consists of slicing or slashing each plastic bag of waste material with a sharp instrument. There are to be two slashes in each bag, at about 180° to each other; each slash is to be a minimum of 2 in.-long. Bag slash-

ing accomplishes most of the pre-breaching purposes described above, except that it cannot provide an adequate pathway for brine leaching. Slashing does, however, permit moisture transport by vapor pathways and provides an entrance path for small amounts of backfill material to contact the wastes.

Pre-breaching of the waste bags is also desirable for waste transportation. Gas generation and collection from within the smallest waste bag inside of the overall waste container is not then the limiting factor in TRUPACT-II waste cask licensing considerations [Warrant, 1989].

The facilities for pre-breaching wastes and direct filling into WIPP test bins currently exists at generator sites, specifically at RFP and INEL, possibly at other waste generator sites. The use of such facilities for WIPP test purposes has been discussed with DOE and staff personnel at both RFP and INEL. Written agreements between DOE/WPO, DOE/RFP, DOE/Idaho, and Sandia on waste preparation, bagging, bag-slicing or puncturing, repackaging, etc., remain to be completed and authorized by the DOE/WPO.

For PS wastes contained within 90 mil-thick drum liners, however, no prebreaching is proposed; refer to Section 8.2.2 for technical reasons. The encapsulating plastic bag for PS wastes will be punctured during the brine injection procedure, whether brine is injected or not! Refer to Section 8.4.

Figure 8-6 shows a schematic of a test bin filled with "specially-prepared" HONG (noncompacted), LONG (noncompacted), or HOOW wastes. Similarly, Figure 8-7 shows a schematic of a test bin filled with "specially-prepared" supercompacted HONG or LONG wastes, or PS wastes.

Specific, step-by-step details follow on waste "special preparation" and filling to be performed at the waste generator/packaging facilities; necessary assumptions are incorporated. For "as-received" wastes, follow steps 1, 4 (without the pre-breaching), 6, and 7 (below) only. Supplemental details on required components or materials are found in Sections 9 and 10.

1. Open and inspect the test bin. Unfold the layers of plastic for the bin liner and let the liner top drape over the top edges of the bin. This liner functions, essentially, as an overall contamination shield during

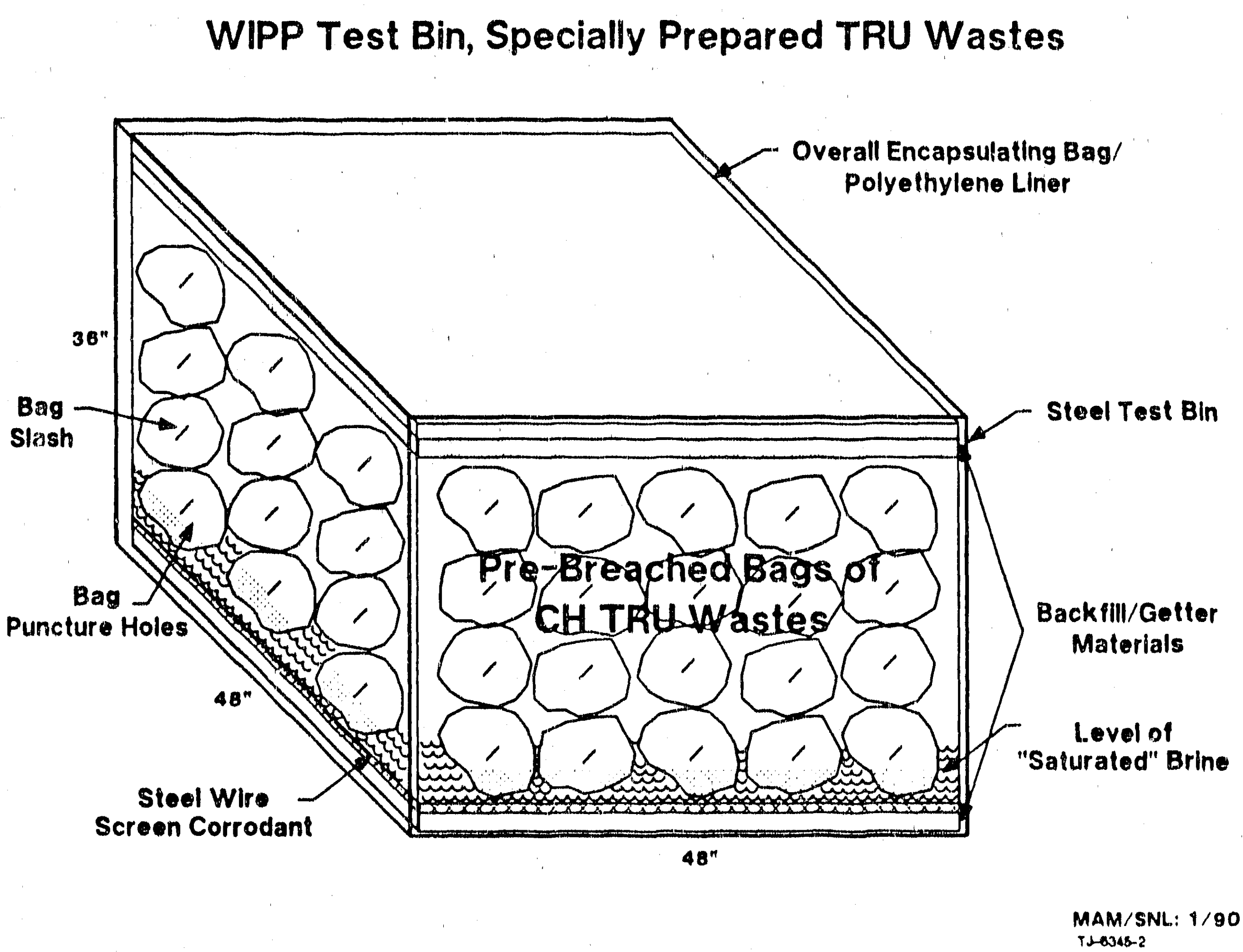



Figure 8-6

Schematic of WIPP Test Bin with "Specially Prepared" Noncompacted Wastes

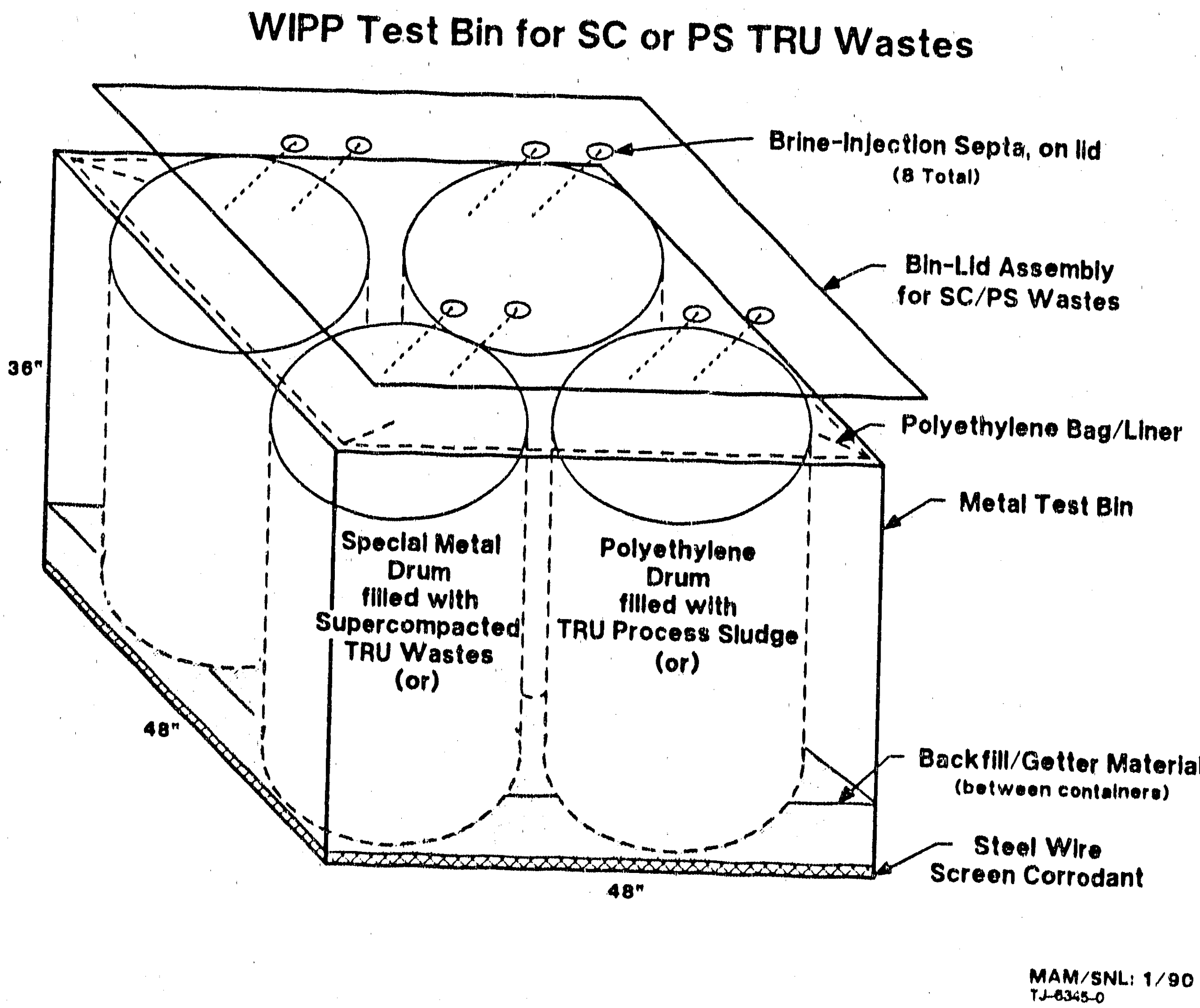



Figure 8-7 Schematic of WIPP Test Bin with "Specially Prepared" Supercompacted or PS Wastes

filling operations. Insert the provided, inner fiberboard liner into the bottom and sides of the test bin.

2. Add 0.5 $ft^3$ of appropriate, prepackaged backfill materials (described in Sections 10.1.4) to the bottom of each bin, within the bag/liner. This material should be spread or poured evenly over the bottom area of the bin. If the waste material is either process sludge or supercompacted waste, perform this step after step (4).

3. Insert a special metal corrodant into the bottom of the bin, over the top of the layer of backfill material. This corrodant consists of several layers of a mild steel wire screen, provided by the WIPP, and is described in Section 10.2.

4. Fill the bin with the appropriate amount, and specific type of pre-characterized CH TRU wastes (refer to Section 8.3.1), as follows:

   (a) approximately 6 drum-volume-equivalents of pre-breached, (with bag puncturing or slashing, as appropriate) plastic-bagged HONG, LONG, or HOOW wastes, or
   (b) 4 upright drum-liners filled with process sludge (PS) wastes, or
   (c) 4 special 55-gallon drums of supercompacted HONG or LONG wastes (refer to Section 8.2), or
   (d) approximately 3 drum-volume-equivalents of pre-breached, plastic-bagged HONG wastes (with bag puncturing or slashing, as appropriate), topped with 2 drum-volumes of manually emplaced, loose PS waste material (Section 8.2.2), or
   (e) other types of waste, to be specified in Phase 3 of this program.

   No solid bacterial inoculants need to be added to test wastes in order to initiate microbial modes of waste degradation and gas generation; refer to Section 10.4.

5. Add 2.5 $ft^3$ of prepackaged backfill material over the top of the wastes in each bin. For PS and supercompacted wastes, the backfill materials will be poured both over the top of the (internal) waste containers and, predominantly, into the interstitial spaces between the waste containers.

6. Insert the top fiberboard bin liner into the bin. Theh, fold-in the edges of the outer plastic bin-liner over the test bin contents and tape shut.

7. Seal the test bin with its mating, bolt-on, gasketed lid (to be provided by the WIPP).

#### 8.3.3 Test Bin Shipping

The following two steps are necessary to ship the waste-filled test bins to the WIPP facility:

1. Check the outside of the test bins for surface contamination and decontaminate, as necessary, according to established practices as required by both the waste generator or shipper for transportation, and as required by the WIPP Waste Acceptance Criteria (WAC) [US DOE, 1989c].

2. Insert the decontaminated, waste-filled test bins into standard TRU waste boxes (SWB) at the generator site. Transport the SWB/test bin combinations to the WIPP facility in TRUPACT-II shipping containers.

The upper gas valves (with integrated, non-gas-sorbing, particulate filters; refer to Section 9.1) on the test bins are left in the open, gas-release position during transportation. Gases released from the bin will then also vent through the carbon-composite filters on the SWB. VOC gases released from the bin will be sorbed on the SWB carbon-composite filters.

### 8.4 WIPP BIN-SCALE TEST EMPLACEMENT

Once the test bins are received at the WIPP facility, they will be removed from the SWB in the CH TRU overpacking enclosure in the Waste Handling Building. The bins will be checked for surface contamination and decontaminated as necessary, per the requirements of the WIPP Waste Acceptance Criteria [US DOE, 1989c], and the following procedures conducted:

1. <u>Gas Sealing:</u> The gas release valves on the test bin are shut. Sealed test bins are then ready to be taken to the underground WIPP test area.

2. Bin Stacking Order: Empty, baseline-reference test bins TP001 through TP008 will be emplaced in Room 1 Panel 1 adjacent to (on the same rib, and as close as practical to) the DAS shed. They will be stacked in the bin-stands (refer to Section 9.3) with the gas baseline-reference bins, TP005 through TP008, on the bottom level of the stand(s), to facilitate periodic gas sampling and other procedures. The pressure baseline-reference bins, TP001 through TP004, which have no periodic gas sampling, will be emplaced on the top row of the bin stand(s).

   Waste-filled test bins, TP009 and up, will be emplaced in Room 1 Panel 1 starting at the north end of the room, furthest away from the DAS shed, then progressing southward as more bins are loaded. This progression is required by radiological safety and ventilation concerns. Waste bins will be emplaced along both the east and west ribs, in an alternating pattern. In this manner, the newest bins can be installed and hooked-up in the ventilation air flow upstream from the other bins. One of the objectives of this emplacement order in rows near the room ribs is to allow ready access (by forklift or other machinery) to the bins, should movement or retrieval of any bins be required, for any reason.

   All identical replicate bins, as listed in Table 8.3, will be emplaced adjacent to, and directly above and below each other, if at all possible.

   When all available (bin-stand) stacking space in Room 1 Panel 1 has been filled with test bins, emplacement operations will be initiated in Room 2 of Panel 1. Space in Room 2 is expected to be necessary at the beginning of test Phase 3. Again, because of radiological safety and ventilation concerns, bin stacking will be started at the northern boundary of the allotted space in Room 2.

3. Initial Gas Sampling: When taken underground and emplaced in the test room area in Panel 1, each bin will be installed on a test stand (Section 9.3). An initial gas sample is taken at this time, emplacement time t = emplacement. Note: Time t = emplacement is different than, and precedes, test time t = 0, following initial bin pressurization and tracer gas injection, as defined in Section 11.1.3.

4. Instruments: All remote-reading instruments (Section 12.1) are hooked up and connected to the MODCOMP data acquisition system (Section 12.2) at this time. All pressure-relief valves and other associated equipment are also installed and checked for proper operation. Instrument monitoring is then initiated. The instrumentation-installation procedures are estimated to take 1 day for each bin.

5. Bin Oxygen Purging: To simulate a long-term, post-operational repository gas environment in the test bins, essentially complete oxygen purging, consisting of gas flushing and oxygen gettering of the bins' as-shipped, internal gas volume is proposed for some of the waste types. Individual bins requiring argon gas flushing and oxygen purging are listed in Table 8.3. Gas flushing and oxygen gettering procedures are described in Section 11.1. These procedures should be initiated within 3 days or less after time t = emplacement.

6. Brine Injection: Within 3 days or less after completion of the oxygen purging procedures, the appropriate type and amount of brine will be injected into the appropriate bins, as designated in Table 8.3. Brine injection is a "one-time-only" operation and must be conducted underground.

For HONG (noncompacted), LONG (noncompacted), HOOW, and PS/HONG wastes, the brine will be injected through the multiple, side-mounted brine injection ports on the bin, as described in Section 9.1 and detailed in [Bali, 1989a]. Brine ports will be kept capped, except for when brine is being injected (refer to Section 9.1, part 5). The bin design includes 4 brine injection ports, each with a check valve, with 2/each on opposite sides of the bin. There are 2 near-top ports on the front side and 2 near-mid height ports on the back side. All 4 of the ports will be used for brine injection. One-fourth of the total amount of brine to be injected will be injected through each of the individual ports. A pump will be used so that brine sprays through the waste materials, not down the inside walls of the bin.

For PS and supercompacted wastes, brines will be injected into the appropriate bins, as designated in Table 8.3, through the multiple brine injection ports/septa on the top of the bin closure lid, as also described in Section 9.1 and detailed in [Bali, 1989a]. There will be a minimum of 8 brine injection septa, with a minimum of two located over each of the (4) internal drums or drum-liners of waste. One-fourth of the total amount of required brine will be injected through each of four brine injection ports, centered over the internal drums. The remaining ports are for backup purposes.

These top brine injection ports will consist of rubber-type septa. Brine will be injected through these septa, penetrating through the overall encapsulating plastic bag (thus breaching it), into the waste materials. Large hypodermic needles (type of apparatus) will be used for these injections. For PS wastes, the needle will be inserted to a depth of 30 to 40 cm (12 to 16 in.) below the bin top, below the level of the top backfill layer. For supercompacted wastes, the injection needle will be inserted until a hard barrier is encountered. Once brine injection is completed, the needles will be crimped shut, snipped off above the crimp, and pushed through the septum, becoming part of the waste. The brine septa will then be permanently capped-off. The needle holes remaining in the (punctured) bin plastic barrier materials provide internal gas and water vapor access and transfer paths.

Note: All PS and supercompacted waste bins, even those with no injected brines (with the exception of 2 "as-received" PS bins and 8 PS/HONG bins, refer to Table 8.3), will be punctured with injection needles, to provide the gas and water vapor pathways.

Radiation-safety temporary containment enclosures may be used during the brine injection procedures. A separate, detailed (quality assurance and radiation safety approved) brine-injection procedure will be prepared by WID and included in the Appendices, Section 18.8.4.

The brine injected into bins occupies an appreciable internal volume. Assuming that the bottom area of the bin is occupied with 50% solid material, 12 L of injected brine will rise to about 2 cm (0.8 in.) in height while the maximum of 120 L of brine will rise to about 20 cm (7.9 in.). The injected brine volume will also increase the internal pressure within the bin if sealed, up to a maximum of about 7.4 psid, due to displaced gas volume. Such a high internal pressure cannot be tolerated; excess pressure will be relieved, as necessary, through the pressure-relief valves. All gas volume displaced through the pressure-relief valve(s) will be measured by gas flow/volume gages (refer to Sections 11.1 and 12.1.3).

7. Initial Bin Pressurization. At this stage (following the steps 5 and 6, whether performed on a particular bin or not) every bin will be initially pressurized to an operating differential pressure of 0.25 psi. Reasons for this pressurization, and procedures for accomplishing it are described in Section 11.1.3.

8. Tracer Gas Injection: At the completion of the initial bin pressurization procedure, all test waste bins will be injected with (nonradioactive) tracer gases, to help facilitate analysis and interpretation of the results; refer to Section 11.1. A separate, detailed (quality assurance and safety approved) tracer-gas injection procedure will be prepared and included in Section 18.11.1.4 in the Appendices. The time of completion of tracer-gas injection is designated as test time t = 0; refer to Section 11.1.4. Another gas sample must be taken within 1 to 4 hours of the completion of tracer-gas injection. The first hour is allotted to the stirring/mixing of the tracer gases through the waste materials, driven by the gas-recirculation fan in the oxygen sensor system; refer to Section 12.1.5.

9. Continuous Testing: At this time, each test bin will be ready for continuous testing, including the periodic sampling and analyses of internal gas and brine-leachate liquid samples; refer to Section 11.

## 9.0 TEST BINS AND ASSOCIATED COMPONENTS

These bin-scale TRU waste tests require multiple large, instrumented metal "bins." The test "bin" is specifically defined and intended to serve as a freestanding test vessel when emplaced in situ, to be used for testing purposes only. WIPP test bins are specifically designed to fit within a TRUPACT-II TRU standard waste box (SWB, [Caviness, 1988] described in Section 9.2) for both transportation to the WIPP and eventual posttest disposal (refer to Section 11.0). In this test vessel capacity, the bin can be regarded solely as another layer of containment within the SWB. It is not to be regarded as a transportation or terminal disposal container. Therefore, the bins do not need to be tested or licensed as Type A shipping containers.

Each independent, leak-tight test bin will have a closely controlled and sealed environment (internal atmosphere; refer to Section 11.1) and be equipped with multiple, redundant monitoring and control instrumentation (refer to Section 12.1. Each bin will have an inner high-density polyethylene liner. Bins also will have multiple, redundant ports for all required instrumentation plus gas injection and sampling ports, and brine injection and sampling ports or septa. All gases sampled or released from each test bin will be particulate filtered with an integral, non-sorbing filter; liquid brine-leachate samples will also be filtered. All engineered components of a test bin will be summarized in this Section. Engineering design details and specifications for the bin are found elsewhere [Bali, 1989a]. Details of the bin stands that support the test bins in the underground test room are found in Section 9.3.

### 9.1 TEST BIN DETAILS

Engineering design details and specifications for the fabrication and testing of WIPP test bins are documented separately [Bali, 1989a]. Summary details provided in this section are to define requirements and overall details for the test bins.

There are two separate "models" of WIPP test bins. The first is termed the "solid waste" bin, the second is termed the "PS/supercompacted" waste bin. Figure 9-1 shows an overall schematic-concept of a WIPP "solid waste" test bin. The "solid waste" bin (WID drawings [Bali, 1989a] 412-N-002-W, Figure 9-2, and 412-F-017-W, Figure 9-3) is specifically designed to contain approximately 6 drum-volumes of non-compacted HONG, HOOW, and LONG wastes. There will be no internal metal drums or polyethylene drum-liners within these bins. All brine injection ports are on the sides of the bin, as described in Section 8.4.

The "PS/supercompacted" waste bin (WID drawings 412-N-002-W and 412-F-017-W, [Bali, 1989a plus Engineering Change Order # ????]) is essentially identical in size and shape to the solid waste bins, but has a different top-lid assembly (WID part # 412-F-017-GR3). The "PS/supercompacted" waste bin is designed to contain 4 drum-volumes of either PS wastes, in polyethylene drum-liners, or supercompacted wastes, in special metal drums. In addition, the "PS/supercompacted" waste bin has 8 recessed brine injection septa on the special top-lid assembly of the bin, as described in Section 8.4, not on the sides. Although no brine-leachate samples will be taken from the PS and supercompacted waste bins, the bottom brine-sampling ports should not be totally eliminated; they may be used for posttest brine or gas flushing ports, or other purposes. Other differences between the two bin models will be described where appropriate.

1. Dimensions and Volumes: The test bins have been designed [Bali, 1989a] to have an external, rectangular shape of about 48 in. long by 48 in. wide by 36.5 in. high, excluding handling fixtures.

The internal bin dimensions available for wastes are about 43 in. long by 43 in. wide by 35.5 in. tall, with a calculated inner volume of about 38.0 $ft^3$ or 1.08 $m^3$. A DOT 17-C, 55-gallon CH TRU waste drum has an internal volume of 7.42 $ft^3$ with, nominally, about 6 $ft^3$ of waste contained inside. The actual void volume within a waste-filled drum is assumed to be about 50%. Therefore, about 6 drum-volume equivalents of CH TRU wastes, about 36 $ft^3$ of wastes, should readily fit within a test bin. It is not, however, mandatory that integral numbers of waste drum-volumes be filled into each test bin; this will be a decision of the waste generator/packager. Assuming some volume efficiency is gained going from multiple cylindrical drums of waste to one large rectangular bin container, there should also be ade-

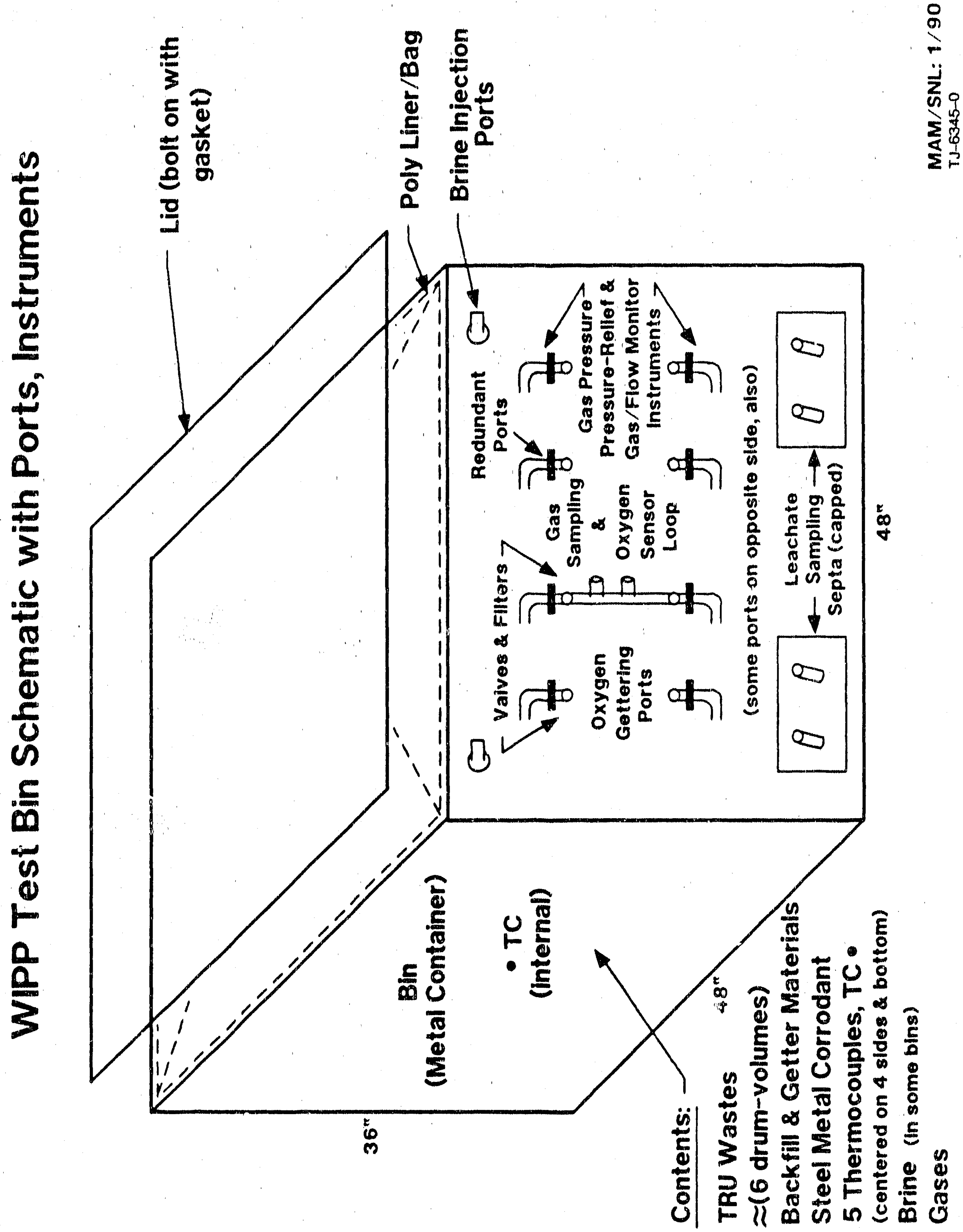



Figure 9-1 WIPP CH TRU Solid Waste Test Bin Overall Schematic

quate available volume inside the bin for including other required components, below, in addition to the TRU wastes:

(a) A polyethylene bin-liner. This bin-liner is about 30 mil-thick (WID drawing 412-F-017-W [Bali, 1989a]) and is for overall contamination control. The liner has appropriately spaced, molded ports, to accommodate penetrating instrumentation and inlet or outlet ports. It is held against the bin walls with hardware.
(b) Fiberboard liners within the bin-liner, to protect the liner from damage during waste loading [D'Amico, 1989]. The fiberboard is similar to shoe box cardboard and is about 1.3 to 3.2 mm-thick (50 to 125 mils). This fiberboard liner must be considered as an integral component of the waste or waste packaging; it cellulosic mass must be considered in future calculations on gas generation. The side, bottom, and top fiberboard liners have been designed by WID [Bali, 1989a], are illustrated in Figure 9.2, and will be provided to the waste preparers by the WIPP project.
(c) Metal corrodant material; refer to Section 10.2.
(d) Backfill and getter materials, with a total volume of 3.0 $ft^3$; refer to Section 10.1.
(e) Injected brines, with a maximum volume of 120 L; refer to Section 10.3.
(f) Internal containers. There will be no metal drums within the bins, except in the case of supercompacted wastes, described in Section 8.2.3.

For future gas volume calculations, the internal void (gas) volume within the bin, as packed with waste materials and the other components, is assumed to be about 1/3 of the available internal bin volume. The gas void volume is, therefore, about 360 L (0.33 x 1.08 $m^3$). The actual (not assumed) gas void volume within each test bin will be measured during the initial bin pressurization procedure, as described in Section 11.1.3.

2. <u>Bin Gas-Tightness and Pressurization</u>: The test bin plus bolted-on lid assembly will be gas-tight during in situ testing; there will be no permeable gaskets. The specification for gas-tightness is defined to be a maximum of 1% (volume released/outflow) per month. The bin will be designed to safely hold a differential, internal (working) overpressure of 0.5 psig; refer to Section 11.1. The test bin will also be designed and fabricated to have a maximum internal pressure of at least 1 psi, as a safety factor allotment. Details on bin gas-tightness/pressurization testing following fabrication are

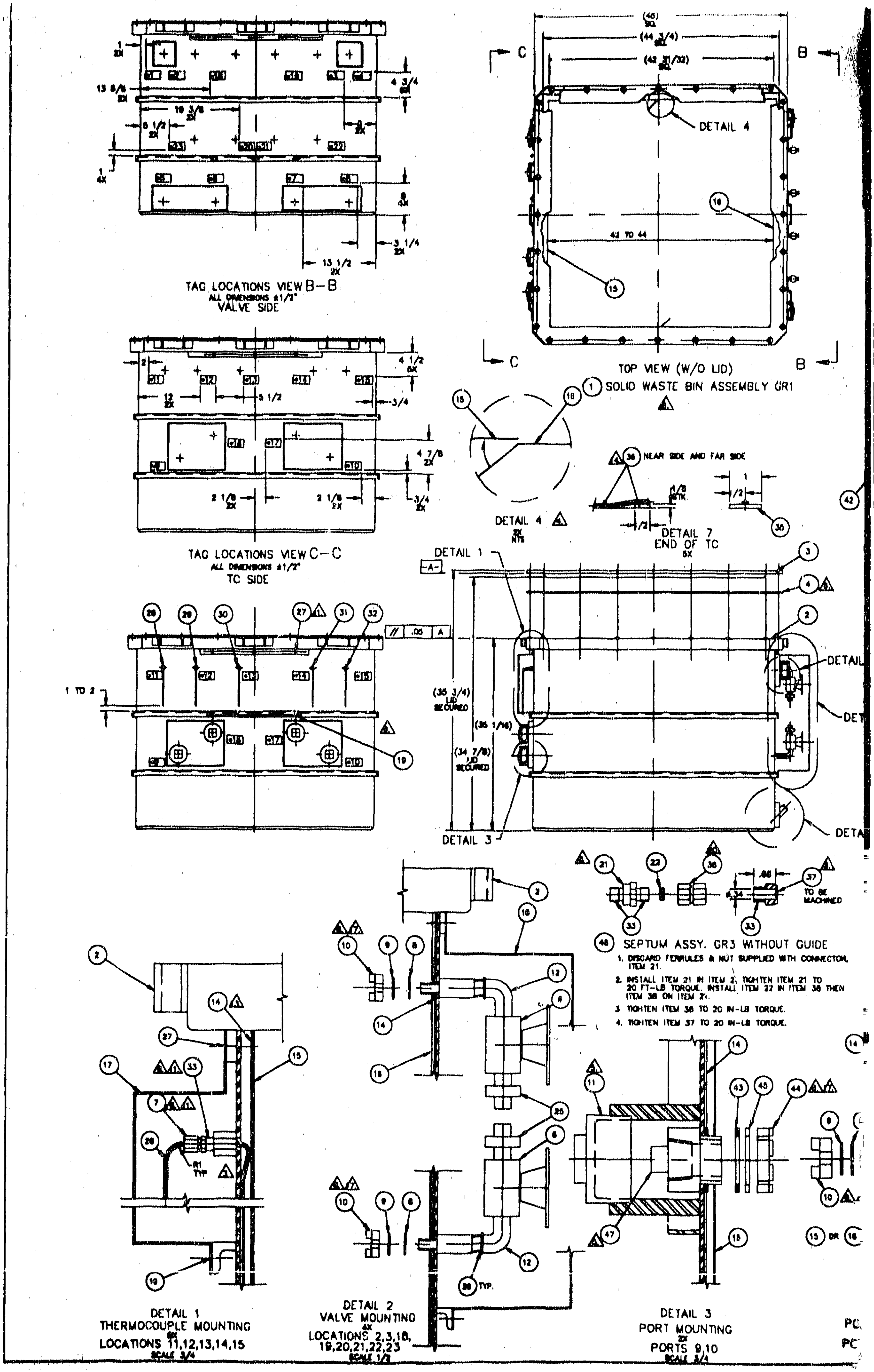
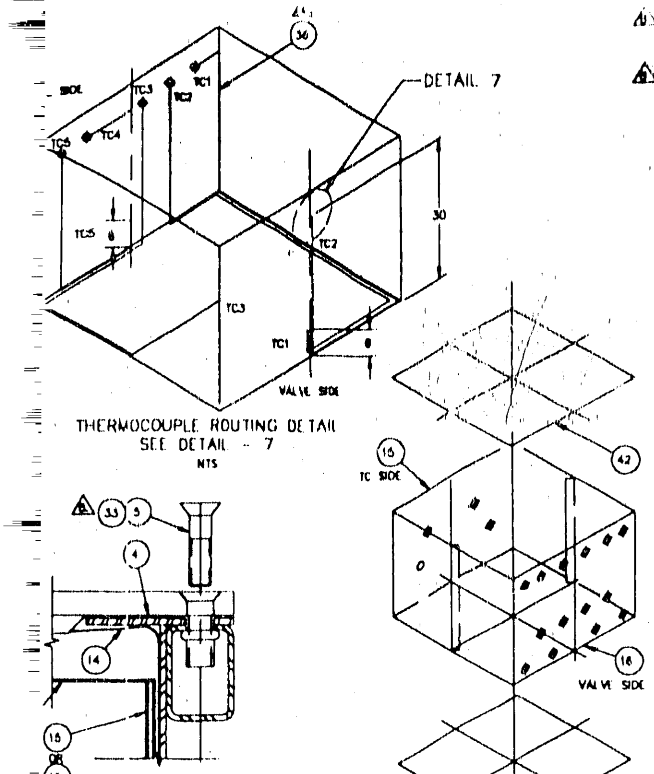


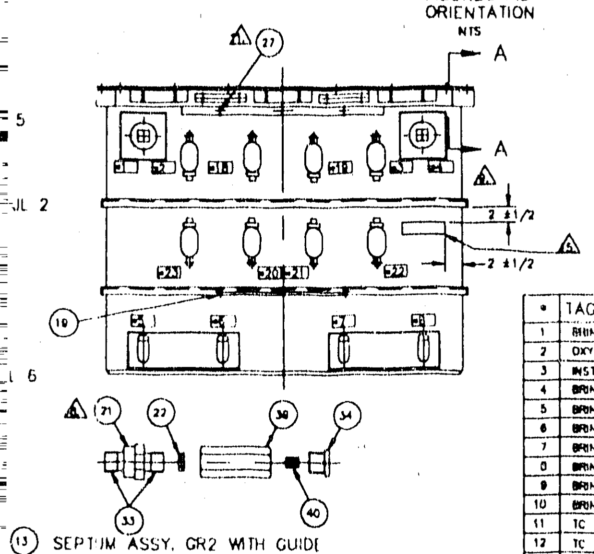

Figure 9-2 WIPP CH TRU Solid Waste Bin Assembly Drawing




THERMOCOUPLE ROUTING DETAIL
SEE DETAIL - 7
NTS

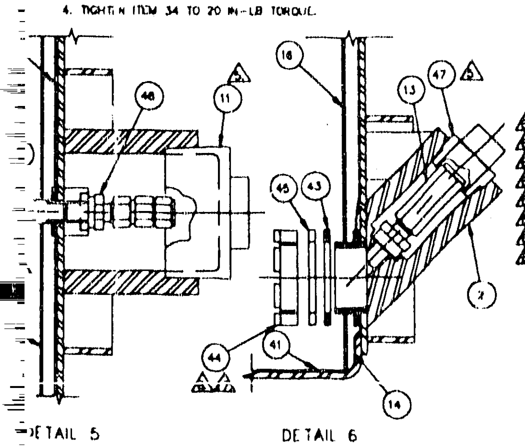
SECTION A-A
COVER AND GASKET IN PLACE
SCALE 3/4

FIBERBOARD
ORIENTATION
NTS




(13) SEPTUM ASSY, GR2 WITH GUIDE

1. DISCARD FERRULES & NUTS SUPPLIED WITH CONNECTOR ITEM 21
2. INSTALL ITEM 21 IN ITEM 2. TIGHTEN ITEM 21 TO 20 FT-LB TORQUE. INSTALL ITEM 22 IN ITEM 30 THEN ITEM 19 ON ITEM 21.
3. TIGHTEN ITEM 39 TO 20 IN-LB TORQUE.
4. TIGHTEN ITEM 34 TO 20 IN-LB TORQUE.



DETAIL 5
T MOUNTING
4X
TS 1,4,16,17
SCALE 3/4

DETAIL 6
BRINE SAMPLE PORT MTG.
4X
PORTS 5,6,7,8
SCALE 3/4

| REV | GR4 | GR3 | GR2 | GR1 | NOTE | ITEM | PART NAME/DESCRIPTION | PART NO. OR NU. DWG | MATL/SPEC |
|---|---|---|---|---|---|---|---|---|---|
| | | | | - | | 1 | SOLID WASTE BIN ASSEMBLY | 412-N-002-GR1 | |
| | 1 | | | 1 | | 2 | BIN BODY ASSY. | 412-F-017-GR1 | |
| Δ | | | | 1 | | 3 | SOLID WASTE LID ASSY. | 412-F-017-GR2 | |
| | 1 | | | 1 | Δ | 4 | LID GASKET | 412-F-017-H21 | |
| | 28 | | | 28 | Δ | 5 | SOC.FLT.HD.CAP SCR. 1/2-13 NC 3A X 1 3/4 LG | | SAE GRADE 8 |
| | 8 | | | 6 | Δ | 6 | VALVE | SS-63TF8 | WHITEY CO. |
| | 5 | | | 5 | | 7 | THERMOCOUPLE FITTING | TH-274TN-125 | GORDON CO., IL. OR EQUAL |
| | | | | 12 | | 8 | GASKET | 95630A248 | McMASTER CARR OR EQUAL |
| | | | | 12 | | 9 | WASHER | 90107A037 | McMASTER CARR OR EQUAL |
| | | | | 12 | | 10 | NUT | 412-F-017-H29 | |
| | 14 | | | 6 | Δ | 11 | PIPE PLUG 2 1/2" NPT | | 150# MALLEABLE IRON |
| | 8 | | | 8 | | 12 | 90° STREET ELBOW 1/2 NPT | | SST TYPE 304 |
| | 4 | | - | 4 | | 13 | SEPTUM ASSY WITH GUIDE | 412-N-002-GR2 | |
| | | | | 1 | Δ | 14 | POLYETHYLENE LINER | 412-F-017-H30 | |
| | | | | 1 | | 15 | TC SIDE FIBERBOARD | 412-F-017-H26 | |
| | | | | 1 | | 16 | VALVE SIDE FIBERBOARD | 412-F-017-H27 | |
| | 1 | | | 1 | Δ | 17 | THERMOCOUPLE HOOD | 412-F-017-H23 | |
| | 1 | | | 1 | Δ | 18 | VALVE HOOD | 412-F-017-H24 | |
| | 6 | | | 6 | | 19 | SELF TAPPING SCR. | 90052A110 | McMASTER CARR OR EQUAL |
| | | | | AR | Δ | 20 | GLASS CLOTH TAPE | | SCOTCH BRAND #27 OR EQUAL |
| | | 1 | 1 | | | 21 | CONNECTOR | SS-400-1-OR | SWAGELOCK OR EQUAL |
| | | 1 | 1 | | | 22 | SEPTUM 11mm (7/16) 2-0658 THERMOGREEN | LB-1 | SUPELCO, INC. OR EQUAL |
| | AR | | | AR | Δ | 23 | ENGRAVING MATERIAL 2-PLEX | 448-422 | NEW HERMES INC. OR EQUAL |
| | AR | | | AR | Δ | 24 | SUPER GRIP TAPE | 990-111 | NEW HERMES INC. OR EQUAL |
| | 8 | | | 8 | Δ | 25 | PARTICULATE FILTER | | |
| | AR | | | AR | | 26 | TEFLON TAPE | 4591K12 | McMASTER CARR OR EQUAL |
| | 6 | | | 6 | | 27 | HOOD SCR | 90283A10( | McMASTER CARR OR EQUAL |
| | 1 | | | 1 | Δ | 28 | TC1 | | |
| | 1 | | | 1 | Δ | 29 | TC2 | | |
| | 1 | | | 1 | Δ | 30 | TC3 | | |
| | 1 | | | 1 | Δ | 31 | TC4 | | |
| | 1 | | | 1 | Δ | 32 | TC5 | | |
| | AR | AR | AR | AR | | 33 | LOCTITE THREAD LOCKER 262 | 91458A17 | McMASTER CARR OR EQUAL |
| | | | 1 | | | 34 | HOLLOW HEX PLUG | SS-4-HPS1 | SWAGELOCK OR EQUAL |
| | 5 | | | 5 | Δ | 35 | NYLON PAD | 8539BK11 | McMASTER CARR OR EQUAL |
| | AR | | | AR | | 36 | CEMENT | 7482A22 | McMASTER CARR OR EQUAL |
| | | 1 | | | | 37 | HEX HEAD PLUG | SS-4-PS1 | SWAGELOCK OR EQUAL |
| | | 1 | | | | 38 | DOUBLE FEMALE UNION | SS-2-VCR-6-DF | SWAGELOCK OR EQUAL |
| | | | 1 | | | 39 | SEPTUM NEEDLE GUIDE | 412-F-017-H47 | |
| | | | 1 | | | 40 | SEPTUM, 8mm (1/4) x 8mm (5/16) LG | 6524 | ALLTECH, OR EQ |
| | | | | 1 | | 41 | BOTTOM FIBERBOARD | 412-F-017-H34 | |
| | | | | 1 | | 42 | TOP FIBERBOARD | 412-F-017-H35 | |
| | 6 | | | 6 | | 43 | SAMPLE PORT GASKET | 95630A228 | McMASTER CARR OR EQUAL |
| | 6 | | | 6 | | 44 | SAMPLE PORT NUT | 412-F-017-H28 | |
| | 6 | | | 6 | | 45 | WASHER | 90107A040 | McMASTER CARR OR EQUAL |
| | 12 | - | | 4 | | 46 | SEPTUM ASSY, WITHOUT GUIDE | 412-N-002-GR3 | |
| | 6 | | | 6 | Δ | 47 | PIPE PLUG 1" NPT | | 150# MALLEABLE IRON |
| Δ | 1 | | | | | 48 | PS/SC LID ASSEMBLY | 412-F-017-GR3 | |
| Δ | - | | | | | 49 | PS/SC BIN ASSEMBLY | 412-N-002-GR4 | |

NOTES:

1. THE BIN SHALL BE FABRICATED PER THIS DWG. AND EQUIPMENT SPECIFICATION E-A-334

2. NUCLEAR FILTER TECHNOLOGY, INC. OR EQUAL, MADE PER REQUIREMENTS IN SPEC. E-A-334.

3. THERMOCOUPLE BEND RADIUS IS APPROXIMATE.

4. FIBERBOARD LINERS TAPED TOGETHER AT TAB END WITH ITEM 20.

5. FABRICATOR TO TIGHTEN ITEM 11 & ITEM 47 TO 1-2 FT-LB TORQUE. WIPP TO TIGHTEN ITEM 11 & ITEM 47 TO 2-3 FT-LB TORQUE AFTER INSTALLING ITEM 11 & ITEM 47 WITH 2 LAYERS OF ITEM 26

6. SHIP ITEM 4 PLACED INSIDE ITEM 2

7. TAGS TO BE RED WITH WHITE LETTERING ON A 3" X 2" TAG WITH 1/2" CHARACTERS. TAGS TO BE MOUNTED WITH ITEM 24. TEXT OF EACH TAG SHOWN IN TAG IDENTIFICATION TABLE.

8. INSTALL WITH ITEM 33 APPLIED PER MANUFACTURER'S INSTRUCTIONS

9. ITEM 17 AND 18 REMOVED FROM BIN ASSEMBLY, GR1, FOR CLARITY.

10. DIMENSIONS SHALL CONFORM TO ASA B18.3-1963. SQUARE HEAD DIMENSIONS SHALL CONFORM TO ASA B18.2-1960 FOR 1 1/2" NOMINAL WRENCH SIZE.

11. TIGHTEN TO 20 FT-LB TORQUE

12. CADMIUM PLATE TO QQ-P-416 TYPE II CLASS III. ALL THREAD CLASS. APPLY AFTER PLATING.

13. LEAVE TOP OF ITEM 14 LOOSE AFTER INSTALLING ITEMS 15, 16, 41, & 42

14. APPLY CEMENT, ITEM 36, 1" EVERY 6" PER MANUFACTURER'S INSTRUCTIONS. THE LAST APPLICATION SHALL BE 6" FROM THE TIP OF THE THERMOCOUPLE.

15. STENCIL BIN EQUIPMENT NO. AND THREE DIGIT SERIAL NO. LETTERS SHALL BE 1/2"-1" HIGH INDELIBLE WHITE. LIDS AND BINS OF THE SAME SERIAL NUMBER SHALL BE SHIPPED TOGETHER. SOLID WASTE BIN EQUIP NO.: 63-S-001 S/N -001, ETC. PS/SC BIN EQUIP NO.: 63-S-004, S/N -001, ETC.

16. THERMOCOUPLES SHALL BE SUPPLIED BY SANDIA NATIONAL LABS. THERMOCOUPLE INSTALLATION PROCEDURES, INSTRUCTIONS, AND TRAINING FOR INSTALLATION SHALL BE PROVIDED BY SANDIA NATIONAL LABS. ALL MATERIALS, INSTRUCTIONS, AND TRAINING SHALL BE APPROVED BY W-WID PRIOR TO IMPLEMENTATION.

17. TIGHTEN TO 30 FT-LB TORQUE.

18. VALVE TO BE INSTALLED WITH THE FOLLOWING:
HANDLE KIT #SS-51K-63K-OG
FASTENER KIT #SS-61K-63 (IF REQD)

19. NYLON 6/6 FED. SPEC. LP-410a

20. PLUG LEAK TEST PORTS IN ITEM 36 WITH WELD FILLER MATERIAL.

| # | TAG IDENTIFICATION TABLE Δ |
|---|---|
| 1 | BRINE INJECT 1 |
| 2 | OXY GETTERING IN |
| 3 | INSTR PORT |
| 4 | BRINE INJECT 2 |
| 5 | BRINE SAMPLE 1 |
| 6 | BRINE SAMPLE 2 |
| 7 | BRINE SAMPLE 3 |
| 8 | BRINE SAMPLE 4 |
| 9 | BRINE STABILIZE 1 |
| 10 | BRINE STABILIZE 2 |
| 11 | TC - 1 |
| 12 | TC - 2 |
| 13 | TC - 3 |
| 14 | TC - 4 |
| 15 | TC - 5 |
| 16 | BRINE INJECT 3 |
| 17 | BRINE INJECT 4 |
| 18 | OXY SENSOR OUT |
| 19 | OXY SENSOR OUT BACKUP |
| 20 | OXY SENSOR IN |
| 21 | OXY SENSOR IN BACKUP |
| 22 | INSTR PORT BACKUP |
| 23 | OXY GETTERING OUT |
| 24 | BRINE INJECT 5 |
| 25 | BRINE INJECT 6 |
| 26 | BRINE INJECT 7 |
| 27 | BRINE INJECT 8 |
| 28 | BRINE INJECT 9 |
| 29 | BRINE INJECT 10 |
| 30 | BRINE INJECT 11 |
| 31 | BRINE INJECT 12 |

| REV | DATE | ISSUE DESCRIPTION | BY | ENG | ECO | EWP |
|---|---|---|---|---|---|---|
| B | 01/02/90 | REVISED & ADDED SHT 2 PER ECO | DEC | JG | 4074 | |
| A | 12/11/89 | APPROVED FOR USE | AES | MB | 3256 | |
| - | 11/9/89 | ISSUE FOR REVIEW | AES | MB | 3256 | |

INTERPRET DWG. PER ANSI Y14.5
DIM. IN INCHES BASED ON 68° F
UNLESS OTHERWISE SPECIFIED TOLERANCES
FRACTIONS ±1/8
TORQUE ±3 FT-LB
OR +2 -0 IN-LB

ENGINEERING RELEASE
BY WID-WIPP
ECO ____ DATE ____

DFTO A.L. SEWALD 10/30/89
CHKR D. HUGHES 1/12/90
COG ENG J.J. GARCIA 1/11/90
COG MGR J.J. GARCIA 1/12/90
Q.A. JAMES F. ALLDI 12/8/89
SAFETY C.A. JACKSON 12/8/89
APPD W.R. WHITE 12/8/89
APPD TERRY D. MERCING (SNL)
DFTG MGR 1/12/90
ENG. MARTY A. MELCHE 12/8/89
DOE L.K. HUNTER 12/11/89
SCALE 1/8 UNO

U.S. DEPARTMENT OF ENERGY
Westinghouse Waste Isolation Division
Waste Isolation Pilot Plant
CARLSBAD, NEW MEXICO

BIN SCALE TESTS
BIN ASSEMBLY

SYS. WH06 DWG NO 412-N-002-W REV B SH 1 OF 2

| B | B | REVISION |
|---|---|---|
| 2 | 1 | SHEET |

REV STATUS OF SHEETS

Figure 9-2 (continued)

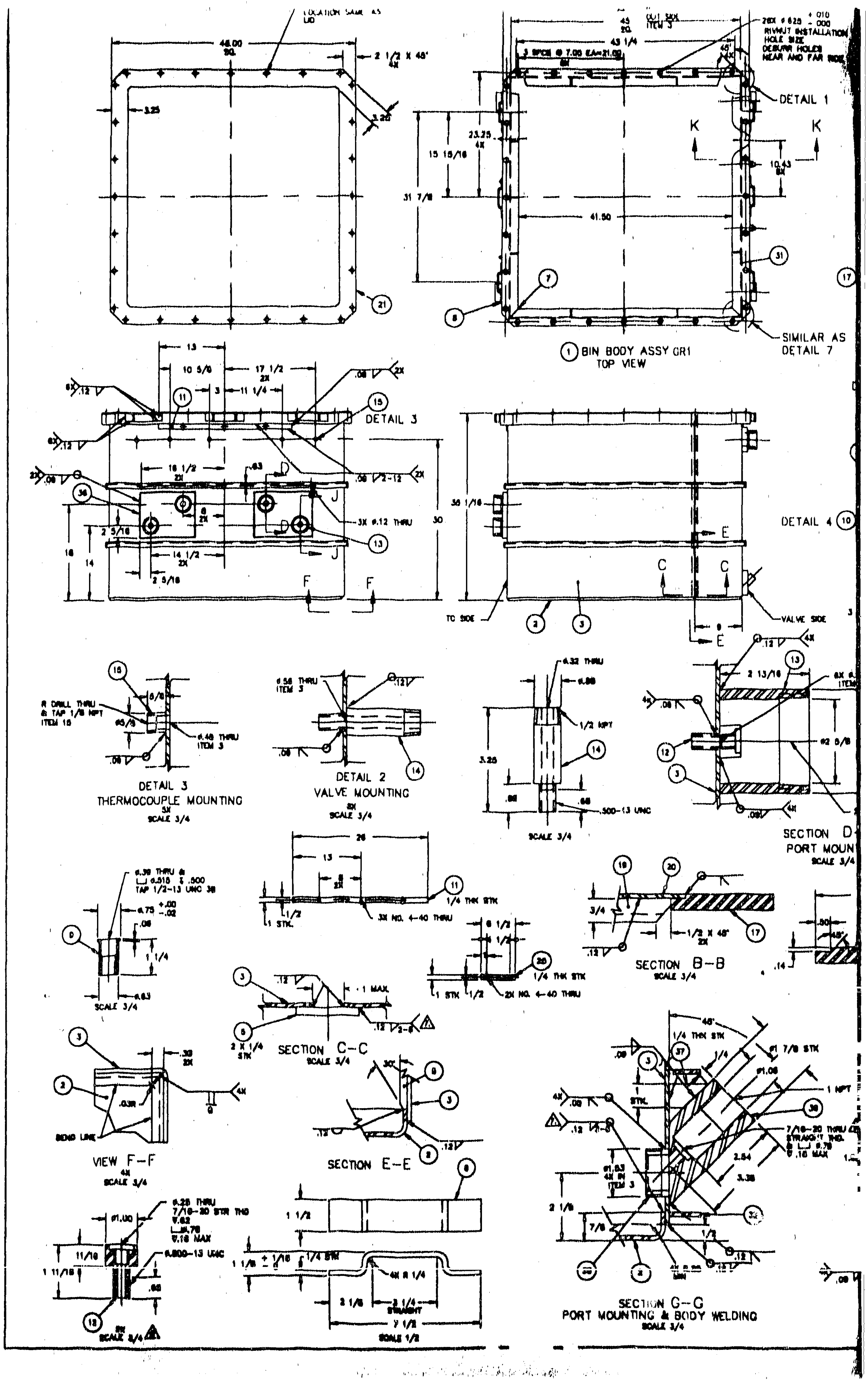
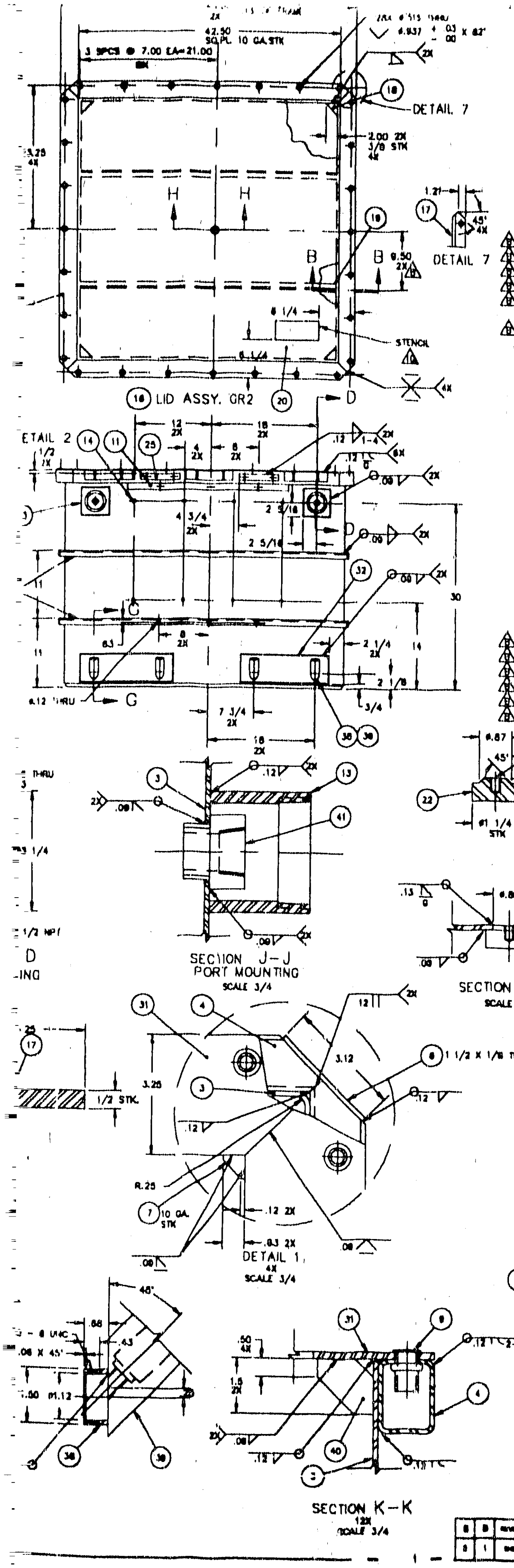
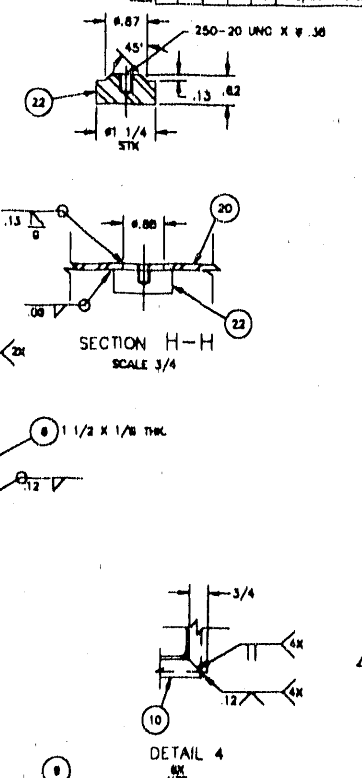



Figure 9-3 WIPP CH TRU Solid Waste Bin Details Drawing



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | – | | 1 | BIN BODY ASSY. | 412-F-017-GR1 | |
| | | | 1 | | 2 | BOTTOM PL. 10 GA. | | ASTM A-569 |
| | | | 1 | | 3 | SIDE PL. 10 GA. | | ASTM A-569 |
| | | | AR | | 4 | TUBE TS 1 1/2 X 2 X 11 GA. | | ASTM A-513 |
| | | | 1 | | 5 | JOINER | | ASTM A-569 |
| | | | 4 | | 6 | TUBE END PL. | | ASTM A-569 |
| | | | 4 | | 7 | BIN CORNER PL. | | ASTM A-569 |
| | | | 8 | | 8 | LIFT CLIP | | ASTM A-36 |
| | | | 2[illegible] | △4 | 9 | RIVNUT 1/2-13 UNC 3B | | ASTM 1214 |
| | | | 8 | | 10 | L 1 X 1 X 1/4 | | ASTM A-36 |
| | | | 2 | | 11 | HOOD BAR | | ASTM A-569 |
| | | | 4 | | 12 | SEPTUM MOUNT | | SST 316L ASTM A-276 |
| | | | 8 | | 13 | PORT PROTECTOR | | ASTM-A36 |
| | | | 8 | | 14 | VALVE MOUNT | | SST 316L ASTM A-276 |
| | | | 5 | | 15 | THERMOCOUPLE MOUNT | | ASTM-A36 |
| △B | | – | | | 16 | SOLID WASTE BIN LID ASSY. | 412-F-017-GR2 | |
| △B | 4 | 4 | | | 17 | LID SEATING BAR | | ASTM A-569 |
| △B | 4 | 4 | | | 18 | LID CORNER PL. | | ASTM A-569 |
| △B | 2 | 2 | | | 19 | STIFFENER L 1 X 1 X 1/4 | | ASTM A-36 |
| △B | | 1 | | | 20 | SOLID WASTE BIN LID PL. 10 GA | | ASTM A-569 |
| | | | 1 | △3 | 21 | LID GASKET 1/2 THK. EPDM RUBBER 45-50 DURO | | ASTM D-1056 |
| △B | 1 | 1 | | | 22 | LIFT NUT | | SST 316L ASTM A-276 |
| | | | 1 | | 23 | THERMOCOUPLE HOOD | | ASTM A-569 |
| | | | 1 | | 24 | VALVE HOOD | | ASTM A-569 |
| | | | 2 | | 25 | GUIDE BAR | | SST 316L ASTM A-276 |
| | | | 1 | △5 | 26 | TC SIDE FIBERBOARD | | PPP - F - 3200 |
| | | | 1 | △5 | 27 | VALVE SIDE FIBERBOARD | | PPP - F - 3200 |
| | | | 1 | | 28 | SAMPLE PORT NUT | | |
| | | | 1 | | 29 | NUT | | SST 316L ASTM A-276 |
| | | | 1 | △6 | 30 | POLYETHYLENE LINER | | |
| | | | 4 | | 31 | TUBE SEATING PL. 10 GA. | | ASTM A-569 |
| | | | 2 | | 32 | SAMPLE PORT GLOVE MTG. | | ASTM A-569 |
| | | | 2 | | 33 | UPPER INJECT. PORT GLOVE MTG. | | ASTM A-569 |
| | | | 1 | △5 | 34 | BOTTOM FIBERBOARD | | PPP - F - 3200 |
| | | | 1 | △5 | 35 | TOP FIBERBOARD | | PPP - F - 3200 |
| | | | 2 | | 36 | MID PORT GLOVE MTG. | | ASTM A-569 |
| | | | 4 | | 37 | GUSSET | | SST 316L ASTM A-276 |
| | | | 4 | | 38 | MTG. RING | | SST 316L ASTM A-276 |
| | | | 4 | | 39 | PORT | | SST 316L ASTM A-276 |
| | | | 12 | | 40 | GUSSET | | ASTM A-569 |
| | | | 2 | | 41 | PLUG MOUNT | | SST 316L ASTM A-276 |
| | | | 1 | | 42 | SEPTUM NEEDLE GUIDE | | SST 316L ASTM A-276 |
| △B | – | | | | 43 | PS/SC BIN LID ASSY. | 412-F-017-GR3 | |
| △B | 8 | | | | 44 | PORT PROTECTOR | | ASTM A-36 |
| △B | 8 | | | | 45 | SEPTUM BOSS | | SST 316L ASTM A-276 |
| △B | 8 | | | | 46 | PORT PROTECTOR BOTTOM PL. 10 GA | | ASTM A-569 |
| △B | 32 | | | | 47 | GUSSET | | ASTM A-569 |
| △B | 1 | | | | 48 | PS/SC BIN LID PL. 10 GA | | ASTM A-569 |



NOTES:

1. WELD PROCEDURES, WELDER QUALIFICATIONS SHALL BE PER EQUIPMENT SPECIFICATION E-A-334. ALSO NOTE SUBMITTAL REQUIREMENTS IN THE SPECIFICATION.
2. BREAK ALL SHARP EDGES TO A .06" X 45°.
3. △ DATE OF MANUFACTURE OF GASKET MATERIAL SHALL BE WITHIN 6 MONTHS OF FABRICATION.
4. △ CADMIUM PLATE TO QQ - P - 416 TYPE II CLASS III. ALL THREAD CLASS APPLY AFTER PLATING.
5. △ TYPE SF, CLASS DOMESTIC, GRADE 125, THICKNESS : .051" MINIMUM.
6. △ LINER MATERIAL SHALL BE FIBER-REINFORCED POLYETHYLENE, NOMINAL THICKNESS .030". SUGGESTED SUPPLIER: FLEXI-LINER CORPORATION. P.O. BOX 1070 AZUSA CA 91702
7. △ SKIP WELD FORMAT APPLIES, EXCEPT AT CORNERS. THE CORNERS SHALL HAVE A CONTINUOUS 1/8" FILLET WELD EXTENDING FROM THE CORNER IN BOTH HORIZONTAL DIRECTIONS FOR A MINIMUM OF 3".
8. PAINT EXTERNAL SURFACES OF BIN WITH STEELCOTE EPO-TAR IV, COAL TAR EPOXY #150-B-113, OR EQUAL. PAINT COATING SHALL BE .010" + .010 - .000. APPLY PAINT AFTER WELD TESTS AND APPROVALS SPECIFIED IN EQUIPMENT SPECIFICATION E-A-334.
9. PAINT INTERNAL SURFACE OF BIN AND UNDERSIDE OF COVER WITH WITH PAINT 1050-5, WHITAKER COATINGS, 1500 LATHEM ST., BATAVIA, IL. 60510 OR EQUAL. APPLY FIRST COAT .0003"- .0004" DRY AND BAKE 10 - 12 MINUTES AT 300° - 315° F. APPLY SECOND COAT .0003" - .0004" DRY AND BAKE 10 - 12 MINUTES AT 400° - 425°F. APPLY FIRST COAT AFTER WELD TESTS AND APPROVALS SPECIFIED IN EQUIPMENT SPECIFICATION E-A-334.
10. △ △B STENCIL BIN EQUIPMENT NO. AND THREE DIGIT SERIAL NO. LETTERS SHALL BE 1/2"-1" HIGH INDELIBLE WHITE. LIDS AND BINS OF THE SAME SERIAL NO. SHALL BE SHIPPED TOGETHER. SOLID WASTE BIN EQUIP. NO.: 63-S-001, S/N -001, ETC. PS/SC BIN EQUIP. NO.: 63-S-004, S/N -001, ETC.
11. △ REINFORCE HOLES IN LINER WITH TEFLON WASHER, EMBEDDED IN THE LINER. WASHER SHALL BE McMASTER CARR OR EQUAL.

| REV | DATE | ISSUE DESCRIPTION | BY | CHKD | ECO | EWP |
|---|---|---|---|---|---|---|
| B | 01/12/90 | REVISED FOR ECO | DEO | JQ | 4074 | |
| A | 12/11/89 | APPROVED FOR USE | DEO | MB | 3260 | |
| – | 3/6/89 | ISSUE FOR REVIEW | [illegible] | MB | 3260 | |

U.S. DEPARTMENT OF ENERGY

Westinghouse Waste Isolation Division
Waste Isolation Pilot Plant
CARLSBAD, NEW MEXICO

UNLESS OTHERWISE SPECIFIED TOLERANCES · FRACTIONS ±1/8

BIN-SCALE TESTS
BIN DETAILS

WH06 · DWG NO. 412-F-017-W · REV. B

Figure 9-3 (continued)

found elsewhere [Bali, 1989a]. The measurement and control of internal bin pressures during test operation is described in Sections 12.1.2 and 12.1.3.

Gasket materials used between the main body and lid of the bin(s) are required to be essentially nonpermeable to oxygen gas, in order to assure that the internal bin atmosphere can remain anaerobic, as required (Section 11.1). This gasket nonpermeability requirement is defined to mean that less than 2 ppm of $O_2$ can permeate into the bin per year. Since the inside of the bin is kept at a slight positive pressure during the test period, oxygen permeation is expected to occur only by osmosis through the gasket material. Appropriate gasket materials selection and sizing are considered to be of critical importance to the success of test objectives.

3. Bin Corrosion Resistance: The metal test bins will be painted on both sides for multi-year corrosion resistance, both from the test environment and external brine drips. The inside paint on the bin will be the same as used in standard DOT 17-C waste drums, in order to provide the same internal chemical environment. The paint used in drums (manufactured) for RFP [D'Amico, 1989], is a clear phenolic resin, lacquer rust inhibitor, 105C-5. Based on previous laboratory and WIPP in situ testing, [SNL, 1979, Section 7; Braithwaite et al., 1980; Molecke, 1986; Tyler et al., 1988], the exterior paint on the bins must be significantly more corrosion resistant than the standard paint on the drums. A 16-mil-thick coating of Steelcote Epo-Tar IV, coal tar epoxy #158-B-113 [Braithwaite et al., 1980] is specified for the exterior of each WIPP test bin.

4. Bin Gas Inlet and Outlet Ports: The test bins will have multiple, redundant gas inlet/outlet and sampling ports located on two opposite sides of the bin, as illustrated in Figures 9-1, 9-2, and WID drawings 412-N-002-W and 412 -F-017-W [Bali, 1989a]. There will be a minimum of two, redundant gas sampling ports for obtaining internal gas samples for composition analyses, Section 11.2. These gas sampling ports will be located on an externally mounted, particulate filtered, closed gas recirculation loop; this recirculation loop is shared with the specific oxygen sensor instrumentation, Section 12.1.5. Tracer gases, Section 11.1.4, will also be injected through these ports on the gas recirculation loop. A minimum of two gas inlet ports will also be located on the opposite side of the bin, near the bottom, for initial internal gas purging and pressurization, Section 11.1; these ports can be shared

with the oxygen-gettering system, Section 11.1.2. There will be a minimum of two, valved gas outlet ports, with a connected gas pressure gage (Section 12.1.2), gas pressure-relief valve (Section 12.1.3), and gas flow/monitor gage (Section 12.1.4). There may also be other, redundant valved ports for other objectives, to be defined, or for backup purposes.

All gas inlet/outlet ports will be capped when not being used, to ensure a better seal and a double level of containment. The caps will be designed to trap a near-zero volume of air against the face of the port.

All gases released or sampled through a port must first pass through a particulate filter. The filter media must be fabricated of materials which cannot significantly sorb or interact with any of the gases to be quantified, specifically the VOC gases. Standard carbon-composite (Nucfil) filters are known to sorb VOCs and are, as such, specifically disallowed for use in the bins. Kevlar filter media have the desired non-gas-sorbing properties and are recommended; these filters are available from Nuclear Filter Technology or alternate suppliers. No releases of particulate materials through the filters will be allowed. Filters must be 99.7% effective for removing particulates of less than or equal to 0.3 micron in size (equivalent to a Nucfil carbon-composite filter) [Clements, 1989].

During transportation of waste-filled bins to the WIPP within a SWB, the test bin gas inlet/outlet valves will be left open so that internal bin pressurization cannot occur. There will be a minimum of two gas ports of each type for redundancy, in case one should become plugged or inoperative during the planned lifetime of the tests. In addition, all gas sampling ports and components external to the valves must be detachable and replaceable during the operational lifetime of these tests, without the possibility of unwanted gas releases. Further details on these gas port components are found elsewhere, in WID drawings 412-N-002-W and 412-F-017-W [Bali, 1989a].

5. <u>Bin Brine-Injection and Sampling Ports:</u> Each test bin will have multiple, redundant brine injection ports/septa and a minimum of two redundant, bottom-mounted, brine-leachate valves, with sampling septa. Fabrication details and locations of these ports are found in WID drawings 412-N-002-W and 412-F-017-W [Bali, 1989a]. Locations of the injection and sampling ports are also schematically illustrated in Figures 9-1 and 9-2. All brine injection

and sampling ports or septa will be capped when not being used, to ensure a better seal and a double level of containment. These caps will also be designed to trap a near-zero volume of air against the face of the ports. This is also to minimize the potential for oxygen permeation through rubber septa. Provisions will also be made to attach radiation-safety, temporary containment enclosures to the brine sampling ports, to greatly minimize the potential for contamination release during periodic brine sampling.

As listed in Table 8.3 and described in Section 8.4, the appropriate type and amount of brine will be injected into the appropriate bins, in the underground WIPP facility, through the brine injection ports or septa (for the PS/supercompacted waste top-lid assemblies). Periodically, after the start date of the test (different for each bin), brine samples will be taken through a rubber-type septum attached to the brine-leachate valves. The brine-sampling septa must also be replaceable, to avoid potential leaks after repeated sampling. The test bin will be tipped at a slight angle (on the test bin stand, Section 9.3) so that any excess brine within the bin will collect near these sampling valves for sampling and analyses (Section 11.3) or for posttest removal (Section 14.0).

## 9.2 TRUPACT-II Standard Waste Box (SWB)

The TRUPACT-II Standard Waste Box ,SWB, DOT 7A Type A, 49 CFR 178.350 [Caviness, 1988] used to transport WIPP test bins has external dimensions of 71" long (including semicircular ends) by 54.25 in. wide (excluding lifting attachments) by 37 in. high. For this test program, it has a bolted-on lid closure, Style 1. Figure 9-4 illustrates a schematic of a TRUPACT-II SWB. A waste-filled, WIPP test bin is specifically designed to fit within a SWB (WID drawing 412-G-001-W [Bali, 1989a], Figure 9-5). The bin cannot move more than about 1/4 in. in any direction within the SWB because of close bin-SWB size matching. No modifications to the SWB design are anticipated due to their use in the bin-scale test program.

Each SWB is vented to the atmosphere (or to the TRUPACT-II) with carbon-composite, HEPA filters (NUCFIL or equivalent). The carbon-composite filters sorb any volatile organic compounds, preventing their release to the atmosphere. An empty SWB (bolted, Style 1) weighs 738 lb (333 kg) and has a maxi-

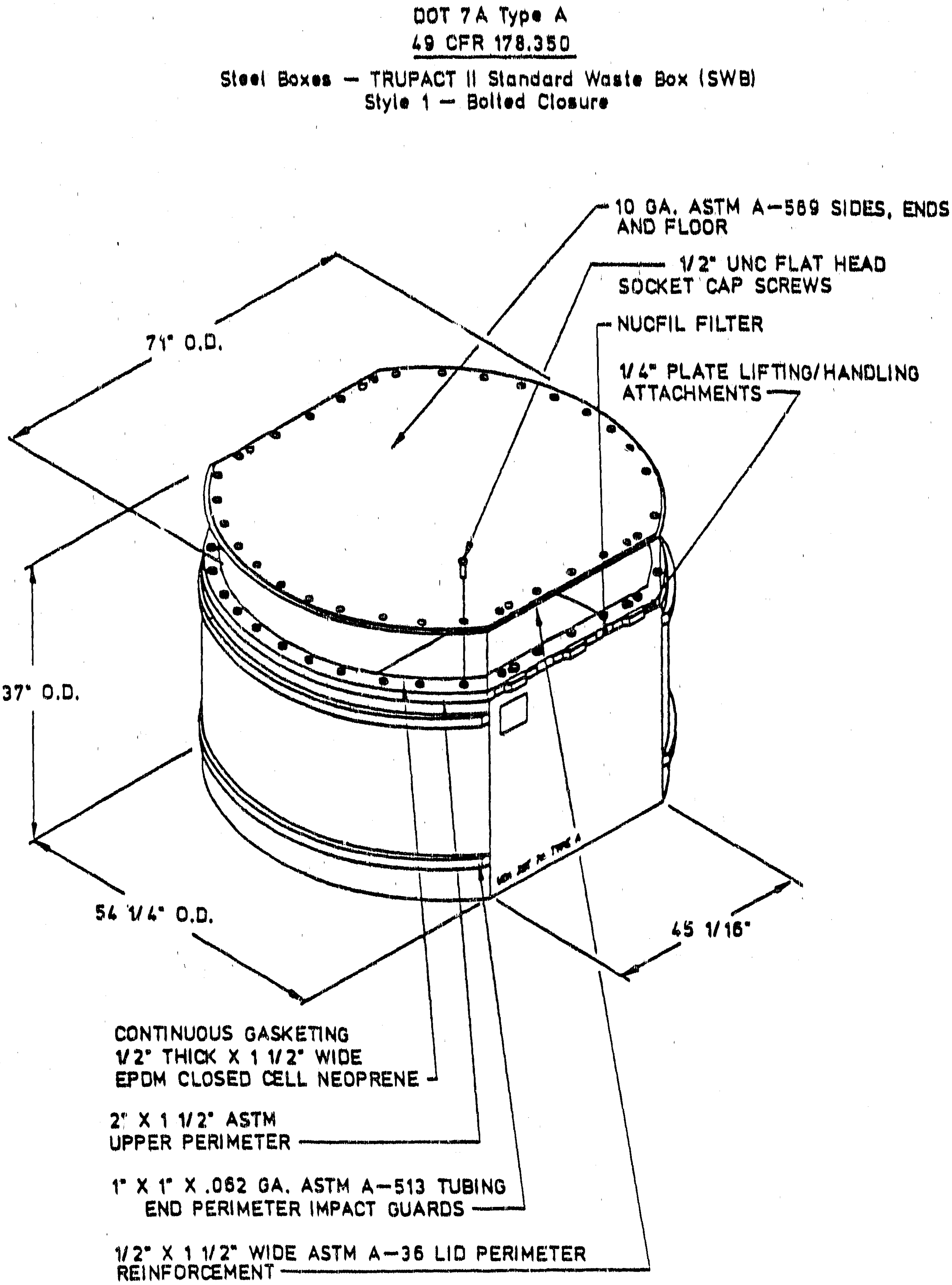



Figure 9-4 Schematic of a TRUPACT-II TRU Standard Waste Box (SWB)

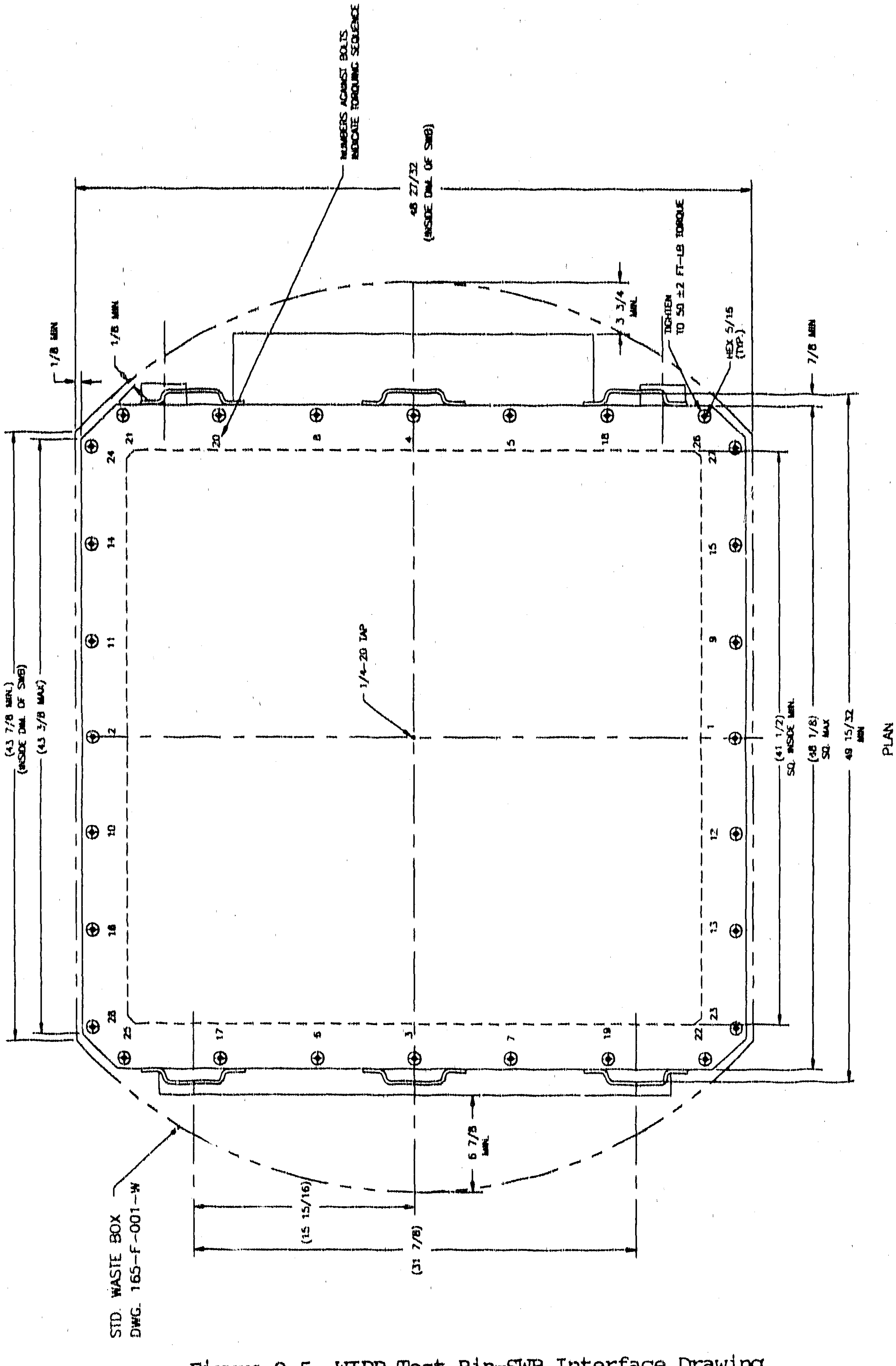



Figure 9-5 WIPP Test Bin-SWB Interface Drawing

mum authorized payload of 4000 lb (1820 kg). It can contain solid materials or particles, or 4 overpacked CH TRU drums, up to 1000 lbs. per drum. Therefore, the maximum gross weight of a waste-filled test bin, as carried within a SWB, must be limited to 4,000 lb.

## 9.3 TEST BIN-STAND HARDWARE

In order for the maximum, practical number of test bins to fit within each test room, bins must be arranged in a stacked, two-high pattern, in two rows, in each test room. The bins will be on approximate 8-foot centers, lengthwise, and no closer than 3 ft. to the rib. This arrangement permits easy person-access on all sides of the bin(s) for emplacement, installation procedures, periodic gas and brine sampling, and other maintenance purposes.

Specially designed bin-stand support fixtures will facilitate the two-high stacking of bins. These bin-stands must provide the following features:

1. The bottom of the lower bin should be near floor level, but not on the floor surface.
2. All bins must be tilted slightly downward, at least 5° forward, so that any excess brine inside will collect near the brine sampling ports, as discussed in Section 9.2). The degree of tilt should be adjustable, to accommodate any unevenness, or changes in, the room salt floor.
3. The bin stand must be able to accommodate the weight of two waste-filled test bins.
4. The bin stand must be able to accommodate any required radiation-safety required brine-containment enclosures for the bins. The design, obtainment or fabrication, and attachment of radiation-safety enclosures to the test bins is a WID responsibility.
5. The bin stand will accommodate the attachment or support of instruments (Section 12.1) or associated hardware connected to the test bins.

Further engineering design and construction details for these bin-stands are described elsewhere, in WID drawing 412-L-004-W [Bali, 1989b].

## 10.0 OTHER TEST PACKAGE COMPONENTS

Several materials or components have been mentioned or described in Sections 8 and 9 as being necessary for "special preparation" of CH TRU wastes and for conduct of the tests. These components include backfill materials, getter materials, salt/other materials, grouts, different brines, metal corrodants, and bacterial inoculants. Each component planned to be used in Phases 1 and 2 of this test program will be detailed in this Section. Other components are anticipated for testing in Phase 3 of this program but cannot be adequately described at this time. These components could include additional (existing) waste forms, future waste forms to be developed or processed by waste generators, additional backfill and getter materials, and engineered modifications or fixes developed for the purpose of limiting gas generation potential. Forthcoming details on these Phase 3 test components will be included in a future, separate Test Plan Addendum, as available.

### 10.1 BACKFILL MATERIALS

Several types of backfill and getter materials will be included in Phases 1 and 2 of this test program. The backfill materials, to be described, are either crushed WIPP rock salt or a granular mixture of 70 wt. % crushed WIPP rock salt and 30 wt. % bentonite clay. The getter materials will be specified later, based on the results of ongoing laboratory experiments [Brush, 1989]. The test bin requirements for specific backfill and/or getter materials were listed in Table 8.3. It must be emphasized that the backfill and getter materials selection, use, and emplacement procedures used in this test program are necessary to provide the desired, required data for WIPP PA analyses and evaluations. These test choices are not intended to set precedents for future (full-scale or experimental) WIPP site operations.

Although crushed salt has long been assumed to be the standard backfilling material for use in the WIPP, crushed salt/bentonite backfill (CSB) has several distinct advantages and will be used in addition in this TRU waste test program. The CSB backfill material can serve as an engineered barrier around the TRU wastes (for effective brine sorption and for retarding or sorbing leached radionuclides), possibly satisfying (draft) EPA regulations (40

CFR 191, regarding engineered barriers for transuranic wastes) [Weart, 1983]. CSB could, potentially, also be used for room and tunnel fill as well.

The chemical and physical behavior and advantages of the bentonite clay component of the backfill have been the subject of laboratory research and development at Sandia National Laboratories since 1977; results have been well documented in the literature [Tyler et al., 1988]. CSB backfills have also been tested specifically for TRU waste utilization at the WIPP in a series of in situ, simulated CH TRU waste technology experiments since 1985 [Molecke, 1986; Tyler et al., 1988].

### 10.1.1 Crushed Salt and Crushed Salt/Bentonite Backfills

The crushed salt for these experiments will be taken from WIPP mining operations, then mechanically screened to remove all particles larger than about 0.64 cm (0.25 in.). A salt screening plant to perform this screening was purchased, installed underground, and calibrated for previous WIPP Simulated CH TRU Waste Technology Experiments; [Molecke, 1986] a WIPP QA approved procedure for the use of this salt screening plant was previously prepared and approved. This salt-screening plant/equipment is available for use in this test program, or can be replaced with other similar equipment of larger capacity. The salt-screening plant removes the larger salt particles, leaving about 80 wt.% of the original mine-run crushed salt for use as backfill material. The initial bulk, dry density of this screened salt is 1290 kg/m$^3$ (80.5 lb./ft$^3$). For those test bins (refer to Table 8.3) requiring 3.0 ft$^3$ of crushed salt backfill, 242 lb. (110 kg) of crushed salt will be needed. Other details, grain size distributions, etc., on this screened salt are described elsewhere [Molecke, 1986; Pfeiffle, 1987].

The other backfill material component is bentonite clay (Wyoming bentonite, essentially sodium and calcium montmorillonite). Bentonite clay was selected because of previous SNL-WIPP testing for its beneficial properties as a backfill material, primarily brine sorption and TRU radionuclide sorption [Sandia National Laboratories, 1979; Tyler et al., 1988]. It has been tested in the laboratory since 1977 and in situ at WIPP since 1984 [Molecke, 1986]. MX-80 bentonite was selected for in situ testing [Molecke, 1986] because of its granular texture which helps minimize dusting problems during mixing and emplacement procedures. MX-80 is a pre-dried (10 % maximum water content, quite dry to the touch) and screened bentonite clay, free of chemical additives, and is commercially available from the American Colloid Co., Skokie, IL. Other technical details, grain size distribution, etc. for MX-80 bentonite are described elsewhere [Molecke, 1986].

Specific details on the preparation and properties of the CSB backfill materials are as follows. A mixture of the screened, crushed salt (70 wt.%) and granular MX-80 bentonite (30 wt.%) will be mechanically blended to +/- 2%. The initial bulk density of this granular CSB material is 1300 kg/$m^3$ (81.2 lb./$ft^3$) and has a maximum moisture content of about 3%. A blending plant was previously obtained, installed underground, and calibrated to perform the backfill mixing in the WIPP [Molecke, 1986], and is available for use in this test program. A WIPP QA approved procedure for the use of this backfill blending plant was previously prepared and approved. This blending plant consists of two dry materials feeders (with variable feed rates) and a blending auger, and has a capacity to mix about 28 to 56 $m^3$/hr (990 to 1,980 $ft^3$/hr) of backfill. Backfill materials can be blended, then stockpiled underground until test emplacement. The approximate, required quantities of CSB backfill material required are 3.0 $ft^3$ per test bin (244 lb., 110 kg), installed in two separate layers (refer to Section 8.3.1).

As listed in Table 8.3, about 8 of the test bins will have crushed salt backfill, 50 will have salt/bentonite material, and another 30 will have salt /bentonite and getter material of as yet undefined proportions (refer to Section 10.1.2, following). Required volumes and weights of all required (Phase 1 and 2) backfill materials defined at present are listed in Table 10.1. Details on bagging of the backfill materials will be described in Section 10.1.4.

### 10.1.2 Getter and Other Backfill Additive Materials

Backfill additive materials, termed getters, have been proposed [Bertram-Howery and Hunter, 1989] that would chemically react with, remove, or prevent the production of various gases generated and trapped in TRU waste storage rooms. Such getter materials are currently being tested in a laboratory program [Brush, 1989] to evaluate and quantify their effectiveness in removing gases generated from various waste degradation mechanisms. Laboratory studies, these bin-scale tests, and the parallel in situ alcove CH TRU waste

Table 10.1 Required Quantities of WIPP Bin-Scale Backfill Materials

| Material | Bins | Volume | | Weight | |
|---|---|---|---|---|---|
| | | ($ft^3$) | $m^3$ | lb. | kg |
| INPUT: | | | | | |
| Crushed Salt | | 192 | 5.44 | 15500 | 7030 |
| MX-80 Bentonite | | 72 | 2.04 | 5940 | 2700 |
| Getter Materials (TBD, assume 0 volume for these calculations) | | | | | |
| OUTPUT: | | | | | |
| Crushed Salt | 8 | 24 | 0.68 | 1930 | 880 |
| Crushed Salt/Bentonite (70%/30% wt.) | 50 | 150 | 4.25 | 12200 | 5530 |
| Salt/Bentonite/Getter (?/?/? % wt.) | 30 | 90 | 2.55 | 7310 | 3320 |

tests [Molecke, 1989b] will also evaluate the impact of expected salt mine environmental variables, (e.g., moisture, atmosphere, geochemistry) on gas gettering efficacy. Most laboratory getter studies revolve around the removal of carbon dioxide gas, probably the most abundant microbially produced gas under most anticipated repository environmental conditions. Getters may also be tested for their effectiveness in hydrogen removal. Studies of possible effects of proposed backfill additives on the closure of WIPP disposal rooms are also being evaluated [Bertram-Howery and Hunter, 1989].

Brush and Anderson [1988a, also Bertram-Howery and Hunter, 1989] proposed the use of four backfill additives to remove carbon dioxide from WIPP disposal rooms: calcium carbonate, calcium oxide, potassium hydroxide, and sodium hydroxide. Calcium carbonate would remove carbon dioxide only if brine were present. Calcium oxide, potassium hydroxide, and sodium hydroxide would remove carbon dioxide in the absence of brine. The benefits and/or disadvantages of using these specific getter materials, or others to be developed, in the WIPP TRU waste storage environment have not as yet been fully evaluated and quantified. The impacts of these getter additives on waste degradation mechanisms and on the eventual waste-brine solution (leachate) chemistry system, e.g., very high pH values, increased $Ca^{+2}$ and $CO_3^{-2}$ solution con centrations, etc., are also not known at this time. Further laboratory development, testing, and evaluations are planned [Brush, 1989; US DOE, 1989a].

The required quantity of any backfill getter additive for the removal of carbon dioxide or other gases cannot be accurately estimated at this time because of current unknowns. As such, the required quantities are not listed in Table 10.1. The exact composition of getter additives to be used, and the proportion or quantities of getters to be added to the backfill materials will, presumably, be available in early FY 91, as an outcome of the laboratory research process [Brush, 1989]. At that time, results will be documented. Because of these current unknowns, no gas getter materials have been included in Phase 1 of this test program. Getter additives will be incorporated into Phase 2 of the bin-scale test program, as available, for efficacy testing with actual CH TRU wastes.

In the long-term time period, other materials emplaced in the repository, in the vicinity of CH TRU wastes, could become a significant component of the waste-intruding brine leachate chemistry system. Materials used for sealing shafts and drifts, such as salt-cement based grouts, are of considerable interest [Nowak, 1989] and could be of importance in regards to waste degradation and gas generation. These cementitious materials would also have a significant impact on intruding brine leachate chemistry, e.g., very high pH values, increased $Ca^{+2}$ and $CO_3^{-2}$ solution concentrations, etc., similar to the effects of other proposed getter additives.

In a situation similar to the getter materials, the exact compositions of salt/grout additives to be used, and their proportion or quantities will, presumably, be an outcome of the laboratory research process [Nowak, 1989]. Salt/grouts are a potential future addition to test Phase 3, for system-chemistry impacts testing with actual CH TRU wastes.

If an eventual decision is made not to use any getter additive materials or grouts, or to use very limited quantities (for whatever reasons), then the bin backfill tests using such materials may be deleted or conducted with CSB backfill (70 %/30 %) material only.

### 10.1.3 Backfill and Getter Materials Emplacement

As described in Section 8.3.1, backfill/getter/other materials will be added to many bins in two separate layers. The bottom layer of backfill-additive materials, 0.5 $ft^3$ in volume, can be installed in the bin at a non-remote (nonradioactive) location at the generator/preparer site. The top layer, 2.5 $ft^3$ in volume, will then be poured in over the wastes before the bin is sealed. To make bin backfilling operations as simple as possible for the waste generator/preparer, the appropriate salt/backfill/getter/other materials will be blended at the WIPP and packaged in individual paper sacks (like cement bags) containing 0.5 $ft^3$ (about 41 lb., 18.6 kg) each. Each test bin, as designated in Table 8.3, would thus require a total of 6 bags of backfill/getter/other materials. The WIPP project will supply the prepackaged bags of backfill materials to the waste generator/packaging sites for use in preparing WIPP bin-scale test wastes. Procedures for mixing and bagging such backfill materials at WIPP, and transporting them to the waste generator sites, will be prepared by WID.

## 10.2 METAL CORRODANTS

The potential, long-term, anaerobic/anoxic corrosion of steel (or other metal) CH TRU waste containers or metal wastes (within the containers) in a salt repository [Bertram-Howery and Hunter, 1989] can yield significant quantities of $H_2$ gas. Initially, aerobic/oxic corrosion of metals will occur within the waste containers until all oxygen is used up, predominantly by radiolytic conversion to carbon oxides [Kosiewicz, 1981; Molecke, 1979]; dissolved $CO_2$, concentrations of $CO_3^{-2}$ in solutions could also increase. Oxygen may also be consumed by reactions with chemical anti-oxidants used as additives in some plastics [Warrant, 1989]. Then anaerobic corrosion can begin to generate hydrogen gas. However, continued radiolytic production of oxygen within the waste container may prevent a sufficient anaerobic (bin-internal) environment, thereby suppressing the generation of hydrogen. Anaerobic corrosion is one of the major modes of gas generation, and impacts thereof, to be quantified in these in situ test measurements.

A bare, mild steel (wire mesh) corrodant material will be used in the test bins instead of actual steel drum sheet metal. This substitution is intended to minimize the weight, but not the surface area, of available steel. It is recognized that the geometry of the wire mesh, and its lack of weld zones, is different from the drum sheet metal. However, the metal corrodant mesh is intended to accelerate the corrosion reactions during the course of this test program, and, presumably, the amount of hydrogen generated anaerobically over the test time interval. The total (theoretical) amount of hydrogen that can be generated anaerobically will not be altered.

The metal corrodant material will be added at the bottom of every WIPP test bin, except those termed "as-received" in Table 8.3. The corrodant will provide approximately the same steel surface area as 6 standard 55-gallon CH TRU waste drums, about 300 $ft^2$ (27.9 $m^3$, both sides of all the drums). The metal corrodant material will be multiple layers of bare mild steel wire screening, about 0.41 mm in diameter (0.16 in.), and 23 kg (51 lb.) total weight. This wire screening will be pre-cut to fit within the bottom of the test bins. Steel wire screening has the advantage of being quite inexpensive and requires minimal preparation or fabrication. The multiple layers of screening will occupy a small volume in the of the bin, with a total thickness of about 6 mm (0.25 in.), and will, in most cases, be totally immersed under the bottom layer of injected brine. Prepared metal corrodant materials' details will be specified by WID [Bali, 1989a] and provided by the WIPP project to the waste generator/packaging facilities.

## 10.3 BRINES

CH TRU wastes potentially may experience a variety of moistness conditions as a function of time after repository emplacement. General moistness conditions include those in which:

(a) The humidity within the waste and backfill materials is buffered by the emplaced wastes and backfill present.
(b) The humidity in the wastes and backfill materials is at least in local equilibrium with the brines present in the host rock salt and its disturbed rock zone, DRZ.
(c) Free brine is present in at least a portion of the waste(s).
(d) The repository is largely saturated with brines.

A variety of these general conditions are included and will be tested in this experimental program. The expected moistness condition in the short-term, repository operational phase is essentially dry. "Dry" is also the as-shipped and the reference short-term condition, before or unless the humidity of emplaced wastes equilibrate with brines in the surrounding Salado formation. "Dry" is also a possible condition in the longer-term, if the generation of waste-degradation gases effectively drives brine far enough from the waste-emplacement area to make vapor-phase transport of water inadequate to maintain humidity. Bins being tested under "dry" repository conditions, i.e., those with no injected brines, are listed in Table 8.3.

After several years of repository isolation, the wastes could be expected to be "moistened" slightly with intruding Salado brine, or by equilibration of the humidity of the waste materials with brine present in the Salado formation, as a result of vapor-phase transport. Small occurrences of Salado brines are found naturally at the WIPP repository horizon. This "moist" test condition will be directly relevant to two major time-frames or repository possibilities: (1) When brine concentration is in the process of increasing within the waste/backfill system in the relatively near-term, but "free" brine is not yet present; and, (2) at time periods in the longer-term, when repository internal gas pressures may have expelled or excluded any "free" brine from the repository waste emplacement areas, to the extent that it can no longer be argued that the repository atmosphere is in equilibrium with free brine.

For purposes of this test program, "brine moistened" is interpreted to mean waste bins injected with less than 1% by volume of brine. This is the equivalent of injecting 2 L of brine into a 210 L (55-gallon) drum-volume of waste, up to a maximum of 12 L per bin. The less than 1% brine addition is the same quantity of brine that is being injected into containers of wastes used in Phase 2 of the WIPP Alcove CH TRU Waste Test program [Molecke, 1989a], thus providing a similar environment, to aid in the interpretation of gas data from each type of test. This quantity of brine should be adequate to moisten wastes, primarily through the vapor phase, to sustain microbial degradation activity, and to initiate corrosion of contained metals. The added quantity of brine, less than 1%, should also not provide a problem during test termination and retrieval activities (refer to Section 14). Less than 1% of brine is allowable in the WIPP Waste Acceptance Criteria [US DOE, 1989c], if the posttest wastes are shipped to another site. The exact quantities of brine used to "moisten" wastes in each test bin are listed in Table 8.3.

In the post-operational, longer-term repository phase, wastes would probably become saturated with Salado brine -- assuming that long-term gas generation under "humid" conditions was inadequate to generate sufficient pressure to keep brines from entering the waste emplacement areas of the repository. Also, in the post-operational, longer-term phase, specifically in the case of potential human intrusion, the wastes possibly could become saturated with Castile brine. Castile brines originate in the geologic formation about 1,000 ft. below the repository horizon.

For purposes of this test program, brine "saturation" is being limited to mean the addition of about 10% by volume of brine, essentially 20 L per 210 L drum-volume of waste, or a maximum of 120 L of brine per test bin. For PS and supercompacted wastes, the maximum amount of brines to be added is being limited to about 5% by volume, about 10 L per 55-gallon drum-volume. There should be an adequate quantity of brine in each case to leach the waste forms in the bin and allow leachates to be sampled (except for PS and supercompacted wastes) and analyzed as a function of time (refer to Section 11.3). The exact quantities of brines used to "saturate" wastes in each test bin are listed in Table 8.3.

It is assumed that the injected brine will trickle down through the wastes, partially wetting them. Some of the brine will either sorb on the wastes or in the bottom backfill material layer. The remaining, nonsorbed brine volume will be available for periodic leachate sampling (Section 11.3) This brine will also contribute to the formation of a high-humidity environment within each test bin. The high-volume of brine injected in the "saturated" test bins, about 10 % by volume of waste, is to ensure that free brine is, in fact, present within the test bins. This is the "expected" condition should free brine actually be present in the repository, or should the repository room contents remain in equilibrium with brines within the DRZ.

Representative ionic compositions of (artificial formulation) Salado and Castile brines are listed in Table 10.2 [Brush and Anderson, 1988; Brush, 1989; D'Appolonia, 1982; Popielak et al., 1983], in units of millimoles/liter [mM] and Moles/liter [M]. Brine A [Molecke, 1983] is also listed in Table

10.2 for backup purposes. Brine A is also an artificial Salado brine that has been previously used in a multitude of WIPP-related laboratory and in situ tests [Tyler et al., 1988; Molecke, 1986]. A listed of chemicals to prepare 200 L batches of artificial Salado and Castile brines is being prepared [Brush, 1989]; the preparation formulation for Brine A is listed below. All chemicals to be used should be either reagent or technical grade, except for the NaCl, which can be WIPP mined and screened salt.

<u>Brine A</u>: $MgCl_2 \cdot 6H_2O$ 58.42 kg; NaCl 20.02 kg; KCl 11.44 kg;
$Na_2SO_4$ 1.24 kg; $Na_2B_4O_7 \cdot 10H_2O$ 390 g; $CaCl_2$ 332 g;
$NaHCO_3$ 192 g; NaBr 104 g; LiCl 25.0 g; RbCl 5.45 g;
$SrCl_2 \cdot 6H_2O$ 3.0 g; KI 2.6 g; $FeCl_3 \cdot 6H_2O$ 2.5g;
CsCl 0.25 g; conc. HCl 2.5 ml. Remainder - water, to 200 L.

Table 10.2

Preliminary Compositions of Artificial Salado and Castile WIPP Brines

| Ionic Compo-sition | Artif. SALADO (PAB 1) | Brine A | CASTILE Brine (WIPP-12) |
|---|---|---|---|
| $B^{3+}$ [mM] | 152 | 20 | 92 |
| $Ca^{2+}$ [mM] | 10 | 20 | 8.7 |
| K+ [mM] | 500 | 770 | 74 |
| $Mg^{2+}$ [M] | 1.0 | 1.44 | 0.066 |
| Na+ [M] | 3.9 | 1.83 | 6.00 |
| Br- [mM] | 13 | 10 | 6.4 |
| Cl- [M] | 6.04 | 5.35 | 5.02 |
| $SO_4^{2-}$ [mM] | 160 | 40 | 190 |
| pH (std. units) | 6.0 | 6.5 | 7.06 |
| Specific Gravity | 1.22 | 1.2 | ? |

In addition to the artificial brines, naturally occurring Salado formation brines need to be collected in WIPP underground areas and added to both the artificial Salado and artificial Castile brines. Other underground brines, such as residues of fluids spread on the floors of the drifts to control dust, or accumulations of fluids dumped down the air intake shaft are unacceptable [Lappin, 1989b]. A memorandum describing the need for collected, naturally occurring WIPP brines has been distributed [Lappin, 1989b]. This memo describes needed quantities (to be revised, refer to Table 10.3) and summarizes collection and storage restrictions.

Table 10.3 WIPP Bin-Scale Test Brine Requirements

| | | | | |
|---|---|---|---|---|
| Phase 1: | Salado Brine | 872 L | Castile Brine | 560 L |
| Phase 2: | Salado Brine | 1256 L | Castile Brine | 1036 L |
| Subtotal: | | 2128 L | | 1596 L |

Salado Brine: 90% Artificial = 1915 L + 10% Collected = 213 L

Castile Brine: 90% Artificial = 1430 L + 10% Collected (Salado) = 160 L

TOTAL Salado Brine: Artificial = 1915 L, Collected = 373 L

TOTAL Castile Brine: Artificial = 1430 L

There is currently no available source of naturally collected Castile brine. Therefore, collected Salado brine(s) will be added to the artificial Castile brine as well as to the artificial Salado brine. The purposes of this natural plus artificial brine addition are to provide:

1. A source of representative WIPP repository microorganisms, including halophilic, halotolerant, and those that could develop halotolerance. These potential brine microorganisms are in addition to any and all microbial colonies which may already exist in the TRU waste materials or that may contaminate the WIPP crushed salt (due to proximity to human or other environmental occupation of the facility) used for backfill or other purposes; refer to Section 10.4.

2. A source of naturally occurring trace minerals, not occurring in the artificial brines, which may have have some subtle but important impact on long-term waste degradation mechanisms.

The collected, naturally occurring WIPP Salado brine will be added to the artificial brines in the ratio of 10% natural to 90% artificial. This was the ratio recommended during the formal, external peer review panel meeting in August, 1989, as described in Section 3.6.1.

The total quantities of required artificial Salado and Castile brines, and natural, collected Salado brine for Phases 1 and 2 of this bin-scale test program are listed in Table 10.3 (revised).

## 10.4 MICROBIAL INOCULANTS

With the exception of potential microbial populations contained in WIPP collected Salado brines, no additional (solid) microbial inoculants need to be added to test wastes during the special preparation procedures (Section 8.3). Previous laboratory research [Molecke, 1979; Caldwell et al., 1987] has indicated that sufficient microbial populations or contaminants already exist within the waste forms (from previous human and other environmental contact) both to initiate and sustain microbial TRU waste degradation and subsequent gas generation.

# 11.0 GAS AND LIQUID CONTROL, SAMPLING, AND ANALYSES

This section describes the details and requirements for controlling and sampling both the gases and the waste-brine leachates within each test bin. Preliminary details are also described for analyzing both the gases and brine leachates, as produced, depleted, and/or impacted by the degradation of CH TRU wastes and other materials in contact with the wastes.

## 11.1 GAS ATMOSPHERE CONTROL

The gas atmosphere within each test bin must be closely controlled and monitored starting at test setup time t = emplacement (Section 8.4) and continuing after test time t = 0 (after tracer gas injection, Section 11.1.4). Close control is necessary for the following reasons:

1. To prepare the internal gas atmosphere within a bin to be representative of either the anticipated operational-phase of the repository (initially aerobic/oxic) or the post-operational, long-term phase of the repository (assumed anaerobic/anoxic, for WIPP PA modeling).

2. To monitor and control the internal pressures within each of the sealed bins, for both safety and test purposes.

3. To prevent (with the use of a slight, positive internal pressure) and monitor (with the use of stable tracer gases) potential gas leaks out of the bins, or air leaks into the bins, that could potentially dilute and contaminate gases generated from waste degradation. Since the bins are designed to be closed, essentially gas leak-tight test systems, gas leakage is assumed to be negligible (maximum of 1 % volume/month) but will still be monitored.

### 11.1.1 Bin Gas Oxygen Purging

All test bins will initially contain an air atmosphere following waste filling procedures at the generator/packaging facilities. Some of these bins will require no further internal atmosphere modifications or oxygen purging.

This includes 24 of the 56 Phase 1 test bins, and 6 of the 68 Phase 2 bins, as specified in Table 8.3 as "Initial Atmosphere - Air." Changes to this initial air atmosphere, caused by waste degradation mechanisms (discussed in Section 8.2.1), will then be analyzed as a function of time; refer to Section 11.2.

Oxygen purging will be required in all the other test bins, as specified in Table 8.3 as "Initial Atmosphere - Argon." Oxygen purging of the as-shipped, bin internal gas volume consists of the procedures of argon gas flushing and the use of an oxygen-gettering reactant system, as discussed in Section 11.1.2. Oxygen removal procedures are conducted to provide an initial anaerobic (< 10 ppm $O_2$, maximum; anticipated longer-term) gas environment at the start of this gas testing program. Any subsequent changes to the internal gas atmosphere within individual bins, as a function of time, will be controlled by the waste degradation mechanisms occurring inside; no future oxygen purging is planned. Changes in oxygen (and other gases) content in waste-filled bins will be compared to any changes occurring in the gas baseline-reference bins. The baseline bins provide background or "blank" data for correction purposes. The argon-filled baseline bins provide data on air/oxygen permeation, the air-filled baseline bins monitor, primarily, potential oxygen depletion due to corrosion or other hardware interactions.

Prior to the start of any oxygen purging procedures, an initial gas sample must be obtained for analyses from every bin (whether oxygen purged or not) at bin emplacement time t = emplacement; refer to Section 8.4. This gas sample is quite important, it provides the initial, or pretest level of VOCs in the bin, as opposed to the pretest VOC characterization conducted in the initial individual drums, as described in Section 8.3.1. The initial (time t = emplacement) bin VOC analyses will reflect changes in head-space gas concentrations resulting from repackaging, shipping, handling, and initial gas interactions with the waste matrix within a single bin.

All test bins containing high-organic/old wastes, HOOW, will be oxygen purged. During repackaging of HOOW, the previously established, very-low-oxygen content (< 0.1% $O_2$ [Zerwekh, 1979]) environment is replaced by air; oxygen purging helps reestablish a similar very-low-oxygen, essentially anaerobic environment.

Argon was selected for gas flushing rather than carbon dioxide or nitrogen. This purging gas must have an impurity content of less than 10 ppm oxygen. With the choice of argon, gases generated by microbial degradation (including a large fraction of $CO_2$ [Molecke, 1979; Caldwell et al., 1987], or, potentially, $N_2$ from denitrification or nitrate reduction [Brush and Anderson, 1988a; Bertram-Howery, 1989]) will be more readily detectable in a short time-frame, and not be masked by the flushing gas. The nitrogen concentration remaining in test bins after oxygen purging will, however, not be zero. It is estimated that the residual nitrogen level will be less than 1% by volume.

Gas flushing will be accomplished by connecting a source of (a tank of compressed) argon (purge) gas to one of the bottom gas-inlet/flushing ports and venting (old internal) gas out a top gas-outlet port, through a radioactive particulate filter, a pressure-relief valve (Section 12.1.3) and a gas flow/monitor (Section 12.1.4). Gas flushing may be preceded by, or accompanied with a gas vacuuming step. Several gas flushing/vacuuming cycles may be required. Progress of the flushing procedure towards an anaerobic state will be monitored by the oxygen concentration, analyzed with oxygen-specific detectors (Section 12.1.5) connected in series with the the gas-outlet port. The oxygen concentration may decrease slowly at first because of gas trapped in dead-end spaces or sorbed onto waste materials; oxygen could continue to diffuse out for an appreciable time. Full technical details for this gas-flushing procedure and purchase specifications for the argon gas are still being finalized at SNL and will be documented in a QA-approved procedure and in the Appendices, Section 18.11.1.1.

Argon gas-flushing is, however, not expected to be thorough or fast enough to reduce the internal bin atmosphere to a desired (initial/post-flush) anaerobic level of about 1 ppm $O_2$. To attain this level, an oxygen-gettering reactant system will be required and is described in the following Section.

### 11.1.2 Oxygen-Gettering Reactant System

The described argon-flushing procedure should be capable of reducing the internal gas atmosphere in the (required) test bins to an $O_2$ level of about 1000 ppm or less. A portable oxygen-gettering reactant system will then be used to reduce the residual $O_2$ content down to about 1 ppm. Two commercially available oxygen-gettering systems, the Vacuum/Atmospheres Company model MO-40-2H Purification System, are being provided by SNL. This oxygen-gettering system will circulate the internal bin gases through its own, gas-recirculation closed loop, removing oxygen, then returning the residual gases to the bin. The gases would exit the bin through a top gas-outlet port, traverse the oxygen- gettering system, then reenter the bin through a bottom gas-inlet /flushing port. The progress of the oxygen-gettering removal cycle (and of the eventual depletion of the reactant material) will be monitored by the oxygen-specific sensor on the bin (Section 12.1.5).

After the $O_2$ level within a (specified anaerobic) test bin has been reduced to 1 ppm, the waste degradation reactions within each bin will be allowed to control any further changes in the oxygen level, or of any other gases, just as they would in a sealed, post-closure repository environment. The oxygen content within every test bin will be frequently monitored, both with remote-reading, oxygen-specific sensors (Section 12.1.5), and by periodic gas sampling and analyses (Section 12.2). If the periodic gas analyses indicate any significant inflow leakage of air, the test Principal Investigator will decide whether the oxygen-gettering system will be attached again, or what other corrective actions should be taken.

The type of oxygen-gettering reactant system proposed is used frequently in laboratory, controlled-atmosphere (inert) glove boxes. A similar but much larger scale system will also be used in the parallel WIPP In Situ Alcove CH TRU Waste tests [Molecke, 1989b]. The portable oxygen-gettering system described can be moved on a portable cart (to be designed or obtained by WID) and used on one test bin at a time. Multiple, replaceable columns of reactant material (described below) will be necessary to keep this single system in operation. A complete second oxygen-gettering system has also been obtained to service more than one bin at a time, and for backup purposes.

The oxygen-gettering system is designed around the use of Q-5 Reactant, a replenishable oxygen scavenging material commercially available from Dow Chemical Company. Q-5 reactant is, basically, a copper catalyst supported on a granular aluminum oxide substrate (a granular material, 16-18 mesh). The controlling chemical formulae for the reactions are as follows:

1. $4Cu$ (on $Al_2O_3$) + $O_2$ --> $2Cu_2O$ ($O_2$ removal)

2. $Cu_2O + H_2$ + heat --> $2Cu + H_2O$ (regeneration cycle)

Further details on the design, needs, procedures and safety related issues for using the overall, portable oxygen-gettering reactant system will be documented in the Appendices, Section 18.10.1.2.

### 11.1.3 Test Bin Pressurization

Sealed test bins must be operated at a slight positive internal pressure, to minimize any inward air leakage (contamination) through the gasket or any other potential leak in the bin hardware system. All test bins will be initially pressurized with the appropriate, initial atmosphere gas, either air or argon, to an internal, positive differential pressure of 0.25 psid above the mine ambient pressure. The pressure within each test bin will then be remotely monitored (refer to Section 12.1.2) and maintained within certain limits, both for safety and gas-flow control purposes. The minimum pressure limit is 0.1 psid, the maximum limit is 0.5 psid. In the unlikely event that a bin internal pressure drops to 0.1 psid or below, the bin will be manually pressurized back up to 0.25 psid with makeup argon gas (research grade, with an impurity content of less than 1 ppm of $O_2$.), regardless of the initial atmosphere in the bin. Discussions of computer-controlled gas pressure-relief due to pressurizations of greater than 0.5 psid are found below and in Section 12.1.3.

In the early time-period of this test program, it is conceivable that the pressure within some bins may drop, due to radiolytic depletion of oxygen and the formation of carbon oxides [Zerwekh, 1979; Kosiewicz, 1981], or other mechanisms. The pressure will be allowed to decrease to a minimum level of 0.1 psid before manual argon repressurization procedures are started. Refer to Section 12.1.3 for a description on the control and alarm system for the required repressurization.

It is expected that the internal gas pressure within the bin(s) will rise somewhat (based on multiple observations from previous laboratory experiments [Zerwekh, 1979; Molecke, 1979; Kosiewicz, 1981]) because of the generation of gases from TRU waste degradation. Refer also to Table 11.1 (Section 11.2) for (integrated) pressure increases per year, based on credible ranges of gas generation. For safety reasons, internal bin gas pressures will not be allowed to reach pressures much above 0.5 psid. [NOTE: The bins will be fabricated to safely contain an internal pressure of at least 1 psid.] When the monitored pressure (Section 12.1.2) reaches 0.5 psid, a pressure relief valve will be electronically activated (and controlled by the remotely read pressure gage) to open, release some gas (and monitor the volume), then reseal; refer to Sections 12.1.3, and 12.1.4. For backup safety purposes, if the pressure control circuitry fails to open at 0.5 psid for any reason, there will be a second, redundant pressure gage, relief valve, and control circuit for each test bin. This secondary pressure-control system will be set to open at 0.6 psid.

The volume of gas used to pressurize each test bin will be measured during the initial and any other subsequent repressurization procedure; refer to Section 12.1.4 on gas flow/volume gages. By measuring the initial volume of injected gas and the measured change in pressures, the available bin gas/void volume (the internal bin geometric volume minus the volume occupied by wastes, other added materials, and hardware) can be calculated to within about 1% accuracy. This measured gas/void volume will be more accurate than assumed void volumes, and will be used in future gas calculation.

### 11.1.4 Test Bin Tracer Gases

After the initial bin pressurization procedure is completed, tracer gases will be injected into each test bin. These tracer gases help monitor potential air leakage into the sealed test bins, or loss of gases out of the bins. Evaluations of the changes in concentration over time of these tracers allows compensating corrections to be applied to all the other gases being quantified. Standard chemical spiking calculations, using the changes in tracer concentrations, can be used to assist in the accounting of gas mass/volume balance.

The noble gases Ne and Kr were selected as tracers because they are quite chemically inert. They will not be consumed by any chemical or microbial reactions occurring within the wastes, nor be formed by radiolysis of the test wastes. Neither of these gases are daughters of radioactive elements in the CH TRU wastes. Also, they will not react with the proposed oxygen-gettering reactant system materials.

Both Ne and Kr tracer gases will be injected into each bin through the bin gas sampling port (on the gas sampling loop) at an initial concentration of 100 ppm, each. The concentration of each tracer will be periodically monitored by gas chromatography-mass spectrometry analyses (Section 11.2). Because multiple isotopes occur in commercially available Ne and Kr, mass spectral analyses of the isotopes will also provide a degree of analytical redundancy.

The tracer gases will be homogeneously mixed with the other gases in the test bins by the action of a closed gas-recirculation system fan, part of the oxygen sensor system (Section 12.1.5). If for any reason the tracer gas concentrations are depleted below about one-quarter of their starting concentration, a second, or subsequent, 100 ppm of the tracer will be injected, at the direction of the test Principal Investigator.

The reference initial test time t = 0 for all further gas sampling and analyses (Section 11.2), different and specific to each individual test bin, is defined as the time immediately after tracer gas injection.

### 11.1.5 Radioactivity and Radioactive Particulate Monitoring

Based upon previous laboratory testing [Zerwekh, 1979; Molecke, 1979; Kosiewicz, 1981], none of the gases generated by CH TRU waste degradation within the test bins are radioactive, with the possible exception of small amounts of radon, released as a daughter product in transuranic nuclides decay chains. Other radioactive, gaseous species, e.g., $^{3}H$ and $^{14}C$ are not currently permitted components of TRU wastes to be isolated at WIPP. However, the potential for radioactive gases and radioactive particulate contamination being sampled or released, while exceedingly small, cannot be ignored. Any particulates would have to exit the test bins through particulate filters; such filters are specifically designed to prevent this occurrence. Filters must be 99.7% effective for removing particulates of less than or equal to 0.3 micron in size, equivalent to a Nucfil carbon-composite filter [Clements, 1989], as stated and required in Section 9.1, item 4.

To minimize or eliminate potential radiological safety concerns, gas samples taken for analyses (Section 11.2) will be monitored for particulate radioactivity before being transported out of the underground RMA, radioactive materials area. Radioactive particulate (continuous air, CAM) monitors will be in the downstream of the Panel 1 ventilation air path, as part of the normal waste operations monitoring program. The WIPP Safety Analysis Report (SAR) describes in detail the location and operation of these continuous air monitors. These monitors provide safety information, not test "data." As such, they will alarm locally, they will not be hooked into the SNL Data Acquisition System (Section 12.2). Westinghouse WID Operations is responsible for this monitoring function; refer to Section 16.2. If radioactive particulate contamination is detected within the test area, however, the test Principal Investigator and/or the Sandia In Situ Test Coordinator/Site Safety person (Section 16.1) will be notified, to participate in any problem resolution.

## 11.2 GAS MEASUREMENT AND ANALYSIS SYSTEM

Samples of gas from each sealed test bin will be obtained on a periodic basis for gas chromatograph-mass spectrometer, GC-MS, analyses. A separate, quality assured procedure for obtaining the gas samples has been prepared [Greenlee, 1989]. Gas samples are, briefly, planned to be collected in miniature stainless steel gas sample cylinders. The cylinder assembly will be purged, evacuated, and blanked prior to each use. The sampled gas will be filtered through a 450 nm (nanometer) Teflon membrane disk as it is collected. This removable filter is for ensuring that the gas sample contains no radioactive particulates, i.e., is radiologically safe to allow transport out of the RMA. The Teflon membrane filter is in addition to Kevlar particulate filters located on each end of the gas sampling loop. The gas sampling procedure [Greenlee, 1989] includes details on sampling considerations, needed sampling equipment, step by step procedures, radiological concerns, staff requirements, documentation, quality control and sample data sheets.

All gases within the test bin will be continually stirred by a small fan in a closed circuit loop (that is part of the specific oxygen sensor system, Section 12.1.4) to obtain a homogeneous sample. All gas samples will be prefiltered to remove any potential radioactive particulate contamination. The pre-filter or any other component of the sampling system hardware must not sorb any of the gases to be quantified, Table 11.1, particularly the VOCs.

Relevant gas data to be obtained include:

1. Test bin number.
2. Time and date of sampling: actual and in reference to test time t = 0, for each individual bin (Section 11.1.4).
3. Overall gas compositions, percentages.
4. Individual gas concentrations, in units of parts per million (ppm) by volume.
5. Oxygen level.
6. Tracer gas concentrations.
7. Gas component trends, i.e., increases or decreases in compositions and rates of production or depletion.
8. Water vapor concentration. No separate humidity gages are planned for use in the test bins because of reliability and maintenance concerns; internal bin humidity will be monitored by means of water vapor in the periodic gas samples.

Gases sampled from each test bin will be analyzed by GC-MS for the components listed in Table 11.1 (revised). These analyses and associated calculations allow the evaluation of the various gas compositions, concentrations, and changes in concentrations, to permit the calculation of the rates of generation and/or depletion as a function of time.

Gas concentrations measured from each waste-filled bin will be corrected, as necessary, with background or "blank" data obtained from the gas baseline-reference bins. Gas calculations will also include the dilution effects or quantities of gases added to repressurize the bin(s) as necessary, and gas volumes released through the pressure-relief valves (Section 12.1.4). These data will be made available in both tabular and graphical formats. Further details on data output will be found in the Appendices, Section 18.11.2.

These gases include those generated from waste degradation, released/volatilized from the wastes, e.g., VOCs, atmospheric gases, tracer gases, and daughter products from radioactive contaminants, e.g., radon. The required minimum detectable limit for each gas listed in Table 11.1 is 1 part per million (ppm, by volume). For each individual gas, the test time span required

Table 11.1 WIPP Test Gases To Be Quantified

| | |
|---|---|
| Hydrogen * | VOCs: |
| Oxygen * | Freons |
| Carbon Dioxide * | Xylenes, Mixed |
| Carbon Monoxide * | Cyclohexane |
| Methane * | Carbon Tetrachloride |
| Water Vapor * | Dichloromethane |
| (for humidity, 100 ppm) | Trichloroethylene |
| Neon (Tracer) * | 1,1,1-Trichloroethane |
| Other Tracer Gases * | 1,2-Dichloroethane |
| (and isotopic ratios) | 1,1,1-Trichloro- |
| Argon (mostly alcoves) | 1,2,2-Trifluoroethane |
| Nitrogen (mostly bins) | Perchloroethane |
| Hydrogen Sulfide | Methyl Alcohol |
| Nitrogen Oxides | Butyl Alcohol |
| Ammonia | Acetone |
| Hydrogen Chloride | Others, as detectable |
| Radon | (at > 1 ppm) |

[* = major gas, generated or other]

Table 11.2 Calculated Bin-Scale Total Gas Quantities and Pressures

| Measured Gas Generation Rate (Moles/Year/Drum) | Gas Volume Produced (Liters/Yr/Bin) (at STP) | Gas Concentration Increase ppm | % | Integrated Pressure Build-Up (psi/Yr/Bin) |
|---|---|---|---|---|
| 0.005 (radiolysis) | 0.67 L | $1.9 \times 10^3$ | 0.19 | 0.03 |
| 0.5 (midpoint) | 67 L | $1.9 \times 10^5$ | 19 | 2.8 |
| 5.0 (microbial) | 670 L | $1.9 \times 10^6$ | 190 | 28.0 |

to obtain a given degree of statistical confidence will depend on (at least): (a) the concentration level of the individual gas relative to its minimum detection limit, and (b) the relative heterogeneity measured among the the multiple, replicate bins of a given test configuration.

Table 11.2 provides an indication of the total quantity of all gases, e.g., $H_2$, $CO_2$, $CH_4$, etc., to be generated in each bin per year, based on credible, laboratory measured rates [Zerwekh, 1979; Kosiewicz, 1979, 1980, 1981; Caldwell et al., 1987; Molecke, 1979] of gas generation; refer to Table 5.1. The calculated values in Table 11.2 are based on a range of credible gas generation rates, a bin internal volume of 1.08 $m^3$, 33% void internal volume for gases to collect in, an initial trapped quantity of 16.1 moles of "total" gas, and 6 drum-volumes of waste per bin. Calculated integrated pressure buildup values within a bin are also listed, assuming (unrealistically) that no gases are released for an entire year.

The preliminary (revised) bin gas sampling schedule for individual bins, subject to modification by initial analyses and interpretations, is listed in Table 11.3:

Table 11.3 Bin-Scale Test Gas Sampling Schedule:

Initial: time t = emplacement, then
(Time t = x period, after test reference time t = 0)
Daily: x = 1, 4, 7, and 14.
Weekly: x = 3, 4, 6, and 8.
Monthly: thereafter, up to a minimum of about 5 years after test initiation.

In addition to the GC-MS analyses, oxygen concentrations will also be periodically monitored (every 4 hours) by means of solid state specific sensors, Section 12.1.5, because of the importance of knowing whether each test bin is aerobic or anaerobic (< 10 ppm).

To assure that this bin-scale test program can be initiated within the required time period, it is mandatory that all gas analyses be conducted on-site using a gas chromatograph-mass spectrometer (GC-MS) instrument. The GC-MS and supporting equipment are already on site and currently being brought to an operational state. The GC-MS system must be staffed with appropriately trained lead personnel (Section 16.1) and laboratory technicians, be calibrated (to appropriate SNL and WIPP site Quality Assurance standards), and properly maintained. Details on the operation, calibration, and maintenance procedures for the overall GC-MS system, as well as details on gas sampling procedures will be included in the Appendices, Section 18.11.2.

On-site GC-MS capability is mandatory because of the large number of gas samples to be collected on a periodic, multi-year basis, as well as the need for rapid analyses and interpretations to guide the conduct of further test operation and samplings. The elapsed time from gas sampling to analysis must be kept to a reasonable minimum. It is conceivable that some low concentration or reactive gases could sorb on, or react with the sampling container(s) (and thus not be detected) if allowed to allowed to stand around too long. The on-site, dedicated GC-MS analysis capability should be adequate to handle the currently anticipated sampling schedule. It must be kept in mind that the total number of test bins will be emplaced over a period of months to several years; this should ease possible sampling schedule difficulties.

Should the site GC-MS instrumentation be out of operation for any significant amount of time or be overwhelmed by the total number of samples (predominantly from this bin-scale program, but also from the parallel WIPP In Situ Alcove CH TRU Waste Test [Molecke, 1989b]), a backup, off-site source of GC-MS analyses may be necessary. Potential contract analysis laboratories will be lined up on an as-needed basis.

Data from the GC-MS gas analyses must be available for rapid review by both the lead analysis person [Bill Greenlee, WID] and the test Principal Investigator. Rapid review is necessary to permit possible changes in test bin sampling schedules, to help evaluate potential gas leakage or air infiltration problems (necessitating possible remedial fixes to be decided upon by the Principal Investigator), and to provide rapid, periodic input to the WIPP PA program.

## 11.3 LIQUID LEACHATE ANALYSES

Measurements of the concentrations of radionuclides, dissolved organic components, or dissolved toxic metals present in the bins' leachate brines provide a major, relevant source term data base for WIPP PA modeling and evaluation compared to EPA RCRA regulations. These bin-scale measurement provide the only waste-leachate data from actual CH TRU wastes during the five year DOE WIPP Test Phase [US DOE, 1989a].

The speciation, solubilities, and sorptive properties of radionuclides and other dissolved constituents, as affected by various interactions with components of the waste and additives, will determine their concentrations in any brine present as a function of time. These "in-bin" concentrations are in addition to, and supplementary to both theoretical predictions and laboratory measurements of (simpler system, simulated waste) leached radionuclide source terms [Brush, 1989; Bertram-Howery, 1989]. Measured "in-bin" leachate concentrations can provide kinetic rate data and repository-realistic values with which to calculate thermodynamic parameters, if it can be demonstrated that: (a) brine-leachate analyses from single bins are representative, and (b) measured species concentrations approach "steady-state" concentrations before the end of the test phase.

The speciation, solubilities, and sorptive properties of the important actinide elements in TRU waste (particularly Pu and Am, also U and Th), if present) are very sensitive to Eh and pH, impacts of any organic ligands or other chelating agents in the wastes, as well as the chemical environment within individual waste containers. This waste environment will be influenced by both waste matrix degradation and by-products thereof (e.g., chelate formation, humic-like acids, etc.), and by interactions with other repository components such as brines, sorbed chemicals, metals, backfill or getter additives, etc. These influences and interactions will probably vary significantly with test bin contents and change as a function of time. In addition, potential colloidal (and other suspended particles) transport of actinide elements by brine may be significant. Therefore, leachate brine samples from each (appropriate) test bin will be sampled periodically and analyzed for specific radionuclide concentrations, dissolved organic compounds, toxic (and other) metals in solution, presence of organic chelates, quantities of colloids, and, possibly, characterization of microorganisms.

Several simplistic calculations have been conducted in order to provide some gross or estimates on the total concentration or radioactivity to be found in the bin brine-leachate samples. The following assumptions were used:

(a) There are about 10 g of weapons grade plutonium, $^{wg}$Pu, per drum of initial CH TRU waste; this is conservatively high. $^{wg}$Pu, predominantly $^{239}$Pu, with much smaller amount of $^{240}$PU and $^{241}$Pu, has a gross alpha activity of 0.07 Ci/g [Zerwekh, 1979].

(b) There are about 6 drum-volumes of TRU waste per bin.

(c) There will be about 120 L total of saturating brine leachant in the bins to be sampled. Assume that about 1/4 of the waste within a bin is in contact with the brine. Assume that all Pu in contact with brine dissolves; this is extremely conservative since plutonium oxide, the dominant chemical form in the wastes, is known to be quite insoluble. This last assumption, total dissolution, should more than bound the case for consideration of chelated species, colloidal species, and entrained particulates in solution.

With all these conservative assumptions, the maximum concentration of dissolved plutonium should be (less than) 5.2 x $10^{-4}$ moles/liter [M], with an alpha activity of (less than) 8.8 microcuries/ml. The bin leachate calculated concentration of 5.2 x $10^{-4}$ moles/liter can also be compared with:

(a) the best estimate of Brush and Anderson [1989] of $10^{-6}$ [M] for the solubilities of Pu, Am, Th, and U in any brine that resaturates WIPP disposal rooms as the source term for transport calculations, and

(b) the estimated range of $10^{-9}$ to $10^{-3}$ [M], with an intermediate value of $10^{-6}$ (on a logarithmic scale) that Brush [Brush, 1989] is using in his sensitivity studies of the source term.

### 11.3.1 Liquid Leachate Sampling

Preliminary brine-leachate sampling requirements follow:

1. A 50 ml liquid sample will be obtained periodically (schedule below) from those bins specified as containing "saturated brines" in Table 8.3. These samples will be obtained with a syringe-type apparatus, inserted through one of the bottom-mounted brine sampling septa-ports. Appropriate radiation-safety, temporary containment enclosures may be used to prevent potential contamination during the course of sampling. The design, instal-

lation, and maintenance of such radiation-safety containment enclosures is the responsibility of WID.

2. The liquid sample will be filtered through a 450 nm (nanometer) Nuclepore (or equivalent) filter paper apparatus attached to the front end of the sampling syringe, to remove brine-suspended particulate activity. All dissolved species and colloidal particles will pass through this filter and be collected in the liquid sample.

3. The sampling needle, Nuclepore filter assembly, and brine-containing syringe will each be packaged appropriately, radiologically monitored out of the underground RMA by site Radiation Safety personnel (Section 11.3.2), and brought up to the surface facilities, within an appropriate container.

4. Small, about 50 microliter aliquots of leachate liquid samples may be used to provide a preliminary, total activity quantification. This analysis, if deemed necessary, would require an on-site liquid scintillation system. These preliminary total activity analyses, including associated equipment, procedures, and personnel, are the responsibility of WID.

5. Filter assembly and brine leachate samples will be packaged appropriately for transport to an off-site analysis facility. Further details on handling of such brine-leachate and filtered samples will be found in Section 11.3.2.

A radiation safety and quality assurance approved procedure for obtaining brine leachate samples is being prepared. Further details will be included in the Appendices, Section 18.11.3.

Relevant brine leachate sampling data to be recorded include:

(a) test bin number;
(b) time of sampling -- in reference to test time t = 0 ;
(c) brine volume;
(d) measured total activity
(e) monitored gamma and surface alpha activity levels (if any) of samples;
(f) any sampling problems, etc.

Further details on such sampling data will be found in the Appendices, Section 18.11.3.

Samples of brine leachate, including particulate filters, from each test bin will be obtained on the following preliminary schedule, listed in Table 11.4. The schedule is subject to modification by initial results.

Table 11.4 Bin-Scale Test Brine Sampling Schedule:

(Time t = x period, after test time t = 0 (Section 11.1.4)
(Note: Brine is to be injected on day t = $\leq$ 3; (Section 8.4)

| | |
|---|---|
| Daily: | x = 4, 7, 14. |
| Weekly: | x = 4, 8, 12. |
| Quarterly: | thereafter, up to a minimum of 5 years after test initiation, or as modified. |
| Posttest: | immediately before removing residual brine (Section 14.) |

### 11.3.2 Brine Leachate Samples Packaging

Facilities to analyze adequately the brine leachate, colloid, and particulate filter samples do not exist at the WIPP site, nor are they expected. Therefore, facilities to package up the (low level, radioactive) samples for transport to off-site contractor facilities must be made available at the WIPP site. This will require the services of site Radiation Safety and Transportation Operations personnel, to assure that all radiation safety and transportation regulations are adhered to. Safe operating procedures for these activities will be developed by WID, in cooperation with the contract analysis organization.

### 11.3.3 Leachate Samples Analysis Details

Outside contractor analytical facilities will be required for the analyses of the brine leachate, colloid, and particulate filter samples. Arrangements for these analytical services are currently being accomplished. This contractor laboratory will be [TBD] and will be selected by the Principal Investigator.

Required test brine leachate analytical services for all samples are currently defined to be:

1. Liquid scintillation for total activity (at WIPP, and/or elsewhere if required.
2. Alpha and gamma spectroscopy, to determine concentrations of specific radioisotopes (of Pu, Am, U, and Th) in both the liquid and filtered (suspended) particulate samples.
3. Brine pH.
4. Concentration of dissolved metals, e.g., iron, lead, possibly other toxic components (below). Details on toxic metal analysis procedures remain to be finalized with and by the generators. EPA analysis procedures and protocols will be evaluated for appropriateness for use with concentrated leachate brine samples. EPA test protocols, or modifications thereof, may then be instituted.
5. Other, to be determined after further discussion with consultant and contractor analytical personnel.

A proportion (to be determined) of the samples will be subjected to other analyses, listed below. The scope of these further analyses can not yet be totally specified.

6. Concentration of radioactive species in colloidal form, to evaluate the relative role of colloidal species in brine, relative to potential radionuclide migration. This will require filtering the liquid samples with a 1 nm filter to separate the colloids.
7. Concentrations of major solution ionic species.
8. Concentration of other dissolved toxic metals, e.g., Hg, Cd, Cr, As, Se, Ba, etc., and, possibly, other toxic components.
9. Concentrations of chelated radioactive species (including both organic and inorganic ligands).
10. Liquid chromatography for determining organic chelates and total organic content (dissolved and immiscible, if present).
11. Characterizations of microorganisms in the leachate, to help evaluate the degradation processes occurring within the test system.
12. Other, to be determined after further discussion with consultant and contractor analytical personnel.

Due to the large number of leachate samples to be acquired over the course of this test program, all samples cannot receive all analyses; the sum of total expenses would not be justified.

Following sample analyses, any remaining leachate sample will be archived for possible additional requested analyses. Residual leachate samples will be retained for a minimum of one year at the contract analysis facility location, or until released by the test Principal Investigator and WIPP QA. Following release, it is anticipated that residual leachate liquids will not be returned to the WIPP, but will be disposed of by the analyzing laboratory. If this assumption is modified in the future, a Test Plan addenda will be issued. Return of residual leachate samples to the WIPP would then require both temporary storage and radioactive liquid disposal facilities on site; if required, these would be the responsibility of WID.

Data from the brine leachate analyses must be available for rapid review by both the lead analysis person and the test Principal Investigator. Rapid review of data is necessary to permit possible changes in test bin sampling schedules, to help evaluate potential problems, and to provide rapid, periodic input to the WIPP PA program and parallel evaluations for EPA RCRA concerns.

## 12.0 INSTRUMENTATION AND DATA ACQUISITION

### 12.1 INSTRUMENTATION

Each test bin will be equipped with multiple, remote-reading instruments, with the following major purposes:

1. Thermocouples (5 per bin). To monitor internal bin temperature distributions and changes thereto, as an indicator of impacts of and to waste degradation mechanisms.
2. Gas pressure gages (2). To monitor gas pressures and absolute delta increases in pressure within the test bin, as caused by waste degradation processes.
3. Gas pressure-relief valves (2). To help control gas pressure within the test bin. The gas pressure-relief valves will be in series with the gas flow/volume gages.
4. Gas flow/volume gages (2). To quantify any gases released through the pressure-relief valve and to help provide a gas mass/volume balance.
5. Oxygen-specific gas detectors (1). To provide an independent and remote monitor on internal bin oxygen concentration, as an indicator of whether the bin is anaerobic. These solid-state detectors are used in addition to GC-MS gas content analyses (Section 11.2).

All instruments, as well as the test bins themselves, will be electrically grounded for safety purposes. Each test bin will be wired or attached to a WIPP system grounding bus (available in each test room) at one point, so as to not set up ground loops. Grounding clamps or other devices connecting the bins to the ground bus are acceptable.

The thermocouples will be the only instruments pre-installed in the test bins before waste emplacement and are, therefore, non-maintainable in case of failure. Adequate numbers of thermocouples are installed to compensate for any (low-probability) failures. All other instruments will be on the outside walls of the test bins, in the man-accessible area, and will be maintainable and/or replaceable in the event of problems. Instrument cables will extend from the test bins to junction boxes on the back (roof) above the bins. Twenty-pair jumper cables will then be routed, using messenger cables, to the instrument shed located in the southwestern corner of Room 1 of Panel 1; refer to Figure 7.2. As previously stated, no separate humidity gages are planned because of reliability and maintenance problems experienced in other WIPP in situ tests [Molecke, 1986].

To minimize the impacts of any gage failure and subsequent, potential safety problems, duplicate/redundant gages will be used in all test bin control systems. This includes pressure gages (Section 12.1.3), pressure-relief valves (Section 12.1.3), and gas flow/volume monitors (Section 12.1.4). The duplicate gage output provides a cross-check on its mate and also provides a backup in case of gage failure. The MODCOMP DAS (Section 12.2) will send out an alarm message whenever one of the gage output signals is outside of its expected range; refer to Section 12.2.1. In addition, instrumentation technicians also scan the gage output periodically, searching for suspicious data. Repair or replacement of any defective gage can then be accomplished. Even if both paired gages failed or were out of order (e.g., due to a power outage), no safety-related problems are expected to occur for several days at least; refer to Section 12.2.3.

A summary of (and totals for) all required instruments is provided in Table 12.1. The relative locations of all instruments installed on an individual test bin are illustrated in Figure 9-1. All of the following instruments will be purchased, monitored by the MODCOMP Data Acquisition System, DAS (Section 12.2), and controlled by Sandia National Laboratories. All instruments are to be calibrated before installation as required either by the manufacturer and/or by SNL, in accordance with individual, QA-approved procedures, as specified in the Appendices, Section 18.12.1. Installation of instruments will be performed by WID Experimental Operations technicians, as directed by SNL staff. Refer to Section 16.1 for a description of the SNL instrumentation and data system coordinator and the SNL instrumentation consultant.

The SNL instrumentation consultant (refer to Section 16.1) will coordinate all information about instruments used in this test program. He will also interface with the SNL instrumentation and data acquisition system coordinator (Section 16.1) for instrument control-system, software-related activities.

Table 12.1 WIPP Bin-Scale Test Instrumentation Summary (Revised 11/89)

| | | THERMO- COUPLES | PRESSURE GAGES | PRESSURE RELIEF | GAS FLOW MONITORS | OXYGEN SENSORS | BIN TOTALS |
|---|---|---|---|---|---|---|---|
| Mine Ambient: | | | 2 | | | | 2 |
| Pressure | TB001 | 5 | 2 | 2 | - | - | 9 |
| Baseline- | TB002 | 5 | 2 | 2 | - | - | 9 |
| Reference | TB003 | 5 | 2 | 2 | - | 1 | 10 |
| Bins: | TB004 | 5 | 2 | 2 | - | 1 | 10 |
| Gas | TB005 | 5 | 2 | 2 | 2 | - | 11 |
| Baseline- | TB006 | 5 | 2 | 2 | 2 | - | 11 |
| Reference | TB007 | 5 | 2 | 2 | 2 | 1 | 12 |
| | TB008 | 5 | 2 | 2 | 2 | 1 | 12 |
| Reference Subtotal: | | 40 | 18 | 16 | 8 | 4 | 86 |
| Phase 1 | TB009 | 5 | 2 | 2 | 2 | 1 | 12 |
| Test | TB010 | 5 | 2 | 2 | 2 | 1 | 12 |
| Bins: | TB011 | 5 | 2 | 2 | 2 | 1 | 12 |
| | \|\|\| | 5 | 2 | 2 | 2 | 1 | 12 |
| | \|\|\| | 5 | 2 | 2 | 2 | 1 | 12 |
| | TB056 | 5 | 2 | 2 | 2 | 1 | 12 |
| Phase 1 Subtotal: | | 240 | 96 | 96 | 96 | 48 | 576 |
| Phase 2 | TB057 | 5 | 2 | 2 | 2 | 1 | 12 |
| Test | TB058 | 5 | 2 | 2 | 2 | 1 | 12 |
| Bins: | TB059 | 5 | 2 | 2 | 2 | 1 | 12 |
| | \|\|\| | 5 | 2 | 2 | 2 | 1 | 12 |
| | \|\|\| | 5 | 2 | 2 | 2 | 1 | 12 |
| | TB124 | 5 | 2 | 2 | 2 | 1 | 12 |
| Phase 2 Subtotal: | | 340 | 136 | 136 | 136 | 68 | 816 |
| GRAND TOTAL: | | 620 TC | 250 P | 248 P-R | 240 GFM | 120 $O_2$ | 1478 SUM |
| Phase 3 | TB125 | 5 | 2 | 2 | 2 | 1 | 12 |
| Test | TB126 | 5 | 2 | 2 | 2 | 1 | 12 |
| Bins: | \|\|\| | 5 | 2 | 2 | 2 | 1 | 12 |
| (TBD) | \|\|\| | 5 | 2 | 2 | 2 | 1 | 12 |
| | TB??? | 5 | 2 | 2 | 2 | 1 | 12 |
| Phase 3 Subtotal: | | TBD | TBD | TBD | TBD | TBD | TBD |

### 12.1.1 Thermocouples

As many as 620 remote-reading thermocouples (TCs) will be used for monitoring temperatures in Phases 1 and 2 of these bin-scale tests, 5 in each test bin. Measured temperatures are anticipated to be in the mine ambient range of about 27 to 30°C. Minor increase detected may be indicated of significant microbial activity occurring within a bin. Large, steady increases in monitored temperatures could be indicative of the onset of potential spontaneous combustion processes occurring within a bin. As such, the thermocouples can be considered to be part of a safety monitoring system. Refer to Section 12.2 for a description of out-of-range signals and alarm messages by the SNL DAS system.

All the thermocouples used are Type E Chromel-Constatan and are clad in Inconel 625 sheaths, 3.2 mm (1/8 in.) in diameter, of various lengths. They have high purity MgO internal insulation and an ungrounded hot junction configuration. The thermocouples have an accuracy of better than 1.0 °C, a system resolution of +/- 0.003 °C, and a working range of more than 500 °C. Ten percent of all thermocouples will be tested in the SNL calibration laboratory to verify the stated accuracy. If any fail, all will be tested and those that fail will be discarded.

The thermocouples will be attached to the inner wall of the test bin at 5 separate locations. One TC will be on the bottom of the bin, in the exact center. Two other TCs will be on each of two side walls of the bin, the two sides that contain the other external gages, valves, sampling septa, etc., in the horizontal midpoint position and at two different vertical heights. One will be 15 cm (6 in.) from the bottom, and the other will be 76 cm (30 in.) from the bottom.

The TC leads will be held in place within the bins with the use of small, nonmetallic clips, epoxied to the bin walls. The sensing tip of each such thermocouple will be bent at a slight angle and attached so that it extends into the interior of the test bin, away from contact with the bin wall, for a distance of about 3 mm (1/8 in.). The tip of the TC can be held in place away from the wall with a small, nonmetallic wedge or fixture. Thermocouple wire sheaths will snake over the top of the liner, then exit the test bin through gas-tight, compression fittings in the bin walls. Refer to Figure 9.2 [Bali, 1989a]. All thermocouple leads extending out of the test bin prior to hookup procedure at the WIPP will be taped securely to the external bin walls and also tagged for proper identification.

Once the test bins are emplaced at the WIPP and the thermocouples installed, the external portion of the compression fittings will be epoxied in place, to eliminate any potential gas-leakage pathways. Other relevant details on the thermocouples may be found in the Appendices, Section 18.12.1.1.

A QA-approved thermocouple installation and checkout procedure will be provided by the SNL instrumentation consultant (Section 16.1) and will be included in the Appendices, Section 18.12.1.1. When the first batch of test bins are fabricated at a contractor facility, the SNL instrumentation consultant will instruct and supervise the personnel in the proper installation procedures for the thermocouples.

### 12.1.2 Gas Pressure Gages

The intent of measuring pressure and pressure changes in the test bins is to quantify the buildup and release of gases from TRU waste degradation, and to help control the sealed bins so that they do not become excessively overpressurized (a safety concern) or underpressurized (a sealing concern). The pressure within each bin will be monitored with 2 independent and redundant sealed (gage) pressure gages, yielding pressure values in psig. The sealed, gas pressure gages for all bins should be accurate to better than 1% of the measured value and are interchangeable with each other. The measured pressure data output from each redundant gage (pair) will be intercompared (by the MODCOMP DAS system, Section 12.2) for consistency.

The underground WIPP mine ambient pressure is about 14.1 psi absolute at about 1100 ft above sea level, or, equivalently, at 2150 ft below the surface. It is assumed that the differential pressure within test bins, i.e., the pressure above mine ambient due to internal waste gas generation, should be within the expected, working pressure range of 0.1 to 0.5 psid. This differential pressure could, however, be affected appreciably by external (mine ambient) pressure changes. The effects of mine-ambient pressure fluctuations on internal bin differential pressure can be eliminated by comparison to parallel gages within the sealed, pressure baseline-reference bins. Mine ambient pressure changes will affect the waste-filled and adjacent baseline-reference bins to essentially the same degree. The corrected (waste-filled) bin gas differential pressure, [$P_{Bd}$, for TB###, in psid] can be measured and/or calculated as follows:

$$P_{Bd}, TB\#\#\# = P_{Bg}, TB\#\#\# - P'_{Bg}, ref. + P_{corr.}$$

where $P_{Bg}$,TB### is the measured bin sealed gage pressure (psig), $P'_{Bg}$,ref is the average measured (sealed gage) pressure of all four pressure baseline-reference bins, and $P_{corr.}$ is a pressure correction factor equal to 0.25 psig. The $P_{corr.}$ factor is necessary so that the $P_{Bd}$,TB### value indicates the differential pressure above ambient; $P_{Bg}$,TB### and $P'_{Bg}$,ref. both have an initial value of essentially 0.25 psig (refer to Section 11.1.3.) The MODCOMP DAS system can easily calculate the average $P'_{Bg}$,ref. and $P_{Bd}$,TB###.

Appreciable perturbations or variations in the underground mine ambient pressure are expected on a periodic basis. Underground atmospheric pressure pulses could be due, primarily, to changes in the mine ventilation rate and ventilation routes and, possibly, the up and down (plunger-like) operation of the mine hoist. These sources could cause abrupt, but temporary pressure changes of up to about 0.2 psig [Cook, 1989]. A large weather storm could also potentially cause significant, longer term (negative) mine pressure pulses of possibly larger magnitude. Other sources of periodic pressure fluctuations include normal atmospheric pressure variations (magnitude of 0.2 psig or less per day) and ambient mine temperature changes (causing negligible pressure changes); refer to the Appendices, Section 18.12.1.4. These sources change on a relatively slow time-frame; they are not pulses. Mine ambient pressure variations will be monitored periodically with additional sealed (gage) pressure gages in the vicinity of the DAS shed in Room 1.

All pressure gages will be replaceable in case of failure during the course of this test program. All the sealed, psig, pressure gages have piezoresistive pressure sensors, with four piezoresistive strain gage resistors diffused onto a diaphragm to form a fully active Wheatstone bridge. These pressure sensors (Sensotech model LJS) have the following features: a range of 0 to +/- 2.5 psig, sealed and electrically centered to 14.1 psia; a 4X overpressure capacity; individual pressure calibration by the manufacturer, with 0.25% accuracy, and infinite resolution; a 0.5% long-term stability with a maximum total inaccuracy of less than 0.02 psi (due to temperature changes, hysteresis, and noise); interchangability; integral temperature compensation over the range of 0° to 70°C; sealed, rugged construction for harsh media usage, stainless steel case; solid-state reliability; humidity and corrosion resistance; low noise; moderate size and cost.

All pressure gages are initially calibrated by the manufacturer before shipment. These gages will also be periodically recalibrated at the WIPP (on the surface) on an approximate 6-month time-scale. This will require periodic removal from test bins and exchange by another gage. Other details on these gas pressure gages, including quality assured installation, checkout, and calibration procedures, will be found in Section 18.12.1.2 of the Appendices.

#### 12.1.3 Gas Pressure-Relief Valves

As described in Section 11.1.3, the internal gas pressure within each test bin must be closely monitored and maintained both for safety and for gas -flow control purposes. Therefore, the gas pressure-relief valves are required to release excess pressures as they develop. Each bin has two specially controlled, direct-acting, self-sealing, pressure-relief valves for safety purposes, each individually monitored and controlled. Time-delay circuitry (both hardware and software) will be included in the pressure-relief control system to compensate for potential mine ambient pressure pulses, as described.

Required pressure-relief will be conducted by electrically-actuated (solenoid) valves with a 0.5 in.-diameter exit orifice. The selected valves are Parker Hannefin Corporation Gold Ring solenoid valves series 20, with a maximum differential operating pressure of 3 psid, and with stainless steel 316 enclosures that are both watertight and explosion proof.

Opening of these valves will be controlled by the calculated bin differential pressure gage output, $P_{Bd}$,TB### (Section 12.1.2), fed into, interactively monitored and controlled by the MODCOMP DAS. The first relief valve will be set to open at 0.50 psid, (with release subject to the control of the time-delay compensation circuitry, below), and will be the major, controlling pressure-relief system. The second, or backup pressure-relief valve will be set to open at 0.60 psid, assuming that the first valve did not open.

If the monitored differential pressure reaches 0.55 psid, indicating a problem with the primary pressure-relief valve/relief system, the DAS will first compare the values of both the primary and backup pressure sensors, then print an alarm message on its terminal; this alarm message will also be received in the site computer monitoring room, CMR. Concurrently, the DAS will switch to its "alarm scan mode" for the pressure sensors, increasing the scanning rate to 4 times/hour. When the monitored pressure measurements from either sensor reaches 0.60 psid, the DAS will send out a control signal to ensure that the backup pressure-relief system opens up automatically. Also concurrently, the DAS will send out an alarm message to have the primary system checked and maintained as required.

To help assure that potential short-term pressure pulses in the WIPP do not inappropriately trigger the opening of the pressure relief valves, a time -delay compensation system will be used. When a high (or low, see below) differential bin gas pressure of 0.50 psid or above is recorded, the MODCOMP will switch to its "alarm scan mode" for the pressure sensors, increasing the scanning rate to 4 times/hour. Then, if three successive high pressure readings are recorded (for both bin pressure gages, as a redundant check against gage failure), indicating that the pressure change is real, not a pulse, a control signal will be sent to the primary pressure-relief valve to open, relieving the high pressure. The relief valve will be set to open for 2.0 minutes, then close. Parametric pressure calculations [Beraun, 1989] on pressure -relief valve size vs. a range of gas generation rates vs. time of valve opening (yielding pre- and post-valve opening bin pressures) indicate that the bin internal pressure should decrease about 0.1 psid during this 2.0 minute time interval.

The DAS will continue scanning every 15 minutes for pressures (after the pressure-relief valve has opened) for two more periods before returning to its normal scan rate of every 4 hours (Section 12.2.2). If, however, a temporary pressure pulse was responsible for the high pressure indication, the succeeding pressure readings will return to a lower value and the pressure relief gage(s) will not be actuated. Further details on this time-delay pressure relief compensation system will be found in the Appendices, Section 18.12.1.3.

If the monitored bin differential pressure, $P_{Bd}$,TB###, reaches 0.10 psid, indicative of either a gas depletion reaction or a potential bin leak, the DAS will send out a "Low Pressure" alarm message to its terminal and also switch to its more rapid alarm scan rate. Reasons for bin pressure decrease will have to be ascertained and corrected if necessary or possible. The pressure within the test bin will then need to be be manually repressurized to 0.25 psid, with argon gas, as previously described in Section 11.1.3.

Because of the safety-related nature of the pressure-relief control system, a backup power generator or an uninterrupted power supply (UPS) system must be available to power the control circuitry of this system in the event of a site power failure. Further details on backup power systems are found in Section 12.1.6.

The pressure-relief control system hardware and software are still in the preliminary stages of development. Further details, including quality assured installation and checkout procedures, will be documented in the Appendices, Section 18.12.1.3.

### 12.1.4 Gas Flow/Volume Gages

The volume of gases released by the pressure-relief system(s) above must be monitored as data for purposes of gas mass/volume balance. To calculate accurately the total gas volume within a sealed test bin, the initially enclosed volume must be compensated for the volumes of gases periodically released through the pressure-relief system and the volumes of gas injected to pressurize or repressurize (as required).

The gas flow/volume monitoring system is still in an early stage of development. Various types and manufacturers of components have been evaluated. The compatible components selected are manufactured by MKS Instruments, Inc., and include:

1. Mass flow/volume meters, 2 per each bin, for redundancy and safety purposes, with one being capable of being reversed, to monitor injected gas-

es. These meters are MKS Instruments, Inc. model 0258B, with a full-scale flow-rate range of 5,000 standard $cm^3$/minute, a 1.0% accuracy, 0.2% repeatability, 0.1% resolution, and a fast response time of less than 500 msec.

2. A compatible mass flow meter calibration instrument. The MKS Microcal-F transfer standard calibration system will be located on the surface at the WIPP site.
3. Mass flow calibration transfer standards. MKS Masster-Flow Type 358/1359 thermal mass flow meter/controllers will be used. Two of these standards are being obtained, with one calibrated for nitrogen, the other for argon. The flow meter gages will be calibrated for either argon (initial purge gas in some bins) or nitrogen (residual initial gas in some bins, after the oxygen purging procedure). Conversion factors for essentially all gases of interest in this test program are available. A linearized average of appropriate gas calibration factors can be calculated. This factor can then be used to correct the data output of each flow meter -- after an analysis of the bin gas has been conducted, for an adjacent time period.
4. Associated power supplies.

Parametric pressure calculations [Beraun, 1989] on pressure-relief valve size vs. a range of gas generation rates vs. time of valve opening (yielding pre- and post-valve opening bin pressures) indicate that the bin internal pressure should decrease about 0.1 psid during this 2.0 minute time interval. During this release cycle, about 4 L of gas total (at standard temperature and pressure), at a rate of 2 L/minute should be released [Molecke, 1989d].

Further details and specifications on gas flow/volume gages, calibration equipment, and procedures will be found in the Appendices, Section 18.12.1.4.

All gases released through the pressure relief valves will already have been filtered through a non-gas-sorbing, radioactive particulate filter. This filter will be in series with the gas-relief valve(s). There will be, therefore, minimal possibility of radioactive particulate releases; refer to Section 11.1.5. Released gases, initially Ar (purge gas) or $N_2$ (residual atmosphere after initial oxygen purging), then with increasing concentrations of $CO_2$, CO, $H_2$, ($O_2$ in some bins), tracers, possibly $CH_4$ and other volatile organics, etc., will be vented directly to a mine ventilation duct in the test room(s). No hazardous concentrations of gases will be released where they could be breathed by personnel.

### 12.1.5 Oxygen-Specific Gas Sensors

Oxygen concentrations in all test bins will be periodically sampled and monitored by the GC-MS instrument (Section 11.2). However, because of the importance of knowing whether specific bin atmospheres (identified in Table 8.3) are aerobic or anaerobic, oxygen will also be periodically monitored by means of electronic, oxygen-specific analyzers, with replaceable sensors.

There will be one replaceable oxygen sensor attached to the side wall of each test bin. The digital, trace oxygen-specific analyzers selected for this test program are Nyad model 242 (2 channel controller) with Neutronics/Nyad OS-4 oxygen cell, with integral fan-pump and rotameter. These analyzers have a dual range (0 - 100 and 0 - 1000 ppm $O_2$), 1% accuracy, and a resolution of 0.1/1.0 ppm. The oxygen-specific sensors in these analyzers are small, diffusion-limited fuel cells that convert oxygen concentration by volume (in parts per million) into low-level electrical currents. The oxygen sensors themselves are small, inexpensive, disposable, and easy to replace.

These analyzers require a separate gas sampling port near the bottom of the bin and an exhaust port back into the bin, near its top. A small fan continuously draws a gas stream out of the bin, passes it over the oxygen sensor, then sends it back into the bin, all in a closed loop. This fan provides a means for gently recirculating bin gases, stirring them up so that a homogenous gas samples can be obtained for analyses (section 11.2). The gas sampling port is located on the oxygen-sensor closed recirculation loop.

The oxygen specific sensors will be remotely read (scanned) every 4 hours by the DAS. If a $O_2$ concentration of greater than 10 ppm is recorded, the MODCOMP DAS will send an alarm message to its terminal, requiring some consideration or remedial action. A high oxygen concentration, or a rapid increase in concentration, could be indicative of a leak in the test bin.

Further technical details on the commercially available, oxygen-specific analyzer system and sensors, required control and calibration equipment, and fan-recirculation system will be found in the Appendices, Section 18.12.1.5.

### 12.1.6 Backup Power Supply

A backup source of electric power or power supply system is required to assure that the pressure-relief system (Section 12.1.3) and flow volume gages (Section 12.1.4) are not without power and control for a period of time exceeding approximately 12 hours. Gas pressures within test bins are not expected to increase appreciably (beyond safety limits) within 12 hours or more. Therefore, loss of electric power to the test bins and DAS could be tolerated for up to this time without any safety-related concerns or loss of significant amounts of remote-gage data; an uninterruptible power supply, UPS, should not be necessary. The potential loss of electric power for periods of time greater than 12 hours, however, mandates that a backup source of (WIPP underground) power be available for these tests.

It is proposed [McIlmoyle and Johnson, 1989] that the required underground backup power supply system use a 24 KW diesel generator similar to one previously used in the Sandia-WIPP brine migration technology experiments [Tyler et al., 1988]. This generator can be manually started and has the capability of remote starting and stopping, controlled from the surface. This remote operation helps minimize concern about potential response time and personnel reentry procedures in the case of a power outage. This generator also has [McIlmoyle and Johnson, 1989] an engine approved for underground use, including exhaust scrubber/purifiers, and a proven record of reliability. Operational usage, safety aspects, and other associated details on this diesel generator backup system have been discussed between SNL and WID safety personnel and documented elsewhere [McIlmoyle, 1989].

This diesel generator system can backup the required (pressure, pressure -relief, flow/meter) instruments and some of the other associated equipment in the underground DAS shed. Since most site power outages normally last for periods of several hours or less, it would be adequate if the generator were manually turned-on (remotely, from the surface) within about 12 hours after the initiation of a power outage.

## 12.2 DATA ACQUISITION SYSTEM

The Sandia MODCOMP data acquisition and control system will provide for the data recording needs of this test program (remote-reading instruments, supporting equipment, control circuitry, etc.), including system design, procurement, operations, and maintenance. Arrangements will be made for instrument and utility power, a backup power supply system (Section 12.1.6), design and maintenance of the cable system, and for interfacing with test personnel. The required data acquisition system, DAS, is described in the following sections.

### 12.2.1 System Plan

An operational, on-site MODCOMP DAS will be used to accommodate all remote-reading instrument data output and control circuitry for this test program. This DAS, which currently provides more than 4000 data channels, was designed, procured, installed, and is being operated by SNL. It consists of a surface facility to house the computer system: two MODCOMP 9230 central processing units, 900 Mbytes of high-speed disk storage, dual 9-track magnetic tape drives, 10 IEEE-488 instrumentation busses with extenders to the underground equipment, graphics plotters, line printers, modems, monitors, terminals, and a system console. The DAS is designed to accept and condition signals from the large variety of sensors and equipment used in these tests. This system provides both easy access to test data for evaluation and permanent records for later detailed analysis. Control software has been developed for the DAS used for all the WIPP in situ tests and technology experiments [McIlmoyle et al., 1987; Tyler et al., 1988]. Complete details on this DAS, including QA-related aspects, are found elsewhere [McIlmoyle et al., 1987].

Downhole facilities for this test program are housed in a DAS instrumentation and work shed. This shed is a prefabricated, modular building 31.5 ft-long by 13.5 ft-wide, and will be physically located in the southwestern corner of Room 1 Panel 1. The DAS shed contains the GPIB extenders, scanners, calibrators, digital voltmeters, and monitor and display systems. This shed will also house the required instrumentation monitoring and control circuitry for the similar instrumentation from the WIPP In Situ Alcove CH TRU Waste Tests [Molecke, 1989b].

Figures 12-1 and 12-2 provide a representative, overall view of the MODCOMP DAS system, which will be updated to meet the requirements or changes thereto of the test needs. Changing testing and system requirements may necessitate modifying specific components, as required in the future.

The DAS must accept the following from the WIPP Bin-Scale CH TRU Waste Tests. [Note: Specifications are given per test bin. There will be about 124 bins in Phases 1 and 2 of this test program.]

5 channels of near-field test bin temperature (thermocouple) output, monitored every 4 hours.

2 channels of measured gas (gage) pressure output, and 2 channels of (calculated) differential gas pressure output, monitored every 4 hours, except when an overly high, or low pressure reading is recorded. Then, the scan rate will be increased to 4 times/hour (Sections 12.1.2 and 12.1.3).

2 channels to transmit control signals to the solenoid-actuated, gas pressure-relief valves.

2 channels of pressure relief/gas flow monitor gage output, monitored every 4 hours, except when an overly high, or low pressure sensor reading is recorded. Then, the scan rate will be increased to 4 times per hour (Section 12.1.3).

1 channel of oxygen sensor gage output, monitored every 4 hours.

150 channels held in reserve, for future expansion as required.

Data output is serially multiplexed for transmission from the underground to the aboveground segments of the DAS.

The DAS will be set to provide an alarm output message if any of the monitored gages provide an output signal not within the expected range, indicative of a gage failure, a nonstandard condition, or a safety-related concern. Alarm messages will be printed on the MODCOMP terminal; this alarm message will also be received in the site computer monitoring room, CMR. The alarm system has recently been expanded to include automatic telephone dialer

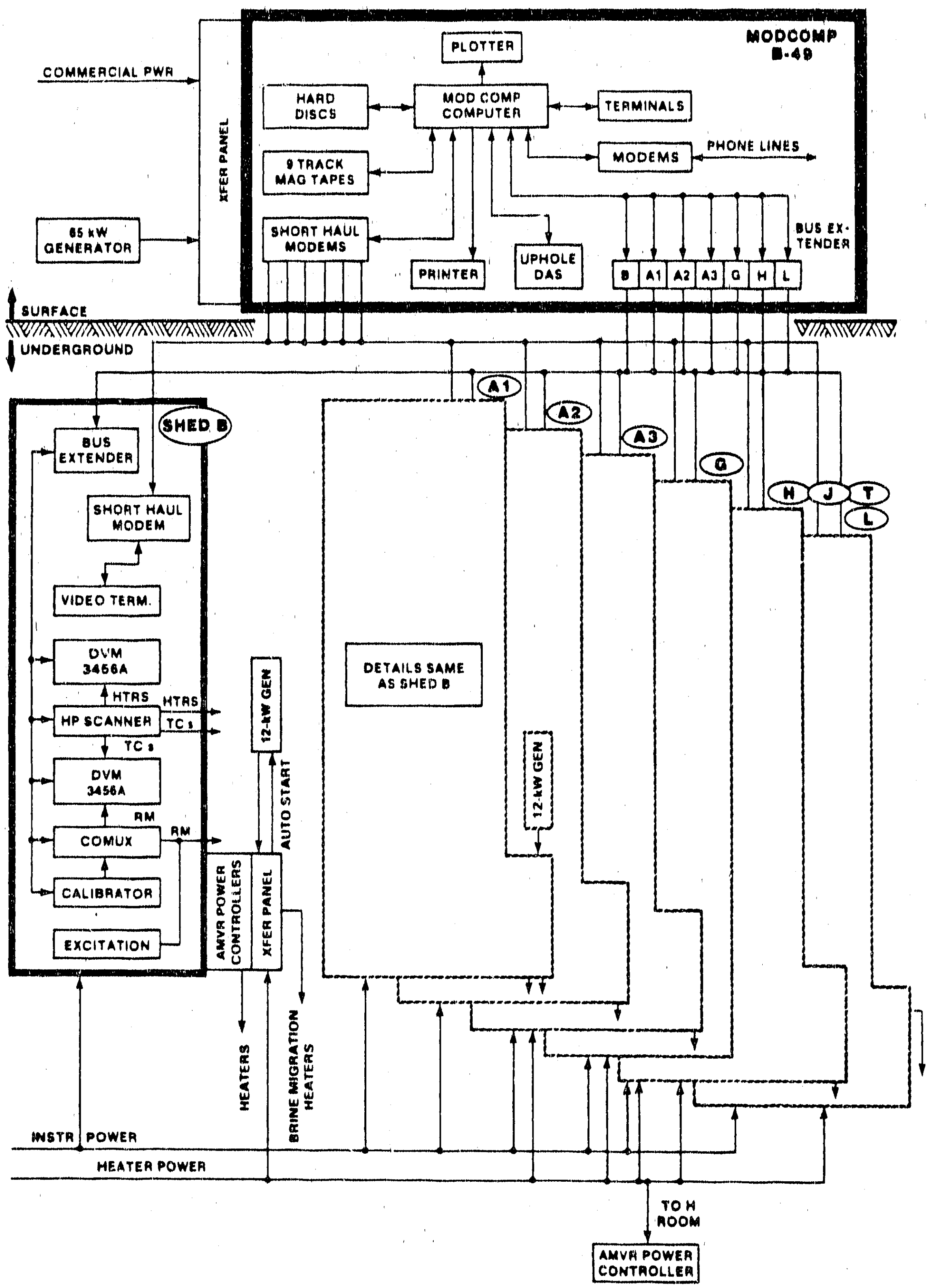



Figure 12-1 Schematic of the WIPP Data Acquisition and Recording System

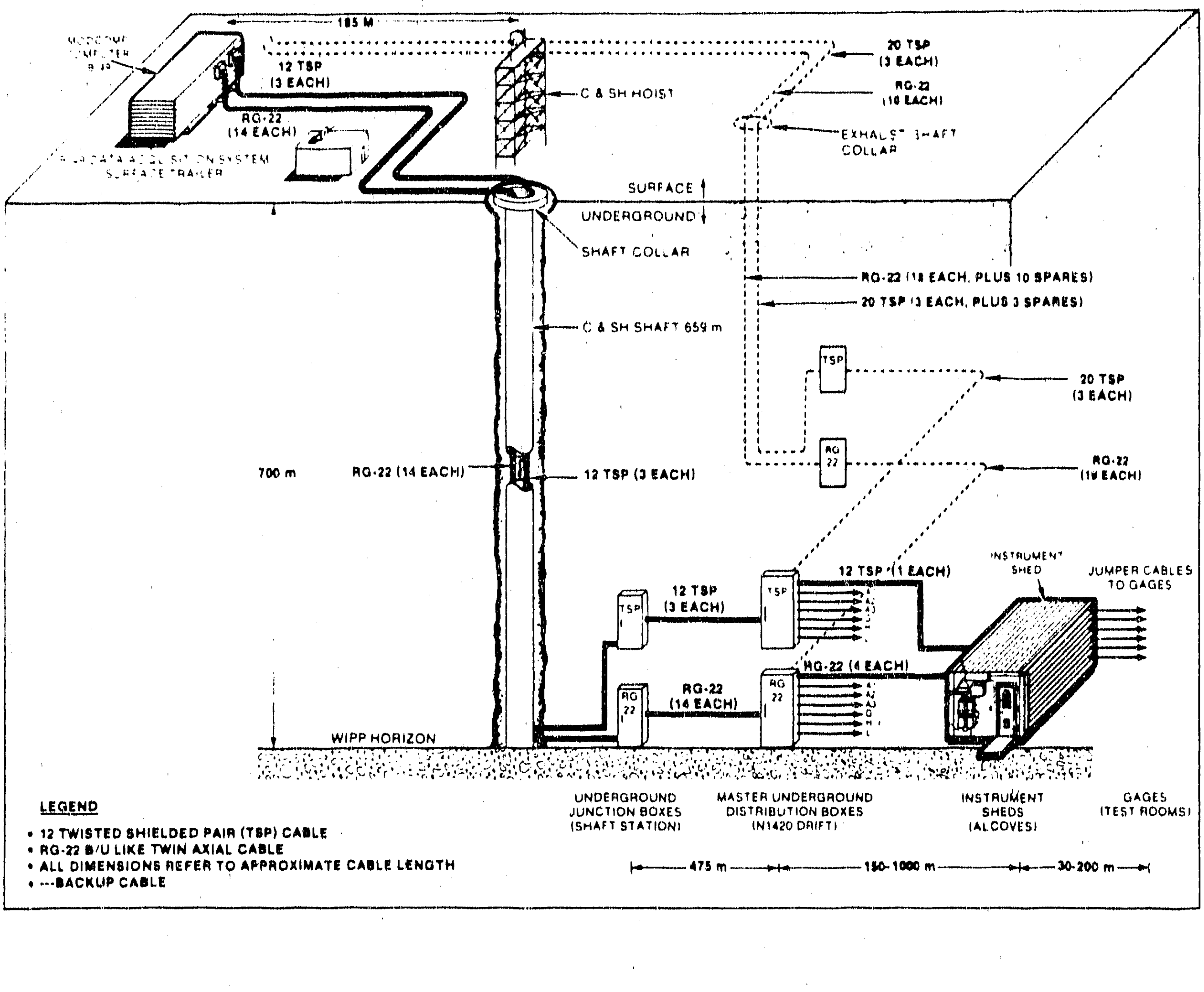



Figure 12-2  Schematic of the WIPP DAS Instrument Cable Distribution System

messages sent to both SNL personnel (at the WIPP site, or in Carlsbad, if after hours), and to site security personnel for forwarding. SNL personnel, under the direction of the SNL instrumentation and data systems coordinator (Section 16.1), will respond to these alarm message on a 24-hour basis, as needed, during week days. If an alarm message is received after normal working hours, or on weekends, and no SNL personnel are available, responsibility for response, as required, will shift to WID experimental operations personnel, also under joint, established direction of the SNL instrumentation and data systems coordinator, or his designate. Appropriate response procedures are, or will be developed. SNL and WID personnel will work closely on this matter of required responses.

Expected instrument data ranges have been specified for temperatures, pressures and parallel pressure-relief valves, and for oxygen concentrations. These ranges can be modified at a later time, after the expected or normal ranges are determined following test initiation. Other ranges may be specified in the future. Major concerns indicated by an out of range instrument reading and alarm message will be discussed in Section 16.3, on unusual circumstances. All range designations and modifications will be made by the test Principal Investigator (PI) and/or his designate.

### 12.2.2 Data Monitoring Requirements

The data requirements of this WIPP Bin-Scale CH TRU Waste Test follow:

1. Installation log with daily summaries of test instrument and associated equipment installation and of gage installation, referencing procedures, deviations, gage identity, and wiring locations.

2. Calibration log for the gages, including initial and operating calibrations.

3. A daily test log with entries of unusual gage operation, problems, system problems, visual observations, and actions.

4. Remote-gage raw data will be available as both MODCOMP-recorded numerical data and graphical data plots. Subsequent data reduction is to be periodically performed on the SNL Department 6340 VAX computer, to provide final

data for analyses and interpretations and to illustrate graphical trends in the data.

(a) Thermocouple temperature data as a function of time and location.

(b) Bin measured gas (sealed gage) pressure data as a function of time and location, $[P_{Bg}, TP\#\#\#]$.

(c) Bin calculated differential gas pressure data as a function of time and location, $P_{Bd}, TB\#\#\# = P_{Bg}, TB\#\#\# - P'_{Bg}, ref. + P_{corr}$.

(d) Bin reference-baseline gas pressure data (measured) as a function of time and location, $P'_{Bg}$, ref. (average of 4 pressure baseline-reference bins).

(e) Mine ambient (measured) gas pressure data as a function of time, $P_{MAg}$, (average of 2 gages located near the DAS shed).

(f) Integrated gas-flow (volume) released (remotely) and injected (manually) as a function of time.

(g) Oxygen (sensor) concentration as a function of time.

5. The following dates and times of the following activities must be recorded in the permanent (SNL) test QA record, and be specific for each, individual bin:

(a) Time of shutting the gas outlet valves, after receipt at the WIPP.
(b) Time of initial gas sampling (Section 8.4).
(c) Time of bin brine injection and gas flushing (Section 8.4).
(d) Reference initial start time t = 0 (Section 11.1.3).
(e) Manual sampling schedule (actual) of gas and liquid samples taken from each test bin, showing sample identification, date, time, sample size, and any appropriate comments or observations.
(f) Time test bin sampling is considered complete and "turned off or discontinued.
(g) Any other significant bin test occurrence.

6. Gas and liquid leachate composition, concentration, and other data. The data base management format for data received from the gas and brine analyses, to be inputted to the SNL Department 6340 VAX computer, is currently being developed.

7. Data Archiving: Raw data tapes (magnetic media) and paper printouts from the test will be periodically archived as follows:
   (a) Original data tapes will be archived at WIPP, by SNL.
   (b) Duplicate data tapes will be archived at the SNL Carlsbad office.
   (c) Duplicate data tapes and paper printouts will also be sent to SNL Department 6340, WIPP Central Files, in Albuquerque, by the test coordinator or his designate.

Duplicates of the data will be made for analyses, as conducted by SNL, in Albuquerque. The originals will be retained for the duration of the test series plus 12 months after publication of the results, or until released by the PI and the SNL QA chief. Duplicates of the test log books or sheets will also be periodically archived to prevent loss or destruction of data. Daily test logs will be periodically forwarded to SNL test QA for review.

8. Photographic and other records of important features of the experiments taken at appropriate phases of the experiment are to be filed in the SNL test QA record. (This is not a "data acquisition" activity.)

## 13.0 TEST SCHEDULES AND COMMITMENTS

This section focuses on the current, preliminary schedules for conducting the WIPP Bin-Scale CH TRU Waste Tests and the commitments of all participants for assuring that the test schedules are successfully achieved. These schedules encompass essentially all of the WIPP 5-year pilot-phase/demonstration period [US DOE, 1989a]. Portions or phases of this test could be accelerated somewhat to obtain earlier data to help satisfy the needs of the WIPP PA study or, conversely, delayed, subject to the future programmat'c needs of the overall U.S. DOE WIPP project.

These bin-scale tests will begin in FY 90 and will be conducted in parallel with the related, parallel laboratory tests [Brush, 1989; Bertram-Howery and Hunter, 1989] and the WIPP In Situ Alcove CH TRU Waste Tests [Molecke, 1989b] as described previously. Preliminary schedules for all three test programs, and how they (their data output) support or relate to the needs of the WIPP PA program current schedule were recently provided elsewhere [Lappin, 1989a]. The schedules to be presented in this section, specific to the bin-scale test program, incorporate this information plus other current plans by all test participants.

Preliminary activities and schedules for this test program will be broken into two segments: (1) prerequisites required before initiation of testing with actual CH TRU wastes, and (2) schedules for testing after first waste receipt.

### 13.1 PREREQUISITES FOR TEST INITIATION

Detailed test planning for the bin-scale tests began in FY 89 and continued through late CY 89. Test procurement actions began in FY 89 and will continue in FY 90. Test room preparation and test installation also began during the later part of FY 89 and will continue for about one year. The bin-scale test program will be initiated at WIPP prior to the first receipt of actual TRU wastes. This involves, basically, the emplacement and hookup of the 8 non-waste containing, baseline-reference test bins, as described in Section 8.1. These operations can be accomplished in the WIPP in the Spring of 1990 (see Table 13.1). This early, nonradioactive segment of the test will be used to specifically initiate, checkout, and debug the overall test system, e.g., instrumentation, gas sampling, routine operations, etc., before test bins with actual TRU wastes are emplaced.

In addition to the 8 baseline-reference bins described, a "cold test" or "mock demonstration" of all significant bin emplacement, handling, sampling, safety, and retrieval operations or procedures will utilize several additional "mock" bins and be conducted (by WID) primarily as a test manpower training program. This mock demonstration program is estimated to require a couple of months. It may be conducted in parallel with the setup and debugging of the 8 baseline-reference test bins, but must be completed prior to testing with real TRU wastes. Since this mock demonstration program is not a part of the scientific studies discussed in this Test Plan, it will not be described further. WID has the responsibility for planning, documenting, and conducting this mock demonstration program.

Table 13.1 (revised) lists all of the various prerequisites and milestones required before initiation of bin-scale testing with actual CH TRU wastes can be accomplished. Like all other real-world schedules, it too is subject to update modifications

## 13.2 TESTING WITH ACTUAL TRU WASTES

Based on recent events and DOE policies, the exact opening date and date for first receipt of wastes at the WIPP are not known. It is currently assumed, however, that first receipt of wastes will be July 1, 1990 at the earliest. The schedules for bin-scale testing with actual CH TRU wastes, as listed in Table 13.2 (revised [Lappin, 1989a]), are, therefore, indicated as time intervals starting at time t = 0. The success of this schedule assumes that all experimental prerequisites for initiation of testing with actual TRU wastes (Table 13.1) have been satisfied prior to first receipt of wastes [Lappin, 1989a]. It also assumes the successful completion of all required Engineering Work Packages and Safe Operating Procedures being conducted by WID; refer to Section 13.3 for experimental support commitments required to accomplish this goal.

Table 13.1 WIPP Bin-Scale Test Prerequisites Schedules

| | | |
|---|---|---|
| 1. | 5/08/89 | Submit Draft Test Plan for WIPP Project internal review. |
| 2. | 6/01/89 | Conduct further discussions with waste generator sites (RFP and INEL) on waste preparation details, concerns, resolutions, waste delivery schedules, etc. |
| 3. | 6/05/89 | Submit Draft Test Plan for WIPP Project, NAS, and EEG review. |
| 4. | 8/09/89 | Conduct final SNL/WID bin design review. |
| 5. | 8/24/89 | Conduct formal, external peer review panel meeting on Test Plan. |
| 6. | 9/18/89 | Review bin-scale test modifications and technical updates with WIPP Panel of the NAS. |
| 7. | 11/15/8 | Complete floor preparation in Room 1 Panel 1, to allow start of DAS shed emplacement and outfitting. |
| 8. | 12/1/89 | Submit Test Plan Final Edition, for management review and approval. |
| | | (items above have been accomplished) |
| 9. | 1/90 | Initiate checkout and training of technical-support technicians. |
| 10. | 1/26/90 | Send SNL and DOE signed-off WIPP Bin Scale Test Plan (Final) to the print shop. Distribute as soon as printed. |
| 11. | 2/15/90 | Complete outfitting of DAS shed, ready for bin hookups. |
| 12. | 2/16/90 | Test bin and test rack stand fabrication starts. |
| 13. | 2/21/90 | Complete outfitting of test Room 1 Panel 1. |
| 14. | 2/28/90 | Receive first 4 test bins for baseline-reference emplacement and testing. |
| 15. | 3/01/90 | Have completed, QA approved procedure for instrument (thermocouple, pressure gage, pressure-relief valves, specific oxygen sensor bin system) installation, calibration, and operation. |
| 16. | 3/01/90 | Have completed, QA approved procedure for bin argon gas flushing procedure, and obtain all required equipment. |
| 17. | 3/01/90 | Have bin oxygen-gettering reactant system available, with QA approved procedure for use. |
| 18. | 3/01/90 | Have completed, QA approved procedure for bin pressure leak-testing. (WID) |
| 19. | 3/01/90 | Have completed, QA approved procedure for bin tracer gas injection procedure, and obtain all required equipment. (WID) |
| 20. | 3/01/90 | Have completed, QA approved procedure for bin gas sampling and GC-MS analysis procedures, and obtain all required equipment. (WID) |
| 21. | 3/15/90 | Initiate testing/checkout of 4 pressure baseline-reference bins |
| 22. | 3/28/90 | Reconvene formal peer review/consultant group for update on bin-scale test program. |
| 23. | 4/01/90 | Have completed, QA approved procedure for bin brine-injection, and obtain all required equipment. (WID) |
| 24. | 4/4/90 | Initiate testing/checkout of 4 gas baseline-reference bins. |
| 25. | 6/29/90 | Complete nonradioactive, pre-waste checkout/debugging phase of bin-scale test program. Ready for test initiation with actual TRU wastes. |
| 26. | 7/01/90 | Have completed, QA approved procedure for bin brine-leachate sampling. |

Table 13.2 WIPP Bin-Scale Test Schedules for Actual CH TRU Wastes
(assumes that time t = 0 is 7/1/90 at the earliest)

1. t = 0: First receipt of actual CH TRU wastes at WIPP. Beginning of bin emplacements for test Phase 1 at WIPP. If test emplacement at alternate location, Phase 1 would be delayed about + 6 months or more.
2. t = 5 mo.: DOE approval of backfill and getter additives for inclusion in Phase 2 tests. Approval assumed to be based on laboratory and modeling studies. Begin initiation of Phase 2 test bins.
3. t = 9 mo.: Initial Data Report (draft). Initial interpretations of early Phase 1 results (gas and brine-leachate analyses), assuming that 6 months are required for reliable data gathering and 3 more months are required for data analysis and initial interpretations.
4. t = 11 mo.: DOE approval of engineering modifications to waste and backfill additives (other than those currently under consideration) for use in Phase 3 bin-scale testing. Initiation of test Phase 3.
5. t = 14 mo.: Second Data Report (draft). Preliminary interpretations of initial results from Phase 2 bin tests.
6. t = 18 mo.: End of emplacement of Phase 3 test bins, assuming 6 months required for the emplacement of each test phase.
7. t = 27 mo.: Third Data Report (draft). End of preliminary interpretations of Phase 3 tests. Interpretations of Phase 1 and Phase 2 tests more advanced.
8. 9/92: Presently scheduled last acceptable date for data transmittal to WIPP PA for use in "final" evaluation of compliance with EPA 40 CFR 191 and 40 CFR 268.
9. Continue the periodic gas and leachate sampling and analyses from individual test bins for an estimated test duration of 5 years after test initiation.
10. Continue evaluations and correlations of bin test data with other parallel tests and analyses. Document results and evaluations in technical reports on a periodic basis, approximately yearly. Disseminate analyzed data and interpretations to WIPP PA and others, as available.
11. t = 60 mo.: Earliest planned termination of Phase 1 test bins.
12. t = 65 mo.: Earliest planned termination of Phase 2 test bins.
13. t = 78 mo.: Earliest planned termination of Phase 3 test bins.

While the starting dates shown in Table 13.2 are still subject to uncertainties, the ending dates are subject to certain bounds if these tests are to successfully provide data and interpretations to the WIPP PA program in a timely manner [Lappin, 1989a]. These tests are needed to provide both WIPP PA and parallel EPA RCRA input and guidance, they cannot simply function as a validation effort after the fact.

Early gas analyses and brine leachate radiochemical data acquisition for these tests are expected to start during FY 90. Test conduct, sampling, analyses, and interpretation are expected to continue for a minimum of about 5 years, or until the data acquired are sufficient to provide adequate statistical confidence in the reliability of the information being obtained. It is presently assumed that 95 % statistical confidence in test data (not conceptual interpretations) will be adequate. Throughout this test effort, at approximately annual intervals, the estimated statistical reliability of test data will be compared with the results of sensitivity studies conducted by, or in cooperation with, WIPP PA. The objective of these comparisons is to decide whether particular test bins are continuing to provide needed data, should be supplemented with additional replicate or similar tests, or should be terminated.

Preliminary test data and interpretations thereof will be transferred to the WIPP PA program, and other interested participants, as available; refer to Section 15. Data and analysis reports will be prepared at appropriate intervals during the testing program, at approximately annual intervals. Final results will determine whether the earlier performance assessment calculations used appropriate data ranges [Bertram-Howery and Hunter, 1989].

## 13.3 TEST COMMITMENTS FOR PARTICIPANTS

This section provides a preliminary list of commitments on bin-scale test hardware items, technical procedures, safe operating procedures, etc. to be provided by all participants for the successful conduct of the overall WIPP test effort. Items to be provided are divided among the major test participants, SNL (Table 13.3), WID (Table 13.4), and the U.S. DOE waste generating facilities (Table 13.5). Since scheduling for these items is still in a great deal of flux, milestone dates will not be presented here. They will be provided as part of the WIPP master plan or integrated test engineering and support plan, currently under preparation by WID.

Table 13.3 Sandia National Laboratories Bin-Scale Test Commitments

1. Argon gas purchase specifications, for flushing and repressurization/makeup gas.
2. Bin argon gas-flushing procedure.
3. Tracer gases, purchase.
4. Backfill and getter materials. Bentonite/salt backfill blending and backfill-bin emplacement procedures.
5. Brine preparations. Artificial brines, materials and mixing procedure.
6. Bin leachate sampling equipment and procedures (joint with brine leachate analysis contractor and WID).
7. Brine-leachate radiochemical and hazardous composition analyses. (SNL joint with contractor laboratory)
8. Bin oxygen-gettering system, portable; operating and maintenance procedures.
9. Bin gas recirculation system design, fan procurement.
10. DAS shed. Associated installation, setup, checkout, and maintenance procedures.
11. DAS internal power supplies, calibrators, data buses, all other associated equipment needed to fully outfit.
12. Cabling from bins to DAS shed, from DAS shed to surface.
13. Backup power supply system, underground.
14. Thermocouples.
15. Pressure gages.
16. Pressure-relief valves.
17. Gas flow meters, calibration transfer standards, calibration system.
18. Specific Oxygen sensor system.
19. All instrumentation calibration, installation, checkout, and maintenance procedures.
20. Remote-gage instrumentation data handling procedures.
21. Gas and liquid-leachate data handling procedures.
22. Posttest VOC, other organic, and brine quantification procedures (joint with WID).

Table 13.4 Westinghouse WID Bin-Scale Test Commitments

1. Test room outfitting, lighting, equipment and procedures.
2. Test room electrical support.
3. Solid Waste Bin Design, Spec. E-A-334. Bins and ports. Not for bins with process sludges or supercompacted wastes.
4. Sludge/Supercompacted Waste Bin Design, Spec. ???, will be similar to E-A-334. Bins and ports.
5. Bin pressure leak-testing procedure.
6. Bin stands, to rack test bins, DWG # 412-L-004-W.
7. Bin internal polyethylene liners.
8. Fiberboard liners for bins.
9. Bin particulate release filters, Kevlar.
10. Special (short) ~55-gallon drums, no side ridges, for supercompacted wastes. Special 35-gallon drum lids, with holes, for generators.
11. Special sludge plastic drum liners.
12. Internal drum stabilizers in bins, for PS and supercompacted waste drums.
13. Waste bag pre-breaching "puncturing paddles," design and fabrication.
14. Argon flushing/purging gas.
15. Bin tracer gas injection procedures (concurrence with SNL).
16. Bin gas sampling procedure.
17. GC-MS system setup, calibration, operation, and maintenance procedures.
18. GC-MS gas analysis procedures.
19. Corrodant steel mesh component for bins; specifications, supplier, and/or fabricator.
20. Backfill material bagging system, sacks, in conjunction with existing backfill blending equipment.
21. Collection, storage of natural Salado brines in WIPP.
22. Brine injection hardware system.
23. Bin brine injection procedures, equipment.
24. Bin off-gas ventilation system.
25. Bin radiological safety secondary containment barriers, for both potential liquid or particulate radioactivity leaks.
26. Bin operational (handling, emplacement) and radiological safety (monitoring, decontamination, parts of sampling) procedures.
27. Brine sample monitoring, packaging procedures, for transport to off-site analyses laboratory.
28. Bin brine-sampling radiological safety glove-bag type containment barriers.
29. Radiological and safety assessments and procedures. W-lead + SNL-safety concurrence.
30. Bin ventilation control system (for released gases), installation.
31. Radiological monitoring equipment, including room and panel continuous air monitors.
32. SWBs.
33. SWB overpack and handling system.
34. SWB handling fixtures.
35. Posttest retrieval operational and engineering design, plan and procedures.
36. Posttest retrieval, vacuum distillation system for VOC posttest characterizations (joint with SNL). Brine measurement and stabilization system. Operational procedures.
37. Test termination, retrieval, overpacking procedures.

Table 13.5 Waste Generator Bin-Scale Test Commitments

1. Pretest waste characterizations, for both transportation and WIPP test needs. Drum head-space gas samples (Generator and/or WID analyses at WIPP). Drum source-term evaluations by non-intrusive techniques. Qualitative visual and quantitative weighing of each individual waste bag within initial waste containers, prior to loading into test bins. Radiochemical and toxic/hazardous characterizations from all PS waste drums used in WIPP tests.

2. Waste bag pre-breaching (Bag puncturing and bag slashing) procedures.

3. Others, to be agreed upon by waste generators, DOE/WPO, and SNL.

## 14.0 POSTTEST WASTE DISPOSAL

The estimated minimum test duration of all phases of these WIPP bin-scale tests is about 5 years. Gas and liquid-leachate sampling and analyses could continue past this time, even after the WIPP has become an operating, full-scale repository, for further, longer-term data gathering and analysis purposes. At the conclusion of the test measurement phase, however, the bins and wastes inside them must undergo several processing steps and posttest characterizations before test termination and waste disposal can be concluded.

All contaminated wastes generated during the course of the test program, as well as those wastes generated in the posttest characterization procedures, will be disposed in a radiologically safe and accepted manner. WID has the responsibility for appropriate disposal procedures and documentation thereof.

### 14.1 POSTTEST WASTE CHARACTERIZATION

In a manner similar to waste pretest characterizations (Section 8.3.1), the primary purpose of posttest waste characterization is to evaluate the total (residual) VOC content in each test bin, for source-term evaluation. In the absence of such data, it would be necessary to assume that experimentally measured VOC values will persist for the entire regulatory period of interest, never declining, even in the event of human intrusion. Such assumptions could significantly bias regulatory baseline assumptions in a negative manner; obtaining real VOC source-term values is much preferable.

A secondary, but parallel posttest objective is to help assure that the wastes to be disposed can meet the requirements of the WIPP Waste Acceptance Criteria [US DOE, 1989c], specifically the requirement that they contain less than 1% by volume of free liquid. Both of the preceding objectives can be obtained by subjecting every posttest waste bin to the process of vacuum distillation. The posttest waste characterization processes must be conducted at the WIPP site, in order to both remove residual brines and also obtain required data on the residual VOC source term.

The bins will be subjected to the vacuum distillation process after several posttest processing steps, numbers 1 to 3 in Section 14.2, have been conducted. The vacuum distillation process requires placing each bin into a large, self-enclosed vacuum furnace. The atmosphere within the bin and furnace will be evacuated to a certain negative pressure level and the bin contents heated to a temperature of less than 100 °C. All brine and volatile organics within the bin will be vacuum distilled out and collected for quantitative analyses. The waste remaining within the bin(s) will contain an extremely low amount of residual moisture and essentially no remaining VOCs. These residual levels will be both monitored and verified by GC-MS analysis of gas samples (Section 11.2) and/or other techniques. Other, alternative processes may be developed in the future, to supplement or replace vacuum distillation. The bin and its contents will then be ready for disposal (steps 5 and above, Section 14.2).

Technical details of the vacuum distillation procedure are currently being developed by SNL. Further procedural details, as available, will be included in the Appendices, Section 18.14; these details will be provided by the SNL materials and chemistry consultant (Section 16.1). The large vacuum furnace will need to be modified or adapted for both operational and radiological safety purposes. The design, procurement, installation, and safe operating procedures for the necessary equipment will be the responsibility of WID; other details on posttest retrieval operations will be incorporated into the WIPP Retrieval Plan [WID, 1989], as developed by WID.

## 14.2 POSTTEST WASTE BIN PROCESSING AND DISPOSAL

The bin posttest processing steps <u>(options)</u> are as follows. Safe operating procedures for these steps will be developed by WID.

1. Obtain a final gas and brine-leachate (as appropriate) sample from each posttest bin.

2. Most of the free liquids remaining within the bins will be removed via the bottom liquid sampling ports. The total volume of brine removed will be measured. These liquids will then be concentrated and/or immobilized

on a sorbent matrix (as is the plan for other liquid TRU wastes which could be generated at the WIPP [WID, 1988], and then disposed of as (solidified) TRU wastes.

3. All external instrumentation on the bins will be removed. All instruments will then be monitored for radioactive contamination prior to assignment to potential reuse or disposal as contaminated waste. All valves on the test bin will be closed and all access ports and valves will be sealed.

4. The prepared bins are now ready for the posttest characterization vacuum distillation procedure (Section 14.1). The definition and development of subsequent waste retrieval operations are the responsibility of WID and are described in a separate WIPP Retrieval Plan [WID, 1989]. The following steps must thus be considered as options.

5. The posttest, vacuum distilled (Section 14.1) bin(s) would then be repackaged within a TRU standard waste box (SWB) as TRU waste.

6. Options for the terminal disposal of these repackaged bin/SWB containers of waste are as follows:

   (a) Move to a waste storage room at the WIPP for permanent isolation.

   (b) Temporarily store at WIPP until transport to another DOE facility is possible.

   (c) Other options, to be determined by the DOE at a later date.

## 15.0 DATA ANALYSIS, EVALUATION, AND REPORTS

The Principal Investigator (PI) is responsible for assembling and coordinating the laboratory and field analysts, design and test engineers, materials scientists, and related waste-management consultant personnel concerned with and/or associated with this test program. These personnel will assist in or lead the data analyses tasks. Lead or cognizant personnel will be specified by task in Section 16.1.

Attainment of sufficient in situ test gas and brine-leachate samples and analyses, and interpretations of the results thereof will be determined through agreement of the PI, analysts and consultants, potential outside consultants or experts, and through peer review of the analyses and interpretations.

During the course of this test program, preliminary data will be analyzed and evaluated nearly continuously for input to ongoing WIPP PA modeling calculations, as available. Analyses and preliminary interpretations of data from the in situ bin-scale, alcove [Molecke, 1989], and supporting laboratory [Brush, 1989] tests will be reviewed by the PI and by the formal, external peer review group (Section 3.6.1) or their designated representatives, and possibly by other consultants. When this group is in agreement, the subsequent and final analyses may proceed.

The evaluation of data from these bin-scale tests will be documented in periodic data-evaluation and topical reports as appropriate for each phase of the program. These reports will contain reduced data and interpretations, evaluations, and conclusions about the results of the tests and the technical issues. These reports will form part of the data base for technology development, model evaluations, and, ultimately, WIPP PA.

At appropriate test intervals, probably on an annual basis, and depending on rate of information accumulation, data will be fully evaluated and documented in reduced Test Data Reports (prepared by the test PI). Such reports will include all available data and preliminary interpretations, as appropriate, and will be distributed to those concerned with analysis of the test results. These reports will be subject to QA requirements of peer review and document control. Other cognizant WIPP project personnel will also be informed periodically of the progress of the test. Copies of the Test Data Reports will be archived in the SNL WIPP Central Files along with the raw and processed, QA-approved data.

Portions of the test analyses, supporting laboratory data, and evaluations thereof may warrant publication separately by members of the analysis teams before final analyses of the entire test are available. These interim analyses, when agreed to by the PI, can be published as Topical Reports that will eventually be incorporated into final Analysis and Evaluation Reports. These Topical Reports will be subject to appropriate control by the PI and the SNL QA program.

News notes on test progress or significant occurrences will be prepared and distributed by the test PI as warranted.

## 16.0 TEST OPERATIONS

The following policies, procedures, and delegation of authority apply to operation of these WIPP Bin-Scale CH TRU Waste Tests.

### 16.1 PERSONNEL RESPONSIBILITIES

The principal test and operations personnel and their duties and responsibilities are discussed individually, as follows:

Technical Direction -- Principal Investigator: Martin A. Molecke, Sandia National Laboratories, Division 6345, phone (505) 844-0781 (Albuquerque), FAX (505) 844-1723, or (505) 887-8422 (WIPP site, Carlsbad), is the Principal Investigator (PI) for this test program.

Overall scientific and technical design and control of this experimental program shall be the responsibility of the PI or his designate. Currently, the designated alternate is L. J. Storz, SNL Division 6345, phone (505) 844-????, or, at the WIPP site, B. Stenson, Re/Spec, Inc., phone (505) 887-8422. The PI is responsible for directing the overall experimental work within the following specific areas of authority:

1. Approval of all test and supporting engineering design activities.
2. Decisions relating to the in situ test procedures, designs, test and instrumentation selection, sampling and analyses procedures, and emplacement of test equipment.
3. Determination of experiment parameters, such as operating temperature and pressures, acceleration of environmental stress variables (e.g., brine injection), gas sampling rates, data to be recorded, and other parameters related to the conduct of the experiment and the data acquisition effort.
4. Decisions about the termination of the experiment and the subsequent removal of wastes and equipment (refer to Section 14).
5. Approval of any proposed changes in the test program.
6. Documentation or control of logbooks, either directly or by designation (refer to Section 15).
7. Review and approval of analysis and evaluation reports.

8. Informing the DOE/WPO as to the proposed nature, extent, and schedule of the test and of any significant modifications during the course of the test program.

Site Operations -- In Situ Test Coordination and SNL Site Safety: T. M. Schultheis (or designated alternate), Sandia National Laboratories, Division 6343, phone (505) 887-8423 (WIPP site), is responsible for the overall in situ test coordination of general and safety related aspects at the WIPP, in coordination with the test PI. He is specifically responsible for the following:

1. Primary approval and delegation of all coordination, scheduling, and associated activities at the test location.
2. Acting as SNL lead person on all site safety related issues, and coordinating safety issues between SNL, DOE, and WID.
3. Coordinate activities for equipment and instruments, site preparation, and installation. This includes cleanup and safety measures, and site security measures.
4. Determining that the test program is being carried out within the intent and description of this Test Plan.
5. Informing Sandia personnel of any facility activities that may affect the overall test program.

Technical Operation -- Instrumentation and Data Systems Coordinators: J.T. McIlmoyle, Sandia National Laboratories, Division 9325, phone (505) 844-2672 (Albuquerque) or (505) 887-8416 (WIPP site), is the Test Data System Coordinator for this in situ test program. J. A. Johnson, Sandia National Laboratories, Division 9325, phone (505) 887-8436 (WIPP site), is the Test Instrumentation System Coordinator. Their duties include the day-to-day operational responsibilities of the test instrumentation and data recording systems and the necessary coordination of all test personnel involved, as follows:

1. Preparing detailed procedures for the collection of data and assuring for himself and QA that these procedures are being followed. Any procedural nonconformances or unusual occurrences will be documented on the QA Form QAPP-6 (Nonconformance Report); refer to Section 16.5.

2. Keeping personnel aware of changes in the test or in the operating procedures, as such changes affect the instrumentation and data recording systems.

Technical Operation -- Instrumentation Consultant: C. B. Kinabrew, Sandia National Laboratories, division 9313, phone (505) 844-6008, is the cognizant person responsible for directing all instrumentation-related activities. His duties include:

1. Coordinating all information about instruments used in this test program in cooperation with the test Instrumentation System Coordinator, and consulting with all personnel interested in specific details.
2. Supervising the purchasing, calibration, installation, initial checkout, and continued operation of all remote-reading instrumentation.
3. Serving as the technical interface with the instrumentation and data acquisition systems coordinators for instrument control-system, software-related activities.

Chemistry and Materials Consultant: P. A. Cahill, Sandia National Laboratories, division 1811, phone (505) 844-5754, is the cognizant person responsible for:

1. Providing chemistry-related information, expected materials behavior, and advice pertaining to components used in this test program.
2. Providing design and chemistry advice on the oxygen-purging (Section 11.1.2) and oxygen-gettering systems (Section 11.1.2) to be used.
3. Providing design and chemistry advice on the oxygen specific-gas analyzer system (Section 12.1.5) to be used.
4. Providing design and chemistry advice on the injection of tracer gases (Section 11.1.4) to be used, in cooperation with with the WID GC-MS technical analyst.

Quality Assurance Chief: S. Y. Pickering, Sandia National Laboratories, Division 6341, phone (505) 887-8430 (WIPP site), is responsible for the SNL Quality Assurance (QA) activities both at SNL Albuquerque and at the WIPP site which pertain to this test program; refer also to Section 16.5 on QA. Pickering is specifically responsible for the following:

1. Establishing and maintaining a documented QA program that meets all applicable QA requirements.
2. Ensuring that the QA program is effectively implemented during all test activities.
3. Ensuring that all personnel are adequately indoctrinated with respect to the QA requirements. The SNL QA program is extremely similar to the WID-WIPP QA program; refer to Section 16.5. The SNL QA program will take precedence in most aspects of the scientific needs and conduct of this test program. It is acknowledged, however, that in many test-related areas, e.g., site operations, radiological safety, etc., however, that the WID QA program should take precedence, particularly as it applies to WID personnel.
4. Interfacing the needs and requirements of the SNL QA program with those similar requirements of the WID QA program. Pickering will be responsible for all QA-related interface concerns.
5. Establishing a QA overview program for site and contractor laboratory activities. Reviewing nonconformance and corrective action reports. Conducting periodic QA audits (both internal and external). Reviewing test plans, procedures, and procurement documentation.

WID Lead Engineer: J. J. Garcia, Westinghouse WID, manager, Radioactive Waste Handling Engineering, phone (505) 887-8187 (WIPP site), or his designate, is the lead engineer for this WIPP Bin-Scale CH TRU Waste Test for all WID-SNL interfaces. His primary test-related duties include all necessary coordination between the Sandia PI and Westinghouse engineering design, fabrication, and purchasing personnel involved with this test. He will also coordinate site activities between Westinghouse engineering, operations, safety, and associated WID organizations, as necessary to get this in situ test to a successful start and for continued operations. As such, he will be the most cognizant technical person in the Westinghouse organization for purposes of this test. His other, test-engineering related responsibilities are listed as follows:

1. Serving as the lead engineer/supervisor in the final design and obtainment of the following required test items (described in [Bali, 1989a] and the Appendices): test bin design, fabrication, and procurement; test bin support stands [Bali, 1989b]; oxygen-gettering system connection hardware (joint design effort with the SNL chemistry and materials consult-

ant); supplying necessary test special components and associated waste preparation supplies to the waste generator/preparer sites; other, to be specified.

2. Record significant dates of relevance to this test program, such as dates of receipt of major items, wastes, or other activities that may be of importance to the overall test program. The record of these dates shall be transferred to the PI and SNL QA, as appropriate.
3. Interfacing with the PI, designated technical experts, waste generators, and other cognizant personnel in the successful design and conduct of this test program.

Technical Analyses -- Gas Chromatograph-Mass Spectrometer Analysis: W.D. Greenlee, Westinghouse WID, phone (505) 887-8342 (WIPP site), is the designated primary/lead technical analyst for all gas analyses related to this test program, and conducted with the GC-MS system. He will coordinate all required test gas analyses and interface with the PI on the preliminary evaluations, interpretations, and reporting of the test gas data. His other, test-related responsibilities are as follows:

1. Performing or supervising all required test gas analyses. This duty also includes related activities of calibrating and maintaining the GC-MS system, preparing written procedures on these activities, and adhering to adequate quality assurance procedures and standards for both SNL and WIPP site QA.
2. Supervising the technical conduct of gas sample obtainment, including sampling procedures, required sampling equipment, support technicians, sampling time schedules, etc.
3. Supervising the technical conduct of tracer gas(es) injection procedures, including associated activities. This will be a joint effort, in cooperation with the SNL materials and chemistry consultant.
4. Transferring all gas analyses data and results, after preliminary interpretation, manipulation, summarization, etc., to the test PI on a frequent basis (estimated weekly), for subsequent and final data analyses.
5. Interfacing with other cognizant organizations on the conduct of gas test analyses and assuring that such analyses (whether conducted in-house or, in the potential case of overload, technical breakdown, or other similar situations, at contractor laboratories) meet quality assurance requirements.

6. Assisting the PI in periodic verification of the appropriateness of the gas data-determination activities and the underground conditions affecting the CH TRU gas (production, leakage, contamination, etc.) and informing the PI of findings.
7. Assisting the PI in periodic verification of the appropriateness of daily test activities and data collection activities, eventual analyses and interpretations of such gas data and test results, and informing the PI of findings.
8. Keeping the PI and other cognizant personnel aware of the evolving gas data and the impact of this evolution on future test analyses, test conduct, and associated data requirements.

Technical Analyses -- Brine-Leachate Radiochemical Analyses: [contractor personnel?, TBD] is the designated primary/lead technical analyst (organization) for all brine-leachate radiochemical analyses related to this test program (Section 11.3). This lead person/organization will coordinate the conduct of all required test leachate sampling (with the on-site person, described below) and analyses, and interface with the PI on the preliminary evaluations, interpretation, and reporting of the test leachate data.

An on-site (WIPP) person [WID or contractor personnel, to be specified later] will be required to conduct or coordinate activities in support of (or in conjunction with) the lead technical analyst (organization) for all brine-leachate radiochemical analyses. His/her test-related responsibilities are as follows:

1. Performing or supervising all required test brine leachate sampling procedures, radioactivity surveying procedures, and necessary packaging to transport such samples off-site to the lead technical analyst (organization) for brine-leachate radiochemical analyses. This duty also includes the related activities of calibrating and maintaining the necessary surveying instruments, preparing written procedures on all (described) activities, and adhering to adequate, required quality assurance procedures and standards.
2. Supervising the technical conduct of brine sample obtainment, including required sampling equipment, support technicians, schedules for periodic sampling, etc.

3. Interfacing with other cognizant organizations on the conduct of test brine-leachate radiochemical analyses, and on assuring that such analyses meet quality assurance requirements.
4. Assisting the PI in periodic verification of the appropriateness of the brine-leachate data-determination activities and the underground conditions that may affect the CH TRU brine leachate (leakage, contamination, etc.), and informing the PI of findings.
5. Assisting the PI in periodic verification of the appropriateness of daily test activities and data collection activities, eventual analyses and interpretations of such test data and results, and informing the PI of findings.
6. Keeping the PI and other cognizant personnel aware of the evolving test data and the impact of this evolution on future test analyses, test conduct, and associated data requirements.

## 16.2 TEST OPERATIONAL SAFETY

Test operational safety will be addressed through safe operating procedures (SOP) developed by the facility operating contractor, WID, in coordination with the in situ test coordinator/SNL safety manager. These SOPs must be approved through the site safety organization, the SNL safety organization, and the PI. The SOP(s) will comply with the requirements of the facility and master mine safety plan. Conduct of this experimental program with full regard to both personnel and radiological safety is of utmost importance. Safety procedures are not normally described in detail in a technical test plan; however, items of special concern are as follows.

1. Radiological safety associated with the in situ emplacement and testing of actual CH TRU wastes. All waste-filled test bins must be safely handled, emplaced, and maintained from the perspective of radiological safety. This includes providing an appropriate level of containment around each test bin to ensure that potential leaks of transuranic-contaminated liquids, particulates, or gases do not escape from the wastes during any phase of testing and/or sampling. Potential contamination of the test room environment and/or test personnel must not be permitted. All appropriate technicians working underground on this program are required to have appropriate levels of training; this includes a minimum of WIPP Rad-

iation Worker "B" and respirator training. WID has the major, overall responsibility in these radiological safety, training, and related areas, and will provide the necessary documentation and SOPs. Specific concerns must be also addressed to the potential release of radioactive particulate contamination and the monitoring thereof. The use of continuous air (particulate radioactivity) monitors, CAMs, was described in Section 11.1.5. The bin-scale test rooms are located within the WIPP Radioactive Materials Area, RMA. There will be administrative controls as far as personnel access and monitoring procedures, based on current WIPP SOPs.

2. Radiological safety associated with the in situ sampling of gases and liquids for on-site GC-MS or off-site brine-leachate radiochemical analyses. Technicians conducting the sampling procedures will be required to have WIPP Radiation Worker "A" training. Again, WID will have the major responsibility in these areas and will provide the necessary documentation and SOPs.

(a) Radiation Work Permits, RWP, must be prepared for most of the test activities performed with the actual TRU wastes. The site Health Physics department (technicians) will monitor sampling and other test-related activities and the Radiation Safety department will review these procedures.

(b) Specific concerns must be addressed to the potential release of radioactive liquid contamination (e.g., brine drips) and the monitoring thereof. Special radiation safety enclosures, e.g., temporary plastic or other glove-bag-type enclosures around the sampling ports will be necessary to control the potential spread of contamination. These will be designed and/or procured by WID. All sampling ports will be capped when not in use. Radiation surveys of these ports, and adjacent areas, both before and after sampling operations will be required to check for contamination.

(c) All gas (pre-filters; refer to Section 11.2) and liquid samples obtained underground must be monitored for radiation prior to being removed from the test area, a RMA.

(d) Packaging and transportation of liquid test samples off-site for analyses (refer to Section 11.3.2) will require special care, radiation surveying, total activity analyses, and other procedures to be developed by WID.

3. Mine safety concerns over the explosibility potential of hydrogen and/or methane gas concentrations (> 5%, in air) within the bin(s) test environment are recognized [Molecke, 1989d; Lappin and Slezak, 1990]. Some of the proposed individual test bins could conceivably concentrate hydrogen and/or methane to internal, potentially combustible and/or explosible concentrations, dependent on the waste form to be tested [Molecke, 1989d]. The only credible ignition source proposed for the gases within the bins is the potential for spontaneous combustion in organic-matrix wastes. Safety mitigation measures to monitor for potentially hazardous conditions, to minimize the risk, and to resolve the concerns, include:

(a) Temperature monitoring. If spontaneous combustion were to initiate, the temperature(s) within a bin would have to rise to more than 450°C [Lappin and Slezak, 1990]. Such an increase would quickly be monitored in its earliest stages by the installed bin thermocouples. A temperature "out of range" alarm signal would then be sent; refer to Section 12.2.1.
(b) Electrical grounding. All bins are electrically grounded, to help eliminate electrical sparking or other related sources of ignition.
(c) Oxygen monitoring. Appreciable oxygen (percent concentrations) within the bins are needed to change the internal gas compositions from potentially combustible to potentially explosible. Based on previous laboratory testing with enclosed containers of waste [Zerwekh, 1979; Kosiewicz, 1981], it is known that (in most cases) the oxygen concentration decreases to very low levels (< 0.1%) as the hydrogen concentration increases. The test bins are monitored for oxygen level every 4 hours. If an initially low oxygen content increased within a bin to a level (i.e., > 1%) where potential explosibility was a credible concern, an oxygen "out of range" alarm signal would be sent.
(d) Gas monitoring. The internal oxygen, hydrogen, methane, and other gas concentrations within the bins will be periodically sampled, analyzed by GC-MS, and closely monitored so that any approach to a potentially explosible gas level will be quite evident. Indeed, it is the bin-scale tests which will provide the best available data for WIPP PA purposes, concerning the reality of potentially flammable and/or explosible gas mixtures during the full-scale waste emplacements at the WIPP [Molecke, 1989d].

(e) Argon purging. If a potentially explosible condition did occur, some argon purge gas could be injected to reduce the overall hydrogen concentration. Options as to when the purging could be accomplished are described separately [Lappin and Slezak, 1990]. Provisions for gas purging are already designed into the bin. However, this bin purging is not desirable, because it would eliminate important information to be gained on the time-dependent concentrations of hydrogen and oxygen (as well as for other gases to be expected in full-scale waste emplacement).

(f) Overall. With all of the above described mitigation measures, the TRU wastes used in these bin-scale tests are maintained in a safe state, more so than the wastes to be isolated in the operational phase of the facility [Molecke, 1989d].

4. Ventilation concerns due to release of gases from the test bins. The major concern here is the release of potentially toxic or VOC gases to the man-accessible environment. All gases released from the bins (due to overpressurization) will be piped directly to mine ventilation system ductwork, not to the man-accessible environment. Westinghouse WID has the major responsibility for designing and controlling the underground mine ventilation system.

## 16.3 UNUSUAL CIRCUMSTANCES

Several unusual circumstances peculiar to these tests must be considered. The most likely of these circumstances are:

1. Loss of power to the test bin pressure-monitoring and pressure-relief control systems. These critical control systems must be connected to a backup power supply system (Section 12.1.6). Loss of power will be noted and the PI or his designate will be informed during normal working hours. Loss of power to these systems for a period greater than approximately 12 hours would be considered unacceptable. The backup power system must be turned on, as required, within 12 hours or less.

2. Loss of gage. This loss is either accepted (for thermocouples) and noted, or is corrected by removing the defective gage and installing another gage, at the discretion of the PI.

3. Loss of Data Acquisition System. The data loss is noted and the PI informed during normal working hours. If the problem is expected to persist for more than 1 day, supplemental portable recording instrumentation may be used, at the discretion of the PI. The data loss will be documented in a SNL nonconformance report.

4. Receipt of an instrument (out of range) alarm message. Major concerns suggested by an out of range alarm message, indicative of a gage failure, a nonstandard condition, or a safety-related concern, include:
   (a) a high thermocouple temperature may indicate the initiation of spontaneous combustion within a bin;
   (b) a high, or low pressure readings could indicate an overpressure or leakage problem; and,
   (c) a high (% range) oxygen concentration could indicate the potential for a explosible mixture to be present.

   Response activities after receiving and evaluating an alarm message were described in Section 12.2.1.

5. Loss or spillage of radioactive leachate sample. The location of the liquid spill will be isolated, surveyed, then cleaned/decontaminated to appropriate levels. Existing site radiological safety/health physics procedures will be adhered to the extent applicable [WID, 1988b]. The loss or spillage of a radioactive leachate sample will be treated and resolved appropriately, as a test nonconformance.

All other test-related unusual circumstances are to be resolved by the PI and/or WID lead engineer, or appropriate designated and cognizant personnel.

Unusual mine circumstances are addressed in the mine safety procedures. If they are not, the in situ test coordinator (Section 16.1) is responsible for notifying the facility operators (WID) for resolution.

## 16.4 TEST INTERFACES

The operating personnel for this test will potentially interface with outside agencies, analysts, and facility operations.

Outside Agencies: Requests for information or access by outside agencies are referred to the PI and/or the facility manager (DOE/WPO).

Technical Analysts: Technical analysts should contact the PI or the in situ test coordinator for access to the underground test area.

Facility Operations: Operating personnel need to recognize the following interfaces:

1. Facility access. Access to the test areas will be controlled. Visits will be arranged where WIPP policy and safety regulations permit, and if there is no interference with ongoing tests and waste operations. Appropriate access procedures for the site will be established in compliance with standard practice and regulations of the facility operators (WID) and the facility manager (DOE).

2. Ventilation. Test operations cannot interfere with facility ventilation. Requests for ventilation alterations or problems with ventilation are to be referred to the facility operator (WID) through the in situ test coordinator.

3. Power. Power is supplied by the facility operator to a terminal box at the test location. Alterations or modifications on the test side of the terminal box are the responsibility of the test operating personnel, provided these modifications do not exceed the capacity of the power supplied to the terminal. Alterations are to be implemented through the WID power configuration controls.

4. Modifications. All modifications on the facility side of the terminal or requests for additional services are to be referred to the facility operator (WID) through the in situ test coordinator.

5. Maintenance. Maintenance of the test area and instrumentation alcove is the responsibility of the test operating personnel. Maintenance outside of these areas is handled by the facility operator (WID). Requests for maintenance in these outside areas is through the in situ test coordinator.

6. Safety. Test operations will comply with all safety procedures established by the facility operator (WID), in coordination with the SNL WIPP site safety manager.

7. Other. Other interfaces, as required, will be handled through the in situ test coordinator and appropriate facility personnel.

## 16.5 QUALITY ASSURANCE (QA)

All Sandia National Laboratories tests are implemented in accordance with the SNL Nuclear Waste Technology Department Waste Isolation Pilot Plant Quality Assurance Program Plan (QAPP) [SNL, 1989]. This Quality Assurance program meets the requirements of NQA-1-1986, DOE 5700.6B, Chapter 11 of the Final Safety Analysis Report, WIPP DOE 87-007 QA Operations Program, and DOE/WPO Management Directives. This QA plan has been approved by the DOE/WPO for all the WIPP activities assigned to Sandia National Laboratories. This QAPP is specific to the WIPP Project. Contractor personnel working with Sandia personnel either at the WIPP site or in Albuquerque are subject to the WIPP QAPP [SNL, 1989]. Specific applications of the WIPP QAPP to this test have been incorporated throughout this Test Plan.

The SNL QA program is extremely similar to the WID-WIPP site QA program [WID, 1989b] in meeting the requirements of NQA-1. The SNL QA program will take precedence in most aspects of the scientific needs and conduct of this test program. It is acknowledged, however, that in many test-related areas, e.g., site operations, radiological safety, etc., that the WID QA program should take precedence, particularly as it applies to WID personnel. As stated in Section 16.1, the SNL QA Chief will be responsible for all QA-related interface concerns between the SNL and WID QA programs.

All test-related activities that are to be performed on a repetitive basis will have a specific procedure drafted and approved by both the test PI and QA, and/or their designates. These specific QA procedures are to be updated, and reapproved, as test details change and (may) require modifications in the procedure. Examples of activities requiring QA procedures include: instrumentation calibration, installation, maintenance; gas sampling and handling; gas chromatography-mass spectrometry calibration, upkeep, and sample analyses; brine-leachate sampling, packaging, analyses, etc.; standard data handling procedures; etc.

## 17.0 GLOSSARY

| | |
|---|---|
| CAM | continuous air (particulate radioactivity) monitor |
| CCDF | complementary cumulative distribution function, for PA |
| CMR | computer monitoring room, part of CMS |
| CMS | computer monitoring system |
| CSB | crushed salt/bentonite clay backfill material |
| DAS | data acquisition system, SNL system at WIPP |
| DOE/WPO | Department of Energy/WIPP Project Office |
| EEG | Environmental Evaluation Group, in New Mexico |
| EPA | U.S. Environmental Protection Agency |
| FY | fiscal year |
| GC-MS | gas chromatograph-mass spectrometer |
| GPIB | general-purpose interface bus, component of DAS |
| HEPA | high-efficiency particulate filter |
| HONG | high-organic/newly generated TRU waste |
| HOOW | high-organic/old wastes |
| INEL | Idaho National Engineering Laboratory |
| LONG | low-organic/newly generated TRU waste |
| MODCOMP | brand name of SNL DAS computer, not an acronym |
| MSDS | material safety data sheets |
| NAS | National Academy of Science |
| NOS | computer network operating system, SNL |
| PA | performance assessment |
| PI | principal investigator |
| PS | process sludge TRU waste |
| QA | quality assurance |
| QAPP | Quality Assurance Program Plan |
| RCRA | EPA Resource Conservation and Recovery Act, 40 CFR 268 |
| RFP | Rocky Flats Plant |
| RMA | radioactive materials area |
| RWP | radiation work permits |
| SAR | Safety Analysis Report |
| SEIS | Supplemental Environmental Impact Statement |
| SNL | Sandia National Laboratories |
| SOP | safe operating procedure or standard operating procedure |
| SPDV | WIPP site preliminary design validation |
| STP | standard temperature and pressure, in relation to gases |
| SWB | TRU standard waste boxes |
| TA | WIPP test alcove |
| TC | thermocouples |
| TRU | transuranic |
| TRUCON | TRUPACT II content codes |
| UPS | uninterruptible power supply |
| US DOE | U.S. Department of Energy |
| VOC | volatile organic compounds |
| $^{wg}Pu$ | weapons-grade plutonium, predominantly $^{239}Pu$ |
| WAC | WIPP Waste Acceptance Criteria |
| WID | Westinghouse Waste Isolation Division |

## 18.0 APPENDICES

The Appendices, of which the following form the outline and preliminary texts, are to be living documents compiled separately as these WIPP Bin-Scale CH TRU Waste Tests are implemented in the field. The contents of the Appendices subsections below may be in simple outline format. If a particular topic below is more fully documented, it will be included in the approved SNL QA record file (storage area) for this test. At present, these Appendices will contain "as-built" drawings, procedures, and processes necessary for test installation, and subsequent analyses and interpretations of the tests.

The subsection numbers below, i.e., 18.#.#.#, refer to the main Section number in the body of this Test Plan.

### 18.8.3.1 Pretest Waste Characterization Procedures

Pretest waste characterization procedures for both head-space gas analyses for VOCs and non-intrusive radionuclide content quantification are in place at various waste generating facilities for use in required transportation analyses. Details on PS waste sample sizes and radiochemical and hazardous waste component analyses remain to be finalized with and by the generators. Results of the transportation analyses are to be shared with the WIPP project for purposes of bin-scale pretest characterizations and test data interpretations. Further discussions between the WIPP project and the generator/shipper sites are required to formalize details of waste characterization analyses and data sharing. Forthcoming details will be appended here as available.

### 18.8.3.2 Waste Pre-Breaching Puncturing Paddles

Puncturing paddles are needed to pre-breach waste bags that are to be emplaced into WIPP test bins and leached in place. These puncturing paddles will be designed and fabricated or procured by WID and will be provided to waste preparers by the WIPP project. Fabrication details will be appended as available.

### 18.8.4 Bin Brine Injection

Details on the brine injection hardware installed on test bins and procedures for injecting the brine into the bins will be prepared and provided by WID. Radiation-safety temporary containment enclosures may be used during the brine injection procedures; this radiation safety equipment will be also designed and/or procured by WID. The brine-injection procedure(s) will be approved by WID and SNL QA, the PI, and site radiation safety.

### 18.9.1 Test Bin Details

Further details on the following WIPP test bin design and associated components will be provided by the WID lead engineer/supervisor, and will b documented separately in WID EWPs [Bali, 1989a; others TBD] and engir drawings.

18.9.2 Test Bin-Stand Hardware Details

Further details on the test bin-stands engineering requirements, design, drawings [Bali, 1989b], fabrication procedures, and installation will be provided by WID.

18.10.1.2 Getter Material Details

The composition of getter additives, and the proportion or quantities of getters to be added to the backfill materials will be provided, presumably, by current laboratory research. Further information in this area will be provided by Larry Brush, Sandia National Laboratories, and by Barry Butcher, Sandia National Laboratories.

The exact composition of salt grout or other materials to be used as an additive within test bins, and their proportions or quantities to be added will be provided, presumably, by current laboratory research. Further information in this area will be provided by Jim Nowak, Sandia National Laboratories.

18.10.1.4 Mixing and Bagging of Backfill Materials

Details on the procedures, equipment, and engineering requirements relating to the mixing and bagging of backfill, getter, and other related materials, and transporting them to the waste generator sites will be provided by the lead engineer in coordination with B. Stenson, Re/Spec, Inc., phone (505) 844-8422.

18.10.2 Metal Corrodant Details

Further details on the procurement, fabrication, and emplacement of mild steel, wire mesh screening, to be used as the metal corrodant material in the bin-scale tests will be provided by the lead engineer.

18.10.3 Artificial Brine Preparation

Further details on the required materials and preparation procedures for making large quantities of both artificial Salado and Castile brines will be provided by both Larry Brush and Martin Molecke, SNL Division 6345.

Further details on the brine injection procedure to inject such brines into test bins will be provided by WID.

18.11.1.1 Bin Gas Flushing Details

Further technical details and procedures for flushing test bins with argon gas in order to approach an anaerobic environment will be provided by Paul Cahill, SNL chemistry and materials consultant.

18.11.1.2 Portable Oxygen-Gettering Reactant System, Design Details

The Q-5 Reactant has an exchange capacity of 2 $cm^3$ $O_2$ per gram of reactant at standard temperature and pressure. According to the manufacturer, Q-5 can be repeatedly regenerated. For this reactant regeneration, the material must be preheated to 200°C. This regeneration could be accomplished above ground or elsewhere, after a fresh, replaceable oxygen-gettering column is attached to the system, substituting for the near-depleted column. During the heated regeneration cycle, a mixture of about 5% $H_2$ gas in $N_2$ gas must be passed through the column (this gas mixture can be purchased pre-mixed, as "forming" gas, or mixed at the WIPP). The resulting exothermic, regeneration cycle reaction causes the temperature to rise to about 300°C, as water is produced and flushed out. The column temperature should be held at 300°C for about one hour. The maximum reactant material temperature must be kept below 400°C. To accomplish this regeneration cycle (formula 2), the following services are needed: electricity for the heating tape, thermocouples, $H_2/N_2$ forming gas, an oxygen sensor at the exit end of the column, a means of removing generated water, and the hardware to recirculate and/or exhaust the used forming gas.

The cognizant technical expert for the operation and associated requirements of the portable oxygen-gettering reactant system is Paul Cahill, SNL, phone (505) 844-5754. He will provide details on the procedures, equipment, and engineering requirements relating to the required oxygen-gettering system(s) for use in this bin-scale test program. Commercial oxygen-gettering apparatus is currently being procured and provided by SNL.

18.11.1.3 Test Bin Pressurization

Details and procedures for providing the initial pressurization of each test bin with argon gas and for quantifying the initial bin void volume will be provided by M. Molecke and P. Cahill, SNL.

18.11.1.4 Tracer Gases

Further details on the injection procedure for tracer gases into the bins will be provided by Paul Cahill, SNL, phone (505) 844- 5754.

18.11.1.4 Radioactivity and Radioactive Particulate Monitoring

Details will be provided by the WID.

18.11.2 Gas Chromatograph-Mass Spectrometer Details and Procedures

Details on the operation, calibration, and maintenance procedures for the overall GC-MS system will be provide by the principal technical analyst, W. Greenlee, WID. A draft of the gas sampling procedures has been prepared [Greenlee, 1989] and is currently being revised and updated.

18.11.3 Brine-Leachate Sampling Details, Procedures

Radiation-safety temporary containment enclosures may be used during the brine injection procedures; this radiation safety equipment will be also designed and/or procured by WID. Further details on the brine-leachate sampling procedure will be provided by M. A. Molecke, SNL, the lead radiochemical technical analyst on site [TBD], and by analytical laboratory contractor personnel.

18.11.4 Brine-Leachate Samples Packaging and Analyses Details

Further details will be provided by the lead radiochemical technical analyst on site [TBD], and by analytical laboratory contractor personnel. The packaging and shipping procedures will be approved by both QA and site radiation safety.

18.12.1 Instrumentation Details

An instrumentation plan will be specified for each of the principal instruments used in this test program. These specifications include design, sensitivity range, calibration requirements, procurement, installation and wiring, power requirements, and operation details.

A NOS (network operating system) file will be prepared and will list all test remote instruments and test measurand numbers. This NOS file is a requirement of the SNL DAS.

A QA-approved instrumentation calibration, installation, hookup, operation, and maintenance procedure will be provided by the SNL instrumentation consultant for each separate remote instrument (type).

18.12.1.2 Pressure Gages

Some interesting pressure calculations and measurements:

1. If the mine ambient temperature, about 30$^{o}$C, changed by 3$^{o}$C (a large change), then the internal bin pressure would change by about 0.15 psig.

2. Preliminary barometric pressure monitoring measurements were conducted at the WIPP surface by site Environmental Engineering for the period of January 1988 - May 1988 (daily) and March 16 - 20, 1988 (hourly). On the basis of these measurements, the reference surface pressure was calculated to be 12.94 psig (26.35 in. Hg). The maximum daily change measured over this period was 0.16 psig (0.33 in. Hg), the maximum hourly change was 0.04 psig, and the maximum overall range was 0.19 psig.

3. Preliminary, short-term pressure monitoring (20 - 30 minutes) was also conducted underground in Room 6 Panel 1 [Cook, 1989]. Pressure fluctuations of about 0.005 psig (0.01 in. Hg) were observed, and were attributed to variations in the mine ventilation system. A pressure "spike" of 0.04 psig (0.08 in. Hg), over about 2 minutes, was also seen.

18.12.1.3 Gas Pressure-Relief Valves and Control Systems

Parametric pressure release calculations as a function of relief-valve size (exit orifice) and time of opening have been conducted [Beraun, 1989]. The primary purpose of these calculations was to assist in purchase of the correct size of pressure relief-valves and of determining how long to open them. Details of these calculations are found in [Beraun, 1989].

18.12.1.4 Gas Flow/Volume Monitoring System

18.12.1.5 Oxygen-Specific Sensors

Paul Cahill, SNL, division 1811, phone (505) 844-5754, is the cognizant person responsible for directing all oxygen-specific sensor-related activities.

Solid state oxygen sensors will be used to continuously monitor the room atmosphere. Such devices are extremely stable and long-lived (>5 years). Such sensors are needed to be accurate and reliable over a range of about 0.1 to 1000 ppm. Additional data on power requirements and calibration techniques will soon be available.

18.12.2.3 Backup Power Supply Details

Further details have been provided in two separate SNL memoranda, [McIlmoyle and Johnson, 1989] and [McIlmoyle, 1989].

18.14.0 Posttest Waste Disposal

Further details on posttest waste characterization procedures for vacuum distillation procedures to obtain VOC gases (and source term) and residual brines in the bins will be developed as a joint effort between SNL and WID. A separate waste retrieval plan [WID, 1989] to describe many of these details and operational and engineering procedures is also being drafted by WID.

A large vacuum furnace will need to be modified or adapted for radiological safety purposes. The design and procurement of the necessary equipment for these procedures will be the responsibility of WID, with consultation with the test PI and SNL materials and chemistry consultant.

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