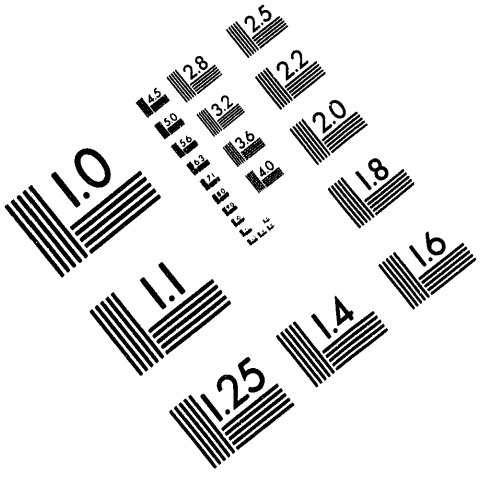

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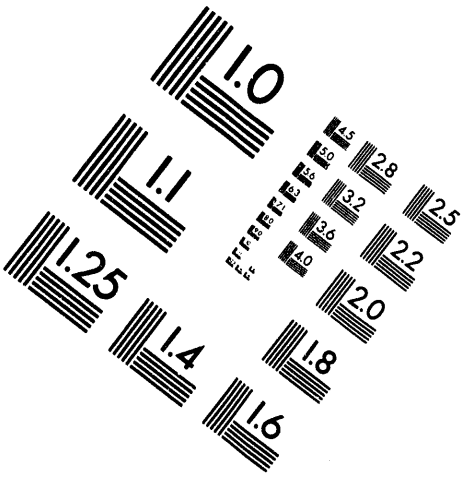

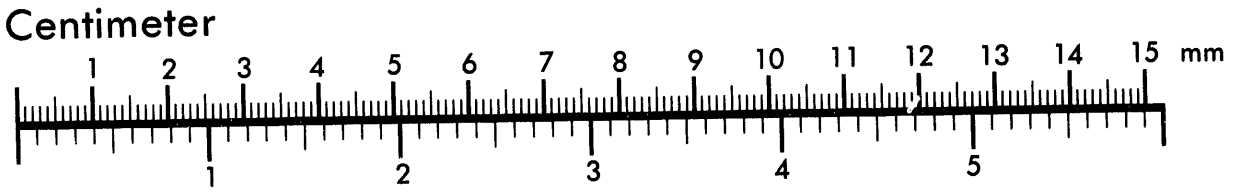

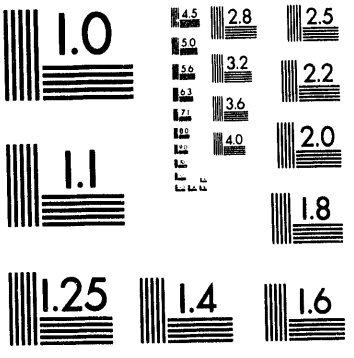

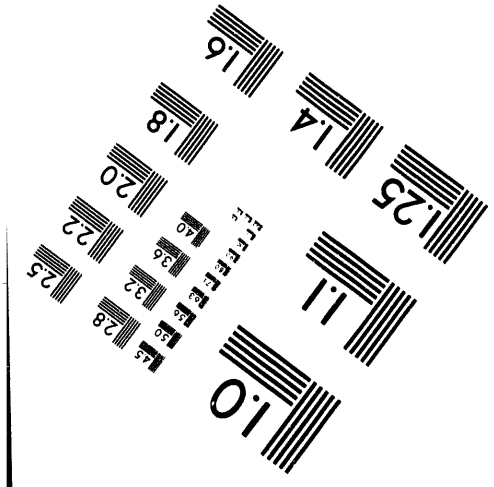

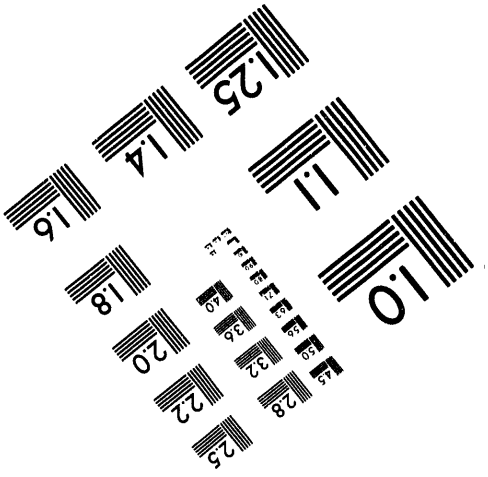

1 of 2

(UCRL-CR-116576)
DOE/MWIP-27

Preliminary Hazards Analysis

Vitrification Processes

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1.0 EXECUTIVE SUMMARY

Joule heating technologies, utilize an electrical current which is passed through a melt material providing a source of resistive heat. A future mixed waste vitrification system utilizing joule heating technologies may be similar to demonstration systems currently under study at Clemson University Environmental Systems Engineering Research Laboratory in associated with the Westinghouse Savannah River Company.

This Preliminary Hazards Analysis (PHA) for mixed waste vitrification by joule heating is performed in accordance with the requirements of United States Department of Energy (DOE) Orders 5480.23, DOE Order 5480.21, DOE Order 5480.22, DOE Order 5481.1B, and the guidance provided in DOE Standards DOE-STD-1027-92. Consideration is given to the proposed regulations published as 10 CFR 830 and DOE Safety Guide SG 830.110.

The purpose of performing a PHA is to establish an initial hazard categorization for a DOE nuclear facility and to identify those processes and structures which may have an impact on or be important to safety. The PHA is typically performed during and provides input to project conceptual design. The PHA is then followed by a Preliminary Safety Analysis Report (PSAR) performed during Title I and II design. The PSAR then leads to performance of the Final Safety Analysis Report performed during the facility's construction and testing. It should be completed before routine operation of the facility commences.

This PHA addresses the first four chapters of the safety analysis process, in accordance with the requirements of DOE Safety Guidelines in SG 830.110:

- Section 2.0 identifies the statutes, rules, and DOE Orders applicable to methods and content of this PHA. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, and proposed rule 10 CFR 830.110 "Nuclear Safety Management," describe the content requirements for the hazards analysis and preliminary classification of a DOE nuclear facility.

- Section 3.0 provides information on natural phenomena and surrounding activities which may affect the safe operation of a facility at major DOE Complex sites. Natural features include site geography, seismicity, meteorology, and surface waters. Manmade features such as transportation systems, land use patterns, and population distributions are discussed.

- Section 4.0 details some of the facility design characteristics important to a future facility that can impact site selection. Although the process is not affected by the location, the environmental characteristics of potential sites can have a significant impact on the design and construction of the facility. This section provides the context for the hazards characterization table in Section 5.

- Section 5.0 describes the various hazard energy sources, the event initiators, anticipated design and administrative measures to prevent or mitigate accidents, potential impacts of worst case accidents, and the method used to identify hazards, analyze events, and determine consequences. Postulated maximum inventories of hazardous and radioactive materials are used to establish the preliminary facility hazard classification. The basic hazards associated with energy sources and materials which may be present in the facility and the bounding accident scenarios are discussed and analyzed. The consequences of these maximum release accident scenarios are enumerated and are used to verify the preliminary facility hazard classification.

The hazards associated with vitrification processes are evaluated using standard safety analysis methods which include: identification of credible potential hazardous energy sources; identification of preventative features of the facility or system; identification of mitigative features; and analyses of credible hazards. Maximal facility inventories of radioactive and hazardous materials are postulated to evaluate worst case accident consequences. These inventories were based on DOE-STD-1027-92 guidance and the surrogate waste streams defined by Mayberry, et al. Radiological assessments indicate that a facility, depending on the radioactive material inventory, may be an exempt, Category 3, or Category 2 facility. The calculated impacts would result in no significant impact to offsite personnel or the environment. Hazardous materials assessment indicates that a Mixed Waste Vitrification facility will be a Low Hazard facility having minimal impacts to offsite personnel and the environment.

2.0 APPLICABLE STATUTES, RULES, REGULATIONS, AND DEPARTMENTAL ORDERS

This section identifies the statutes, rules, regulations, and DOE Orders applicable to the safety basis of any future vitrification facility or integrated facility for the treatment of DOE mixed waste. DOE Order 5480.23, Attachment 1, Section 4.f.(3)(d), Item 5 (DOE 1992a), describes the content requirements for the hazards analysis and preliminary classification of a DOE nuclear facility. Content requirements include a description and inventory of all hazardous materials, including radioactive materials; identification of energy sources which may cause material release; bounding analyses of potential releases; and the hazard classification for all major types of hazards and the facility as-a-whole. Current technical guidance for each area is provided. Proposed rule 10 CFR 830.110 (DOE 1993a) and Proposed DOE Standard DOE-STD-SAFT-0019 (DOE 1993e), *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, were considered in the preparation of this PHA although the proposed regulations and draft guidance document have not been approved.

SCOPE AND CONTENT OF HAZARDS ANALYSIS

DOE 5480.23, *Nuclear Safety Analysis Reports* (DOE 1992a) Draft.

10 CFR 830.110 (Proposed Rule), *Safety Analysis Report* (DOE 1993a).

DOE SG 830.110, *Guidelines for the Preparation of Safety Analysis Reports for DOE Nuclear Facilities and Nonfacility Nuclear Operations* (DOE 1991b) Draft.

DOE Order 5481.1B, *Safety Analysis and Review System* (DOE 1986).

INVENTORY OF HAZARDOUS MATERIALS, INCLUDING RADIOACTIVE MATERIALS

DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (DOE 1992b).

Environmental Protection Agency (EPA), Federal Energy Management Agency, and Department of Transportation (DOT); *Technical Guidance for Hazards Analyses, Emergency Planning for Extremely Hazardous Substances* (1987).

Department of Labor, *Title 29, Code of Federal Regulations, Part 1920.119*, "Process Safety Management of Highly Hazardous Chemicals," Washington, DC (DOL 1993).

Environmental Protection Agency (EPA), "Emergency Planning and Notification," *Title 40, Code of Federal Regulations, Part 355*, Washington, DC (EPA 1993).

ENERGY SOURCES AND PERSONNEL HAZARD SOURCES

UCRL-15910, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards* (Kennedy *et al.* 1990).

Department of Energy (1992d), *DOE Standard - Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components*, DOE, Washington, DC, DOE-STD-1021-92.

Department of Energy (1992e), *DOE Standard - Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites*, DOE, Washington, DC, DOE-STD-1024-92, December.

Department of Energy (1993c), *DOE Standard - Natural Phenomena Hazards Site Characterization Criteria*, DOE, Washington, DC, DOE-STD-1022,92, April 1993 DRAFT.

Department of Energy (1993d), *DOE Standard - Natural Phenomena Hazards Assessment Criteria*, DOE, Washington, DC, DOE-STD-1023-92, April 1993 DRAFT.

Department of Energy (1993f), *DOE Standard - Natural Phenomena Hazards Design and Evaluations Criteria for Department of Energy Facilities*, DOE, Washington, DC, DOE-STD-1020-92, February 1993 DRAFT.

DOE 5480.28, *Natural Phenomena Hazards Mitigation*, (DOE 1993b)

BOUNDING ANALYSES OF POTENTIAL RELEASES OF HAZARDOUS AND RADIOACTIVE MATERIAL

DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (DOE 1992b).

LA-10294-MS/UC-41, *A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities* (Elder *et al.* 1986)

Environmental Protection Agency (EPA), Federal Emergency Management Agency, and Department of Transportation (DOT), *Technical Guidance for Hazards Analyses, Emergency Planning for Extremely Hazardous Substances* (1987).

NUREG-1320, *Nuclear Fuel Cycle Accident Analysis Handbook* (Ayer *et al.* 1988).

DOE/EH-0071, *Internal Dose Conversion Factors for Calculation of Dose to the Public* (DOE 1988d).

DOE/EH-0070, *External Dose Conversion Factors for Calculation of Dose to the Public* (DOE 1988c).

FACILITY HAZARD CLASSIFICATION

DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (DOE 1992b).

DOE 5481.1B, *Safety Analysis and Review System (DOE 1986).*

DOE 5480.23, *Nuclear Safety Analysis Reports* (DOE 1992a).

10 CFR 830.110, *Safety Analysis Report* (DOE 1993a).

DOE SG 830.110, *Guidelines for the Preparation of Safety Analysis Reports for DOE Nuclear Facilities and Nonfacility Nuclear Operations* (DOE 1991b) Draft.

The statutes, rules, and DOE Orders applicable to a mixed waste treatment facility are listed in Tables 2-1 and 2-2. The state and local statutes, ordinances, and other requirements should also be included when a specific physical site is identified and when those requirements could establish safety constraints on a potential future vitrification facility. The tables provide a cross reference to the applicable chapters of a future facility Safety Analysis Report (SAR) where these requirements should be discussed.

Title 29 CFR 1910.119 (DOL 1993) requires implementation of a Process Safety Management program for operations that use hazardous chemicals in excess of the threshold quantities of 29 CFR 1910.119, Appendix A, and pressurized flammables in excess of 10,000 pounds. The program requirements should emphasize prevention of catastrophic releases of such materials and mitigation of consequences if such releases occur. These may apply to a future vitrification facility.

A vitrification facility process safety management program, if required, should include provisions to plan and document worker participation in responding to the requirements, including review of information developed pursuant to the program requirements. The required information includes chemical safety information, process technical descriptions and specifications, process hazards analyses, operating procedures, operational limits, safety system functions, training programs, and pre-startup safety reviews.

The program should include provisions to assure the continuing safety of critical process components. These program elements include maintenance procedures, maintenance training, inspection and testing provisions, methods to document and correct deficiencies, and quality assurance.

The program should contain provisions to prevent accidents during operation or to mitigate accidents should they occur. These should include hot-work permitting, process change control, investigation of incidents, emergency planning and response, and audits of compliants pertaining to the process safety management program. Table 2-3 presents the major elements of 10 CFR 1910.119 and appropriate cross-references to the chapter where the elements should be discussed in the future facility SAR.

Further detail concerning the regulatory requirements that must be met by an integrated mixed waste treatment facility are contained in BHARC-800/92/005, *Regulatory Requirements for Deploying Integrated Demonstration Technologies* (Frahm *et al.*, 1992).

Table 2-1. Other Applicable Federal Requirements

Statute/ Regulation	Title	Description	Applicable SAR Chapter
10 CFR 835	Radiation Protection for Occupational Workers	Establishes radiation protection standards, limits, and program requirements for protecting workers and other persons from ionizing radiation at DOE facilities.	9
10 CFR Part 1021	Compliance with the National Environmental Policy Act	Establishes requirements for performance of environmental assessments.	7
10 CFR 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements	Establishes requirements for floodplain/wetlands environmental reviews.	7
29 CFR 1910, 1926	Occupational Safety and Health Administration (OSHA) Standards	Establishes worker safety provisions. All industrial safety and construction operations shall comply with the applicable OSHA requirements.	17
40 CFR 50	National Ambient Air Quality Standards	Establishes ambient air quality standards for various air pollution constituents.	10
40 CFR 58	Ambient Air Quality Surveillance	Establishes criteria and requirements for ambient air quality monitoring and for reporting ambient air quality data and information.	10
40 CFR 60	Standards of Performance for New Stationary Sources	Establishes pollution standards for any new stationary pollutant source.	10
40 CFR 61	National Emissions Standard for Hazardous Air Pollutants (NESHAPS)	Establishes air emission standards. All airborne radiological and hazardous constituents shall comply with requirements of NESHAPS.	7
40 CFR 116	Designation of Hazardous Substances	Designates hazardous substances under Section 311(b)(2)(A) of the Federal Water Pollution Control Act.	7
40 CFR 117	Determination of Reportable Quantities of Hazardous Substances	Designates the amount of a release of a hazardous substance defined in 40 CFR 116 which is considered to be reportable.	19
40 CFR 122	EPA Administered Permit Programs: National Pollution Discharge Elimination System (NPDES)	Establishes permitting requirements for the discharge of pollutants from point sources into U.S. waters.	7
40 CFR 125	Criteria and Standards for NPDES	Establishes criteria and standards for imposing technology-based treatment requirements; permit issuance to aquaculture projects; compliance date extensions for installing innovative technology; water quality variance grants; secondary treatment requirement modifications; sewage sludge disposal; ocean discharge; best management practices; and alternative effluent limitations.	7
40 CFR 129	Toxic Pollutant Effluent Standards	Establishes effluent standards or prohibitions for toxic pollutants	7
40 CFR 141	National Primary Drinking Water Regulations	Establishes primary drinking water regulations and related regulations applicable to public water systems.	7
40 CFR 191	Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes	Designates radiation dose guidelines for the public resulting from management and storage of spent nuclear fuel, high-level waste, or transuranic waste at facilities operated by DOE.	9
40 CFR 241	Guidelines for the Land Disposal of Solid Wastes	Gives applicable guidelines for the land disposal of all solid wastes and outlines minimum levels of performance required of any solid waste disposal site operator.	7

Table 2-1. Other Applicable Federal Requirements (Continued)

Statute/ Regulation	Title	Description	Applicable SAR Chapter
40 CFR 260	Hazardous Waste Management System: General	Provides general standards and overview information applicable to the Resource Conservation and Recovery Act (RCRA).	7
40 CFR 261	Identification and Listing of Hazardous Waste	Identifies solid wastes subject to regulation as hazardous wastes.	7
40 CFR 262	Standards Applicable to Generators of Hazardous Waste	Establishes standards for generators of hazardous waste for recordkeeping, reporting, exporting, importing, and pretransportation.	7
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste	Establishes standards applicable to persons transporting hazardous waste within United States if transportation requires manifest under 40 CFR Part 262. Regulations do not apply to onsite transportation of hazardous waste by owners or operators of permitted hazardous waste management facilities.	7
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	Establishes minimum national standards that define acceptable management of hazardous waste.	7
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	Establishes minimum national standards that define acceptable management of hazardous waste during periods of interim status and until certification of final closure or, if facility is subject to postclosure requirements, until postclosure responsibilities are fulfilled.	7
40 CFR 268	Land Disposal Restriction	Identifies hazardous wastes restricted from land disposal and defines limited circumstances under which an otherwise prohibited waste may continue to be land disposed. Requirements apply to persons who generate or transport hazardous waste and owners and operators of hazardous waste treatment, storage, and disposal facilities.	7
40 CFR 270	EPA Administered Permit Programs: The Hazardous Waste Permit System	Establishes provisions for Hazardous Waste Permit Program under Subtitle C of Solid Waste Disposal Act, as amended by RCRA. Regulations in this part cover basic EPA permitting requirements such as application requirements, standards permit conditions, and monitoring and reporting requirements.	7
40 CFR 300	Oil and Hazardous Substances Pollution National Contingency Plan (NCP)	Establishes NCP guidelines to provide organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants.	4
40 CFR 302	Designation, Reportable Quantities, and Notification	Identifies reportable quantities for substances designated under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980; sets forth notification requirements for releases of these substances.	19
40 CFR 355	Emergency Planning and Notification under CERCLA	Establishes activity notification responsibilities.	19
40 CFR 370	Hazardous Chemical Reporting: Community Right-to-Know Act	Establishes reporting requirements to the public regarding hazardous chemicals in their community.	10
40 CFR 372	Toxic Chemical Release Reporting	Establishes requirements for reporting toxic chemical releases.	10
40 CFR 373	Reporting Hazardous Substance Activity when Selling or Transferring Federal Real Property	Establishes requirements to report the storage, disposal, and release of hazardous substances on U.S. property when being sold or transferred.	10

Table 2-1. Other Applicable Federal Requirements (Continued)

Statute/ Regulation	Title	Description	Applicable SAR Chapter
40 CFR 761	Polychlorinated Biphenyls (PCBs)-Manufacturing, Processing, Distribution in Commerce, and use Prohibitions	Establishes prohibitions and requirements for manufacture, processing, distribution in commerce, use, disposal, storage, and marking of PCBs and PCB items.	7
49 CFR 100-181	Department of Transportation (DOT) Hazardous Material Transportation Act regulations	Regulates packaging and transportation of hazardous materials.	7
CERCLA/SARA Section 120	Federal Facilities	Establishes coordination between Federal agencies to ensure the protection of human health and the environment at Federal facilities under CERCLA/Superfund Amendments and Reauthorization Act (SARA).	20

Table 2-2. Applicable DOE Orders

Order	Title	Description	Applicable SAR Chapter
DOE 1324.2A	Records Disposition	Assigns responsibilities and prescribes policies, procedures, standards, and guidelines for orderly disposition of records of DOE and of operating contractors.	18
DOE 1540.1A	Materials Transport and Traffic Management	Establishes DOE policies and procedures for management of material transportation activities.	7
DOE 1540.2	Hazardous Materials Packaging for Transport-Administrative Procedures	Establishes administrative procedures for certification and use of radioactive and other hazardous materials packaging by DOE.	10
DOE 4330.4A	Maintenance Management Program	Provides general policy/ objectives for establishment of programs for management and performance of cost-effective maintenance and repair of DOE facilities.	15
DOE 4700.1	Project Management System	Establishes principles and requirements that govern development, approval, and execution of DOE Project Management System.	18
DOE 5000.3B	Occurrence Reporting and Processing of Operations Information	Establishes reporting of unusual occurrences with programmatic significance for DOE operation.	19
DOE 5400.1	General Environmental Protection Program	Establishes general DOE environmental program requirements.	7
DOE 5400.3	Hazardous and Radioactive Mixed Waste Program	Establishes DOE hazardous and radioactive mixed waste policies and implementation of RCRA requirements.	7
DOE 5400.4	CERCLA Requirements	Establishes DOE standards for compliance with CERCLA requirements with regard to hazardous substances.	20
DOE 5400.5	Radiation Protection of the Public and the Environment	Establishes standards and requirements for DOE and contractor operations related to protection of members of public and environment against undue risk from radiation.	9
DOE 5440.1E	National Environmental Policy Act Compliance Program	Establishes DOE standard for compliance with NEPA requirements	7
DOE 5480.1B	Environment, Safety, and Health (ES&H) Program for DOE Operations	Establishes ES&H Program for DOE operations.	6
DOE 5480.15	Department of Energy Laboratory Accreditation Program for Personnel Dosimetry	Establishes radiological dosimetry laboratory accreditation standards.	9
DOE 5480.3	Safety Requirements for Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes	Establishes requirements for packaging and transporting of hazardous materials, hazardous substances, and hazardous wastes.	10, 7
DOE 5480.4	Environmental Protection, Safety, and Health Protection Standards	Specifies environmental protection, safety, and health standards broadly applicable to DOE and contractors, with partial applicability to environmental remediation and decontamination and decommissioning (D&D).	6
DOE 5480.5	Safety of Nuclear Facilities	Establishes nuclear facility safety program requirements.	17
DOE N5480.6	Radiological Control Manual	Establishes standard practices for control of radiological contamination and personnel protection programs.	9

Table 2-2. Applicable DOE Orders (Continued)

Order	Title	Description	Applicable SAR Chapter
DOE 5480.7A	Fire Protection	Establishes requirements for "improved risk" level of fire protection sufficient to attain DOE objectives.	17
DOE 5480.8A	Contractor Occupational Medical Program	Establishes minimal Occupational Medical Program requirements for the DOE.	10
DOE 5480.9	Construction Safety and Health	Protection of workers, public, and property during construction.	17
DOE 5480.10	Contractor Industrial Hygiene Program	Establishes requirements and guidelines applicable to DOE contractor operations for maintaining an effective industrial hygiene program.	6, 10
DOE 5480.11	Radiation Protection for Occupational Workers	Establishes radiation protection standards and program requirements for DOE and contractor workers.	9
DOE 5480.18A	Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities	Establishes performance-based training requirements for DOE reactor and non-reactor nuclear facilities.	13
DOE 5480.19	Conduct of Operations	Provides requirements and guidelines for developing directives, plans, and procedures relating to conduct of operations at DOE facilities.	17
DOE 5480.20	Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities	Establishes selection, qualification, training, and staffing requirements for personnel involved in operation, maintenance, and technical support of DOE-owned, non-reactor nuclear facilities.	13
DOE 5480.21	Unreviewed Safety Questions (USQs)	Establishes definition and basis for determining existence of an USQ.	12
DOE 5480.22	Technical Safety Requirements (TSRs)	Establishes requirements for preparation of TSRs for DOE nuclear facilities and delineation of criteria, content, scope, format, approval process, revision, and reporting requirements of TSR documents.	16
DOE 5480.23	Nuclear Safety Analysis Reports	Establishes requirements for contractors responsible for design, construction, operations, and D&D of nuclear facilities to develop safety analyses that establish and evaluate adequacy of safety bases of facilities. The nuclear Safety Analysis Report (SAR) required by this Order documents results of safety analyses.	1, 5, 6
DOE 5480.28	Natural Phenomena Hazard Mitigation	Establishes requirements and procedures for analyzing facility response to and mitigation of natural phenomena	5
DOE 5480.31	Startup and Restart of Nuclear Facilities	Establishes requirements for readiness reviews of nuclear facilities.	16
DOE 5481.1B	Safety Analysis and Review System	Provides uniform requirements for preparation and review of non-nuclear safety analyses for DOE operations.	1, 5, 6
DOE 5482.1B	Environment, Safety, and Health Appraisal Program	Establishes ES&H Appraisal Program for DOE.	12
DOE 5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities	Establishes requirements and procedures to assure that occupational safety and health standards (prescribed pursuant to Atomic Energy Act of 1954, as amended; the Energy Reorganization Act of 1974; and DOE Organization Act of 1977) provide occupational safety and health protection for DOE contractor employees in Government-owned contractor-operated (GOCO) facilities.	10
DOE 5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements	Establishes requirements and procedures for reporting information of ES&H significance for DOE operations.	12

Table 2-2. Applicable DOE Orders (Continued)

Order	Title	Description	Applicable SAR Chapter
DOE 5500.1B	Emergency Management System	Establishes overall policy and requirements for DOE Emergency Management System (EMS). EMS provides framework for development, coordination, and direction of planning, preparedness, and readiness assurance activities.	19
DOE 5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements	Establishes DOE emergency categories, classes, and notification and reporting requirements to facilitate communication and reporting of emergency events.	19
DOE 5500.3A	Planning and Preparedness for Operational Emergencies	Establishes requirements for planning and preparedness for operational emergencies involving DOE or requiring DOE assistance.	19
DOE 5500.4A	Public Affairs Policy and Planning Requirements for Emergencies	Establishes requirements for DOE public affairs actions for emergency situations, and provides guidelines to develop a public information plan to ensure necessary public affairs actions are planned, coordinated, and taken as an integral part of total emergency response effort.	19
DOE 5500.10	Emergency Readiness Assurance Program	Establishes the requirements for assuring the continued readiness of the Emergency Management System for response to an emergency.	19
DOE 5631.1B	Security Education Program	Establishes physical protection training requirements.	13
DOE 5700.6C	Quality Assurance	Establishes quality assurance requirements for DOE.	18
DOE 5820.2A	Radioactive Waste Management	Establishes requirements for DOE management of radioactive and mixed waste.	7
DOE 6430.1A	General Design Criteria Manual	Provides general design criteria and establishes responsibilities and authorities for development and maintenance of criteria.	21

Table 2-3. Requirements for Process Safety Management

Reference	Title	Description	Applicable SAR Chapters
29 CFR 1910.119(a)	Application	Explains the types and quantities of materials and processes where a program is required.	4, 5, 10
29 CFR 1910.119(b)	Definitions	Defines terms in the regulation.	
29 CFR 1910.119(c)	Employee Participation	Requires employee participation during planning and access to process safety management information.	12
29 CFR 1910.119(d)	Process Safety Information	Requires compilation of significant properties of hazardous materials in process, the design parameters of the process and the equipment therein.	4, 5, 10
29 CFR 1910.119(e)	Process Hazard Analysis	Requires analysis of process hazards using approved methods, identification of incidents involving the process, hazard controls, consequences of failures, siting, and human factors.	3, 5, 10, 11, 14
29 CFR 1910.119(f)	Operating Procedures	Requires operating procedures with instructions for safely operating the process.	13
29 CFR 1910.119(g)	Training	Requires initial training, refresher training, and training documentation.	13
29 CFR 1910.119(h)	Contractors	Describes obligations of the employer and contractor for compliance with process safety management requirements.	12, 13
29 CFR 1910.119(i)	Pre-Startup Safety Review	Requires confirmation that design is in accordance with specification, review of adequacy of procedures, confirmation that hazards analysis recommendations are implemented, and verification of training.	17, 18
29 CFR 1910.119(j)	Mechanical Integrity	Requires provision for maintaining the integrity of the process system.	15, 17, 18
29 CFR 1910.119(k)	Hot Work Permit	Requires documented control of heat sources.	10, 17
29 CFR 1910.119(l)	Management of Change	Requires documented procedure for safety review of changes other than replacements-in-kind	12, 17, 18
29 CFR 1910.119(m)	Incident Investigation	Requires incident investigation of any incident which resulted in, or could have resulted in, a catastrophic release of hazardous material	12, 17
29 CFR 1910.119(n)	Emergency Planning and Response	Requires emergency action plan in accordance with 29 CFR 1910.38, including plans for small releases.	19
29 CFR 1910.119(o)	Compliance Audits	Requires triennial audits of compliance with process safety management standards.	12, 18
29 CFR 1910.119(p)	Trade Secrets	Requires access be given to program information to those with need-to-know; nondisclosure agreements may be required.	12

3.0 SITE CHARACTERISTICS

This section provides information on natural phenomena and surrounding activities which may affect the safe operation of a vitrification facility or integrated mixed waste treatment facility employing vitrification processes. Section 3.1 provides a summary of the setting of major DOE complex sites; Section 3.2 describes the seismic characteristics of candidate sites; Section 3.3 discusses wind hazards at candidate sites; Section 3.4 addresses surface water flooding potential for the sites; and Section 3.5 describes transportation system needs and required utilities.

Future decision-makers may deem many of the DOE Complex sites as clearly incompatible with, or irrelevant to, the deployment of mixed waste treatment technology. Such a determination probably will be made during site assessments incorporating both safety analyses and economic analyses. A conclusive site selection assessment is beyond the scope of this PHA.

3.1 SITE LOCATIONS

This section summarizes the settings and locations of candidate DOE sites for a facility. Property site areas provide a general measure of potential isolation from offsite populations should an accident occur. A general ranking of potential isolation based on site areas is given in **Table 3-1**. This ranking is based on a maximum potential source-to-receptor distance for the particular area specified, i.e., the radius of a circle whose area is equivalent to the site area. The actual distance to potential offsite receptors can only be determined during evaluation of the specific site.

3.1.1 Kansas City Plant

The Kansas City Plant is part of the Bannister Federal Complex, located 12 miles south of downtown Kansas City, Missouri. Manufacturing operations are housed in 3.2 million square feet of building space (DOE 1991c).

3.1.2 Los Alamos National Laboratory

Los Alamos National Laboratory (LANL) occupies about 43 square miles in Los Alamos County, 60 miles north of Albuquerque, New Mexico, and 25 miles northwest of Santa Fe, New Mexico. The laboratory is situated on the Parajito Plateau, a finger-like mesa ranging in elevation from 6,200 ft to 7,800 ft (DOE 1991c).

3.1.3 Mound Laboratory

Mound Laboratory is located within the southern city limits of Miamisburg in southwestern Ohio. The plant site occupies 306 acres of land overlooking Miamisburg and the Great Miami River. The Dayton, Ohio metropolitan area is located 10 miles northeast of the installation (DOE 1991c).

Table 3-1. Maximum Potential Source-Receptor Isolation for DOE Sites

DOE Site	Site Area (m^2)	Maximum Source-Receptor Distance (m)
Nevada Test Site	3.50E+09	3.3E+04
Argonne National Laboratory, West	2.31E+09	2.7E+04
Idaho National Engineering Laboratory	2.31E+09	2.7E+04
Hanford Site	1.45E+09	2.1E+04
Savannah River Plant	8.42E+08	1.6E+04
Los Alamos National Laboratory	1.11E+08	5.9E+03
Pantex Plant	6.48E+07	4.5E+03
Rocky Flats Plant	2.89E+07	3.0E+03
LLNL Site 300	2.85E+07	3.0E+03
Brookhaven National Laboratory	2.15E+07	2.6E+03
Portsmouth Gaseous Diffusion Plant	1.50E+07	2.2E+03
Paducah Gaseous Diffusion Plant	1.39E+07	2.1E+03
Oak Ridge National Laboratory	1.17E+07	1.9E+03
Sandia National Laboratories, Albuquerque	1.14E+07	1.9E+03
Energy Technology and Engineering Center	1.09E+07	1.9E+03
Argonne National Laboratory, East	6.88E+06	1.5E+03
Oak Ridge National Laboratory, K-25 Site	6.07E+06	1.4E+03
Feed Materials Production Center, Fernald	4.25E+06	1.2E+03
Oak Ridge National Laboratory, Y-12 Site	3.28E+06	1.0E+03
Lawrence Livermore National Laboratory	2.59E+06	9.0E+02
Stanford Linear Accelerator Center	1.72E+06	7.4E+02
Sandia National Laboratories, California	1.67E+06	7.3E+02
Mound Laboratory	1.24E+06	6.3E+02
Lawrence Berkeley Laboratory	5.26E+05	4.1E+02
Pinellas Plant, Florida	4.02E+05	3.6E+02
Kansas City Plant	2.97E+05	3.1E+02

3.1.4 Pantex Plant

Pantex is located in the panhandle of Texas, 17 miles northeast of downtown Amarillo, Texas, and ten miles west of the town of Panhandle. Pantex includes a total land area of about 16,000 acres. The total population within a 50-mile radius of the plant was 259,300 in 1980 (DOE 1991c).

3.1.5 Rocky Flats Plant

Rocky Flats Plant is located in northern Jefferson County, 16 miles northwest of Denver, Colorado. The plant site covers 11 square miles (DOE 1991c).

3.1.6 Sandia National Laboratories, New Mexico

Sandia National Laboratories, New Mexico (SNL/N) occupies several parcels of land covering 2,820 acres within Kirtland Air Force Base, directly south of Albuquerque, New Mexico (DOE 1991c).

3.1.7 Sandia National Laboratories, California

Sandia National Laboratories, California, (SNL/CA) lies 40 miles east of San Francisco in the Livermore Valley, three miles east of the Livermore city center. SNL/CA occupies 413 acres of land, only a few city blocks from the edge of the city of Livermore. In 1988, the population within 50 miles was estimated at nearly 6,000,000 (DOE 1991c).

3.1.8 Pinellas Plant

The Pinellas Plant is located on a 99.2 acre site, 6 miles north of St. Petersburg in Pinellas County, Florida. Pinellas County is on a peninsula bordered on the west by the Gulf of Mexico and on the east and south by Tampa Bay. The 1989 census estimated a population of 870,162 in Pinellas County (DOE 1991c).

3.1.9 Argonne National Laboratory, East

Argonne National Laboratory - East (ANL-E) occupies a 1,700 acre tract located 22 miles southwest of downtown Chicago in Dupage County, Illinois (DOE 1991c).

3.1.10 Argonne National Laboratory, West

Argonne National Laboratory - West (ANL-W) is located on the southeastern portion of the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho (see 3.1.12 below) (DOE 1991c).

3.1.11 Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) is located in central Suffolk County, New York, on Long Island, 60 miles east of New York City. The site consists of an 8.3 square mile tract, most of which is wooded, save for a 2.3 square mile developed area. The laboratory is located over an EPA-designated, sole source drinking water aquifer (DOE 1991c).

3.1.12 Idaho National Engineering Laboratory

Idaho National Engineering Laboratory (INEL), situated in southern Idaho along the western edge of the Eastern Snake River Plains, encompasses an area of approximately 890 square miles of desert. The nearest major community is Idaho Falls, population 46,000, located 42 miles southeast of INEL (DOE 1991c).

3.1.13 Feed Materials Production Center, Fernald

The Feed Materials Production Center is located near Fernald, Ohio, northwest of Cincinnati. The site occupies 1,050 acres (DOE 1991c).

3.1.14 Oak Ridge National Laboratory, including X-10, K-25 and Y-12 Sites

Oak Ridge National Laboratory (ORNL) occupies several sites and covers approximately 2,900 acres in Melton Valley and Bethel Valley, 10 miles southwest of downtown Oak Ridge, Tennessee (DOE 1991c).

The Oak Ridge K-25 site occupies a 1,500 acre area adjacent to the Clinch River, approximately 13 miles west of downtown Oak Ridge, Tennessee (DOE 1991c).

The Oak Ridge Y-12 site occupies a 811 acre site in Bear Creek Valley, 2 miles from downtown Oak Ridge, Tennessee (DOE 1991c).

3.1.15 Paducah Gaseous Diffusion Plant

The Paducah Gaseous Diffusion Plant is located 15 miles west of Paducah, Kentucky. The site occupies 750 acres, with 74 acres of process buildings, within a 3,422 acre tract of DOE-owned property (DOE 1991c).

3.1.16 Portsmouth Gaseous Diffusion Plant

The Portsmouth Gaseous Diffusion Plant is located 20 miles north of Portsmouth, Ohio. The site covers 3,700 acres, including 93 acres of process buildings (DOE 1991c).

3.1.17 Nevada Test Site

The Nevada Test Site (NTS) occupies approximately 1,350 square miles of desert in southwestern Nevada. The closest major population center is Las Vegas, 65 miles southeast of NTS (DOE 1991c).

3.1.18 Hanford Project Site

The Hanford Site encompasses 560 square miles within the Columbia River Basin in southeastern Washington State. This high desert area is located immediately to the north of Richland, Kennewick, and Pasco, Washington (combined population 100,000) (DOE 1991c).

3.1.19 Lawrence Berkeley Laboratory

Lawrence Berkeley Laboratory (LBL) consists of 130 acres located near urban Berkeley, California, on land leased to DOE by the University of California. The site is bordered on the north by predominantly single-family residences and on the west by multi-family residences, student residence halls, and commercial districts (DOE 1991c).

3.1.20 Lawrence Livermore National Laboratory Including Site 300

Lawrence Livermore National Laboratory (LLNL) Main Site covers one square mile and is located approximately four miles from the Livermore, California, city center. Medium and high-density housing within the City of Livermore, population 50,000, borders the west side of the site. Low-density industrial and agricultural areas adjoin the north, east, and south borders of the site (DOE 1991c).

LLNL Site 300 - Area 854 is located within the overall Site 300 tract, 15 miles east of the LLNL Main Site. Site 300 covers 11 square miles and is surrounded by low-density agricultural land in the Diablo Range of California (DOE 1991c).

3.1.21 Energy Technology and Engineering Center, Santa Susanna

The Energy and Technology Engineering Center (ETEC) is located within the Santa Susanna Field Laboratory, 30 miles northwest of downtown Los Angeles, California. The ETEC consists of government buildings on a 90 acre site within the overall 2,700 acre Santa Susanna Field Laboratory property (DOE 1991c).

3.1.22 Stanford Linear Accelerator Center

The Stanford Linear Accelerator Center (SLAC) site covers 426 acres of low rolling foothills in unincorporated San Mateo County, California. SLAC is located 25 miles south of San Francisco and 15 miles northwest of San Jose. The eastern border is adjacent to the Stanford University campus. Medium-density shopping, residential, and professional buildings are located north of SLAC. Low-density single family residences are located to the south of SLAC (DOE 1988a).

3.1.23 Savannah River Plant

The Savannah River Plant is located in south central South Carolina, and is bordered on the southwestern side by the Savannah River. The closest major population centers are Aiken, South Carolina and Augusta, Georgia. The total area of the site is approximately 325 square miles with production facilities occupying less than 5 percent of the site area (DOE 1991c).

3.2 SEISMICITY

The safety analysis hazard categorization of a facility determines its designated usage category under UCRL-15910, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards* (Kennedy *et al.* 1990). Each usage category is assigned an annual probability of exceedance for seismic events, as defined by the UCRL, which is used in the analysis of facility response to seismic events. For major DOE sites, UCRL-15910 presents seismic horizontal ground accelerations corresponding to these annual probabilities of exceedance.

Table 3-2 ranks the major DOE sites by respective ground acceleration values for the three standard annual probability of exceedance rates. A facility installed at a site appearing at the top of the table would require less sophisticated seismic hazard evaluation and could be more easily designed to survive credible seismic events.

3.3 EXTREME WINDS

Extreme winds, including cyclonic storms and tornadoes, are assessed by UCRL-15910 (Kennedy *et al.* 1990), with annual probabilities of exceedance assigned for specific wind loads at each DOE site. These wind load criteria and the requirements for DOE Order 6430.1A assure that facilities of a given usage category are designed to withstand credible structural wind loads as well as windborne missiles.

Table 3-3 presents a ranking of major DOE sites by respective fastest-mile wind speeds for each usage category. Sites appearing at the top of the table would require less sophisticated design evaluation for wind hazards and could be more easily designed to withstand credible structural wind loads and missiles.

Table 3-2. Horizontal Ground Motion Criteria and Annual Probability of Exceedance at DOE Sites

DOE Site	Annual Probability of Exceedance		
	2.00E-03	1.00E-03	2.00E-04
Pinellas Plant, Florida	0.04 g	0.05 g	0.09 g
Pantex Plant	0.08	0.10	0.17
Kansas City Plant	0.08	0.10	0.17
Portsmouth Gaseous Diffusion Plant	0.08	0.11	0.17
Savannah River Plant	0.08	0.11	0.19
Hanford Site	0.09	0.12	0.17
Argonne National Laboratory, East	0.09	0.12	0.21
Feed Materials Production Center, Fernald	0.10	0.13	0.20
Argonne National Laboratory, West	0.12	0.14	0.21
Idaho National Engineering Laboratory	0.12	0.14	0.21
Mound Laboratory	0.12	0.15	0.23
Brookhaven National Laboratory	0.12	0.15	0.25
Rocky Flats Plant	0.13	0.15	0.21
Oak Ridge National Laboratory	0.15	0.19	0.32
Sandia National Laboratories, Albuquerque	0.17	0.22	0.38
Los Alamos National Laboratory	0.18	0.22	0.38
Nevada Test Site	0.21	0.27	0.48
LLNL Site 300 - Areas 834 and 836	0.28	0.34	0.51
LLNL Site 300 - Area 854	0.32	0.38	0.56
Lawrence Livermore National Laboratory	0.41	0.48	0.68
Sandia National Laboratories, California	0.41	0.48	0.68
Paducah Gaseous Diffusion Plant	0.33	0.45	*
Stanford Linear Accelerator Center	0.45	0.59	*
Energy Technology and Engineering Center	0.53	0.59	*
Lawrence Berkeley Laboratory	0.55	0.64	*

*Value not given in Kennedy *et al.*, 1990 and must be specifically determined for high hazard facilities.

3.4 FLOODING

Flood hazard curves corresponding to the annual probabilities of exceedance in UCRL-15910 (Kennedy et *al.* 1990) have been estimated for selected DOE facilities during the DOE Natural Phenomena Hazard Project (Savy and Murray 1988). Facility structures, including site drainage, foundation design, and roof design, must meet bounding design criteria for protection against extreme precipitation and surface water intrusion during a Design Basis Flood corresponding to the usage category annual probability of exceedance.

Table 3-3. Recommended Design Wind and Tornado Speed Criteria and Annual Probability of Exceedance at DOE Sites

DOE Site	Low Hazard Wind Load (mph) 2.00E-02/y	Moderate Hazard Wind Load (mph) 1.00E-03/y	High Hazard Wind Load (mph) 1.00E-04/y	Moderate/High Hazard Tornado Load (mph) 2.00E-05/y
Hanford Site	70	80	90	—
Argonne National Laboratory, West	70	83	95	—
Brookhaven National Laboratory	70	—	—	95
Energy Technology and Engineering Center	70	—	—	95
Idaho National Engineering Laboratory	70	84	95	—
Nevada Test Site	72	87	100	—
Kansas City Plant	72	93	107	—
Los Alamos National Laboratory	77	93	107	—
Portsmouth Gaseous Diffusion Plant	70	—	—	110
Lawrence Berkeley Laboratory	72	95	112	—
Stanford Linear Accelerator Center	72	95	112	—
Oak Ridge National Laboratory	70	—	—	113
Lawrence Livermore National Laboratory	72	96	113	—
Sandia National Laboratories, California	72	96	113	—
Lawrence Livermore National Laboratory, Site 300	80	104	125	—
Pantex Plant	78	—	—	132
Sandia National Laboratories, Albuquerque	78	—	—	132
Mound Laboratory	73	—	—	136
Savannah River Plant	78	—	—	137
Feed Materials Production Center, Fernald	70	—	—	139
Argonne National Laboratory, East	70	—	—	142
Paducah Gaseous Diffusion Plant	70	—	—	144
Pinellas Plant, Florida	93	130	150	—
Rocky Flats Plant	109	138	161	—

Table 3-4 presents a ranking of flood hazard curve characteristics for those selected major DOE sites where data are available (Savy and Murray 1988). Flood hazard curves present graphical data on the maximum flood water level for a site versus return period in years. From this, annual probability values can be derived. Sites appearing at the top of the table would require less sophisticated design evaluation for precipitation and flooding hazards and could be more easily designed to withstand credible floods and local precipitation.

Table 3-4. Mean Flood Hazard Elevation Criteria and Annual Probabilities of Exceedance for DOE Sites

DOE Site	Minimum Site Elevation (ft)	Flood Elevation Above Minimum Site Elevation (feet) and Annual Probability of Exceedance					
		1.00E-06/y	1.00E-05/y	1.00E-04/y	1.00E-03/y	1.00E-02/y	1.00E-01/y
Sandia National Laboratories, Albuquerque	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hanford Site (N Reactor)	450	*	27	6	<-9	*	*
Mound Laboratory	710	*	2	-1	-5	-8	*
Pinellas Plant	18.7	*	17	5	-2	-8	*
Sandia National Laboratories, California	640	6	5	4	2.5	0	*
Los Alamos National Laboratory (TA-41)	6940	*	5	3	1	*	*
Rocky Flats Plant	5950	*	8	6	4	3	*
Kansas City Plant	800	*	22	18	13	3	-9

*Flood level unavailable from flood hazard curves.

N/A indicates flood was not credible.

3.5 TRANSPORTATION AND UTILITIES

Each of the major DOE sites discussed in this section contain sufficient industrial infrastructure to support a vitrification or integrated mixed waste treatment facility. An important consideration in site selection may be the availability of transport routes appropriate to the movement of construction materials, system components, mixed waste, and consumables such as diesel fuel. Transportation routes to and from the site must accommodate the weight and sizes of system components. Sufficient water supplies must be provided for process water, fire protection, and drinking water. The site must have suitable provisions for stormwater and sewage. Fire protection, sewer, and stormwater systems for the facility must be designed consistent with DOE design criteria for non-reactor nuclear facilities (DOE 1989a).

System electrical demands are likely to be high during vitrification melter operation. High voltage electrical distribution will be necessary to supply system operational needs. Diesel generators may be employed to supply backup power. Transportation systems and site civil engineering should account for fuel transportation and tank storage needs if diesel generation is used.

3.6 DOE ORDER 5480.28

For several years has UCRL-15910 (Kennedy *et al.* 1990) been used to establish performance goals for new DOE facilities in accordance with the requirements of DOE Order 6430.1A (DOE 1989a) . This DOE *Design Criteria* order is being updated and DOE 6430.1B has been published in draft. These updated criteria are complementary to the new requirements recently issued for nuclear facilities in DOE Orders 5480.23 (DOE 1992a) and 5480.28 (DOE 1993b). The latter introduces new requirements for natural phenomena hazard mitigation for DOE facilities and has several associated guidance documents (DOE 1992d; 1992e; 1993c; 1993d; 1993f) some of which have been issued in final form and some of which are still in draft. These guidance documents revise and update the methods in UCRL-15910. The guidance documents institute a new and expanded performance categorization system over that in the UCRL and necessitate their implementation and use DOE-wide. The new DOE Order 5480.28 categorization and performance criteria are summarized in **Table 3-5**.

As the revised DOE *Design Criteria* Order has not yet been finalized, both systems have been addressed in this PHA. It should be noted that there is no serious conflict between the two systems (i.e., that of UCRL-15910 and that of the 5480.28 guidance documents) as they are based on the same methods and probability curves. These curves were published by Coats and Murray (1984; 1985) and Savy and Murray (1988) and form the basis of both systems.

Table 3-5. DOE 5480.28 Performance Criteria

DOE Site	Estimated Horizontal Seismic Load (g) by DOE 5480.28 Performance Category (PC)			Wind and Tornado Speeds (MPH) by DOE 5480.28 Performance Category						Flood (ft above facility grade)			
	PC 1 (1E-3/y)	PC 2 (5E-4/y)	PC 3 (1E-4/y)	PC 1 Wind (2E-2/y)	PC 2 Wind (2E-2/y)	PC 3 Wind (1E-3/y)	PC 3 Tornado (2E-5/y)	PC 4 Wind (1E-4/y)	PC 4 Tornado (2E-6/y)	PC 1 (1E-3/y)	PC 2 (5E-4/y)	PC 3 (1E-4/y)	PC 4 (5E-5/y)
Argonne NL,E	0.12	0.16	0.26	70	70	—	142	—	196	—	—	—	—
Argonne NL,W	0.14	0.17	0.24	70	70	83	—	95	—	—	—	—	—
Brookhaven NL	0.15	0.18	0.30	70	70	—	95	—	145	—	—	—	—
Energy Technology and Engineering Center	0.59	0.69	—	70	70	—	95	111		—	—	—	—
Feed Materials Production Center, Fernald OH	0.13	0.15	0.24	70	70	—	139	—	192	—	—	—	—
Hanford Site	0.12	0.14	0.20	70	70	80	—	90	—	<-9 (N-Reactor)	-1 (N-Reactor)	6 (N-Reactor)	27 (N-Reactor)
Idaho NEL	0.14	0.17	0.24	70	70	84	—	95	—				
Kansas City Plant	0.1	0.13	0.21	72	72	—	144	—	198	12	15	18	19
Lawrence Berkeley Laboratory	0.64	0.85	—	72	72	95	—	111	—	—	—	—	—
Lawrence Livermore NL	0.48	0.56	0.9	72	72	96	—	113	—	—	—	—	—
Lawrence Livermore NL, Site 300	0.36	0.43	0.63	80	80	104	—	125	—	—	—	—	—
Los Alamos NL	0.22	0.28	0.47	77	77	93	—	107	—	1 (TA-41)	2 (TA-41)	3 (TA-41)	5 (TA-41)
Mound Laboratory	0.15	0.18	0.31	73	73	—	136	—	188	-5	-3	-1	0
Nevada Test Site	0.27	0.34	0.56	72	72	87	—	100	—	—	—	—	—
Oak Ridge NL	0.19	0.24	—	70	70	—	113	—	173	—	—	—	—
Oak Ridge NL,K-25	0.19	0.24	—	70	70	—	113	—	173	—	—	—	—
Oak Ridge NL,Y-12	0.19	0.24	—	70	70	—	113	—	173	—	—	—	—
Paducah Gaseous Diffusion Plant	0.45	0.61	—	70	70	—	144	—	198	—	—	—	—
Pantex Plant	0.10	0.11	0.22	78	78	—	132	—	182	—	—	—	—

— Indicates value not available

Table 3-5. DOE 5480.28 Performance Criteria (Continued)

DOE Site	Estimated Horizontal Seismic Load (g) by DOE 5480.28 Performance Category (PC)			Wind and Tornado Speeds (MPH) by DOE 5480.28 Performance Category						Flood (ft above facility grade)			
	PC 1 (1E-3/y)	PC 2 (5E-4/y)	PC 3 (1E-4/y)	PC 1 Wind (2E-2/y)	PC 2 Wind (2E-2/y)	PC 3 Wind (1E-3/y)	PC 3 Tornado (2E-5/y)	PC 4 Wind (1E-4/y)	PC 4 Tornado (2E-6/y)	PC 1 (1E-3/y)	PC 2 (5E-4/y)	PC 3 (1E-4/y)	PC 4 (5E-5/y)
Pinellas Plant	0.05	0.07	0.11	93	93	130	—	150	—	-2	-1	5	17
Portsmouth Gaseous Diffusion Plant	0.11	0.14	0.20	70	70	—	110	—	166	—	—	—	—
Rocky Flats Plant	0.15	0.17	0.23	109	109	138	—	161	—	4	5	6	8
Sandia NL, New Mexico	0.22	0.28	0.47	78	78	93	—	107	—	No Credible Flood Hazard			
Sandia NL, California	0.48	0.56	0.9	72	72	96	—	113	—	2.5	3	4	5
Savannah River Plant	0.11	0.14	0.24	78	78	—	137	—	192	—	—	—	—
Stanford Linear Accelerator Center	0.59	0.73	—	72	72	95	—	112	—	—	—	—	—
Waste Isolation Pilot Plant	—	—	—	80	80	—	<183	—	>183	—	—	—	—
Yucca Mountain Project	—	—	—	—	—	—	—	—	—	—	—	—	—

— Indicates value not available

4.0 FACILITY DESCRIPTION AND OPERATIONS

4.1 LOCATION AND DESCRIPTION

Although environmental characteristics of potential sites can have a significant impact on the design and construction of a vitrification facility, the process itself is not affected by the location and some general criteria for facility design and operation can be postulated. The following subsections details some of the facility design characteristics which will be important to a future facility and to site selection. The design of current lab-scale and pilot scale vitrification units is also described and potential safety systems which may be included in a future facility are discussed.

4.1.1 Site Location

The location for installation of a vitrification facility or integrated mixed waste treatment facility including a vitrification unit has not been determined.

4.1.2 General Building Requirements

A future vitrification facility or unit in an integrated facility must comply with general building requirements contained in DOE Order 6430.1A (DOE 1989a). Major requirements include the following:

- A building capable of holding the vitrification melter and associated offgas treatment systems.
- An automatic fire suppression system, as the contents of the building will be valued at over $1 million. The fire suppression system should be of the wet stand pipe design since the building will require climate control. A dry stand pipe system is used only in buildings which are not climate controlled with the possibility of water freezing in the pipes. The fire suppression system must meet National Fire Protection Association (NFPA) 13 Standards for Ordinary Hazards (Group 1 for a Low Hazard Facility and Group 3 for a Moderate Hazard Facility). The fire alarm system must be compatible with the system currently in place at the DOE facility where the vitrification unit is located.
- A domestic water supply of sufficient capacity to provide for the cooling water requirements of the melter and the domestic sanitation needs of building occupants. The domestic water supply system will be a separate system from that used by the fire suppression system.
- A back-up electrical system to maintain operation of the melter and off-gas system in case of power failure. The back-up will allow the unit to either remain in operation or go through a controlled shut down.
- Real-time airborne radioactive material monitoring equipment for both the general work area and the exhaust stack to meet both DOE and EPA requirements

- Primary and secondary containment systems for any radioactive, hazardous or mixed waste which may be spilled or leak out of the system.

4.1.3 Building Design Requirements

Building design and structural requirements will depend on whether the operation is classified as low or moderate hazard as defined in DOE 6430.1A (DOE 1989a). Structural and design requirements are based, in part, on earthquake (seismic) activity, wind loading (to include hurricanes and tornadoes), and flooding potential. Design guidelines are contained in UCRL-15910 (Kennedy *et al.* 1990). As discussed in Section 3 of this PHA, updated natural phenomena hazard performance categorization methods and criteria have been and are being developed in association with the issuance of DOE Order 5480.28 (DOE 1993b) and the draft revision of the DOE *Design Criteria* order, DOE 6430.1B.

The performance goal annual probability of exceedance, as defined in the UCRL, for low hazard and moderate hazard facilities for major structural damage or facility collapse that would endanger personnel within the facility are as follows:

- Low Hazard: annual probability of 5×10^{-4} for facility damage to the extent that the facility cannot perform its function
- Moderate Hazard: annual probability of 10^{-4} for facility damage to the extent that the facility cannot perform its function.

Design criteria for low and moderate hazard facilities must meet the annual probability of exceedance criteria for earthquake, wind loading, and flooding as described in **Table 4-1** below:

Table 4-1. Annual Probability of Exceedance

Design Item	Low Hazard	Moderate Hazard
Earthquake	1×10^{-3}	1×10^{-3}
Wind Loading	2×10^{-2}	1×10^{-3}
Tornadoes	Not Applicable	2×10^{-5}
Flooding	5×10^{-4}	1×10^{-4}

DOE site specific design information for wind loading, flooding, and seismic activity is included in UCRL-15910 (Kennedy *et al.* 1990) and outlined in Section 3 of this PHA.

4.2 GENERAL DESCRIPTION OF OPERATIONS

4.2.1 System Description

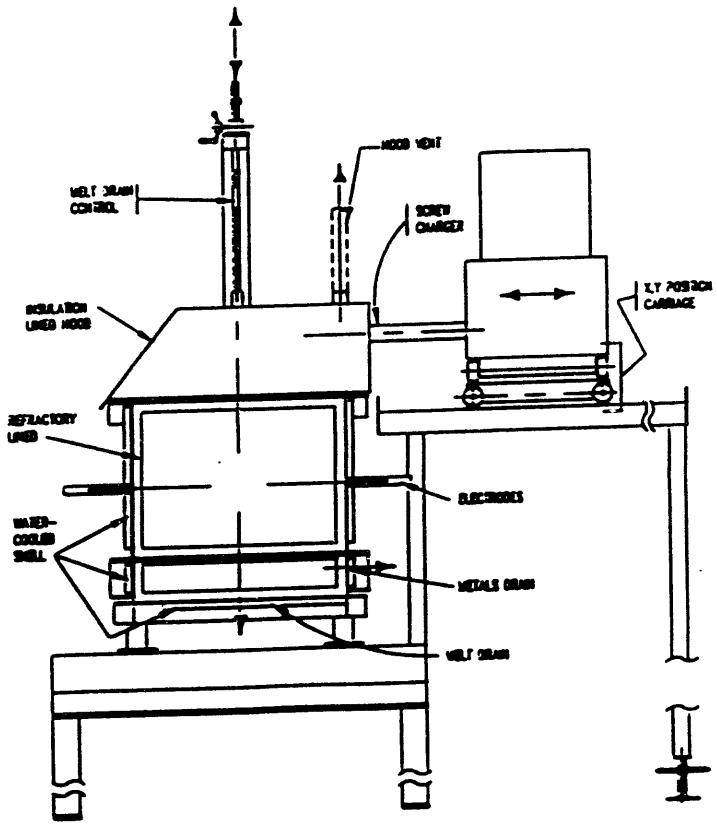
Vitrification of waste by joule heating is a newer application of glass melting technology that has been used in industry for many years. Industrial glass melters include both "cold top" and "hot top" melters, the difference being that, in a cold top melter, unmelted feed covers a significant portion of the top of the vessel and, in a hot top melter, the surface of the melt is maintained liquid by external heaters. Both types typically use electrodes in the sides of the vessel to provide primary process heating and require a start-up heat source to initiate processing. A joule-heated melter was evaluated for treatment of high level waste at the proposed Hazardous Waste Treatment Facility (HWTF), at the Hanford site. A draft *Preliminary Safety Evaluation Document for the Hazardous Waste Treatment Facility* (Pacific Northwest Laboratory 1992) has been issued and provides details of the hazards associated with this type of technology. Many of the hazards and safety considerations applicable to that facility would be applicable to a future vitrification facility or vitrification segment of an integrated mixed waste treatment facility and the *Evaluation* (PNL 1992) is used as a source of information for this PHA. A *Process Hazards Review* (Savannah River Laboratory 1988) was performed for the 672-T Integrated Defense Waste Processing Melter Facility and is also used as a source of hazard and safety information for this PHA. Joule melting technology is also being demonstrated at the Savannah River Site for the treatment of M-area mixed wastes as discussed in the *Draft Environmental Assessment - Treatment of M-Area Mixed Wastes at the Savannah River Site* (DOE/SR 1993).

Historically, the efficiency of melting for glass production was constrained by surface heat transfer limitations. The introduction of joule heating technology, where a current is passed through the melt material providing a source of resistive heat, resulted in an increase in energy efficiency and melting productivity. Larger-scale industrial joule melters have been identified as unsuitable for treatment of mixed waste (Richards and Bickford 1990) but serve to demonstrate the viability of the technology and to provide some information with respect to process hazards, feed requirements, off-gas constituents and quantities, process control requirements, etc.

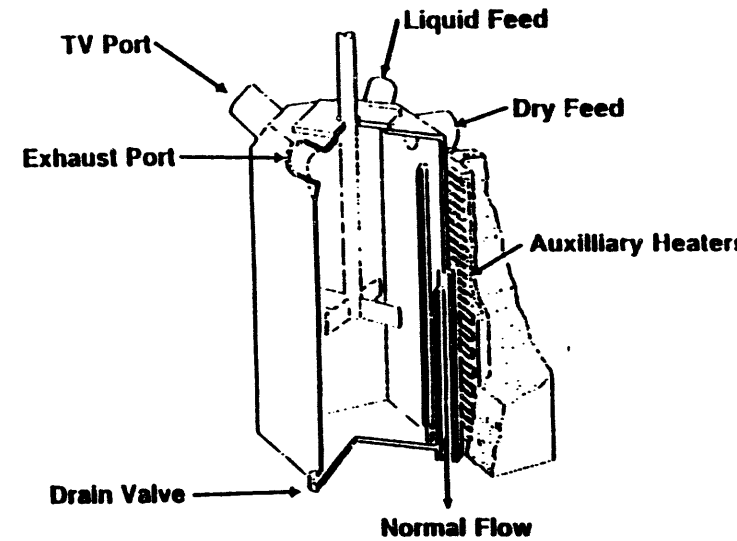
Joule melting technologies are being demonstrated for the Mixed Waste Integrated Program at the Clemson University Industrial Center for Vitrification Research. These are a pilot-scale Stir-Melter™ designed by Glasstech, Inc. and an EnVitCo joule melter (**Figure 4-1**). The Stir-Melter™ technology uses an impeller as one of the electrodes, with the other electrode being in the corners of the vessel. The stirred technology allows both an increase in the heat transfer rate at lower temperature and can produce highly mixed and lower density glasses. The rate of

Figure 4-1. Vitrification Prototypes

ENVITCO EV-16 COLD-TOP HIGH TEMPERATURE MELTER



STIR MELTER WV-0.25 STIRRED TANK MELTER



heating in a stirred system is limited by the maximum current density which is a function of impeller surface area. The EnVitCo system is proprietary and no system details were provided for the PHA.

A future mixed waste vitrification system may be similar to the demonstration systems currently under study at the Clemson University facility. Other candidate systems are being developed and tested at the Pacific Northwest Laboratory including the High Temperature Melter, TerraVit™, VitPac™, and the Liquid Fed Ceramic Melter.

4.2.2 Process Description

Details of the Clemson melters were provided in a private communication by Dalton (1992) from which the following information was taken. The Stir-Melter™ at the Clemson site is a lab-scale melter constructed of alloy 690 with a melt chamber which is 6" square by 1' deep. The melter is auger fed and has a weir type tap for glass removal and a bottom tap for metals removal. It can process approximately 10 lbs per hour and operates at a temperature of ~2,100°F. Stir-Melter™ also produces larger vitrification units up to 20 square feet in surface area. The EnVitCo joule melter is built to pilot-scale and is refractory lined. It has an 18" square chamber and is water cooled. The melter uses molybdenum electrodes mounted in each side wall. The glass tap is a tube that extends from the bottom of the melter into the melt to maintain a minimum level. A bottom tap for metals removal is also incorporated. The melter can process approximately 70 lbs per hour and operates at a temperature of ~3,000°F. It is slurry fed. The off-gas from the units is sent to a common offgas system operating at a slight negative pressure with flows up to 400 scfm. The offgas system consists of a secondary combustion chamber followed by a water/air spray quench, a fiberglass/sand filter, and HEPA filter. No specific safety systems other than the off-gas system were identified as being in use at the Clemson facility.

The DOE MWIP is moving toward demonstration of the vitrification technologies for actual mixed waste at the Westinghouse Savannah River - Clemson site. Demonstration facilities are expected to employ production scale units and to prove the technology both for surrogate wastes and, subsequently, actual wastes. The pilot plants will likely be equipped with additional safety and process systems over and above those in use at the current Clemson facility.

Future melter systems are expected to consist of a bulk material feeder, a primary melt chamber with a collection crucible, perhaps a secondary combustion chamber to assure complete oxidation of volatile effluents from the melt chamber, and exhaust gas pollution control systems. The material for treatment is expected to be continuously fed into the primary chamber, which, like the current demonstration chambers, would be either refractory-lined or alloy 690 vessels. A

collection crucible is expected to be located at the bottom of the primary chamber in which the molten material from the process would be collected.

Products of incomplete combustion would be drawn from the primary chamber as offgas and may be fed into a secondary chamber where combustion is completed. The exhaust gas would then be cooled before entering the air pollution control system which may include particulate bag filters (bag house), high efficiency particulate air (HEPA) filters, cascade water wash systems, charcoal filters, or other commercial filtration materials. Both the primary and the secondary chambers would be kept under a slight negative pressure by the exhaust fans.

4.2.3 Required Support Equipment

A future vitrification facility or facility segment is expected to require support areas including:

- A receiving area for receipt, segregation, and classification of wastes;
- Short-term storage areas which will allow segregated storage of non-compatible wastes or radiological controls and shielding as necessary for the higher activity wastes;
- Processing and preparation areas in which preliminary treatments are performed to prepare the waste for introduction into the vitrification units;
- An off-gas treatment area;
- Post-treatment waste packaging, short-term storage, and shipment area; and
- Other ancillary facilities, such as offices or a laboratory.

Facility services are expected to include building ventilation, process area ventilation which may be HEPA filtered and include carbon absorbers, electrical power (both normal and high voltage) and perhaps back-up diesel power, natural gas to provide building and auxiliary process heating, and water. Other supplies such as compressed gases, compressed air, and supplies of acids or caustics for the off-gas system and waste pre-treatments may be necessary.

4.3 DESIGN REVIEW

4.3.1 Safety Significant Structures

No safety significant structures have yet been identified for the vitrification melters. Proper application of administrative control procedures should prevent the release of radioactive material in the event of a malfunction within the facility. Structures that could be important to safety, dependent on the inventories of radioactive and hazardous materials in the facility, could include the facility structure (containment), ventilation system, off-gas system, monitoring systems, and process control systems.

4.3.2 Structures and Containers

As the location of a future vitrification facility has not been determined, information on a preliminary building design is not available. Containers which may be used to store waste feed stocks are detailed in Table 4-2. Containers used to store reagents and radioactive materials will likely be required to conform to Department of Transportation (DOT) requirements. Pressure vessels shall conform to current American National Standards Institute (ANSI) specifications.

Table 4-2. Types of Mixed Waste Containers

	DOT #	Usage
White or yellow 55-gallon drums (polylined)	6D-2SL	Liquid waste; corrosives
White or yellow 55-gallon drums (unlined)	17E	Liquid waste; no corrosives
55-gallon steel drums	17H	Soils or solids
30-gallon steel drums	17C	Soils or solids
30-gallon polyethylene drum	34	Liquid waste; oils, solvents, corrosives
Fiber boxes	21C	Solids
5-gallon lard cans	N/A	Liquid waste; oils, solvents, corrosives
5-gallon polyethylene containers (carboys)	N/A	Liquid waste; oils, solvents, corrosives

5.0 HAZARDS ANALYSIS

This hazards analysis for vitrification processes follows the requirements of DOE Order 5480.23 (DOE 1992a), DOE Order 5480.21 (DOE 1991d), DOE Order 5480.22 (DOE 1992c), DOE Order 5481.1B (DOE 1986), and the guidance provided in DOE Standards DOE-STD-1027-92 (DOE 1992b). Consideration is given to the proposed rule 10 CFR 830.110 (DOE 1993a), proposed DOE Safety Guide SG 830.110 (DOE 1991b) and proposed DOE Standard DOE-STD-SAFT-0019 (DOE 1993e), *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, in the preparation of this PHA although the proposed regulations and draft guidance have not been approved. A description of the method used in identifying hazards, analyzing events, determining consequences, and assessing risk is presented in Section 5.1. Postulated maximum inventories of hazardous and radioactive materials are discussed in Section 5.2 and their use in establishing the preliminary facility hazard classification is described. The basic hazards associated with energy sources and hazardous and radioactive materials which may be present in a vitrification facility or segment of an integrated mixed waste treatment facility and the bounding accident scenarios are discussed and analyzed in Section 5.3. The consequences of these accident scenarios and their use in verifying the preliminary facility hazard classification are discussed in Section 5.4.

5.1 HAZARDS ANALYSIS METHOD

The method used to perform the hazards analysis involves the use of a list of energy sources and materials to identify the hazards and is outlined in **Figure 5-1**. A team of analysts interviewed project personnel and reviewed available supporting documentation. Records of the characterization of DOE and commercial industry mixed wastes were reviewed to determine the types and quantities of hazardous and radioactive materials that may be treated in a vitrification facility.

Hazards are identified using the "hazardous energy" concept in which potential accidents or abnormal events are distinguished as flows of unwanted energy between a source and a receptor. A hazard source listing specific to a vitrification facility was developed and is presented in **Table 5-1**.

Potential hazards from energy sources, materials, and natural phenomena are characterized by causes, available preventive features, possible methods of detection, potential mitigative features, and consequences. Preventive features are those aspects of the facility or process which reduce the probability of accident occurrence. Mitigative features are those aspects of the facility or process which reduce the level of consequence of accidents. The results of this stage of the

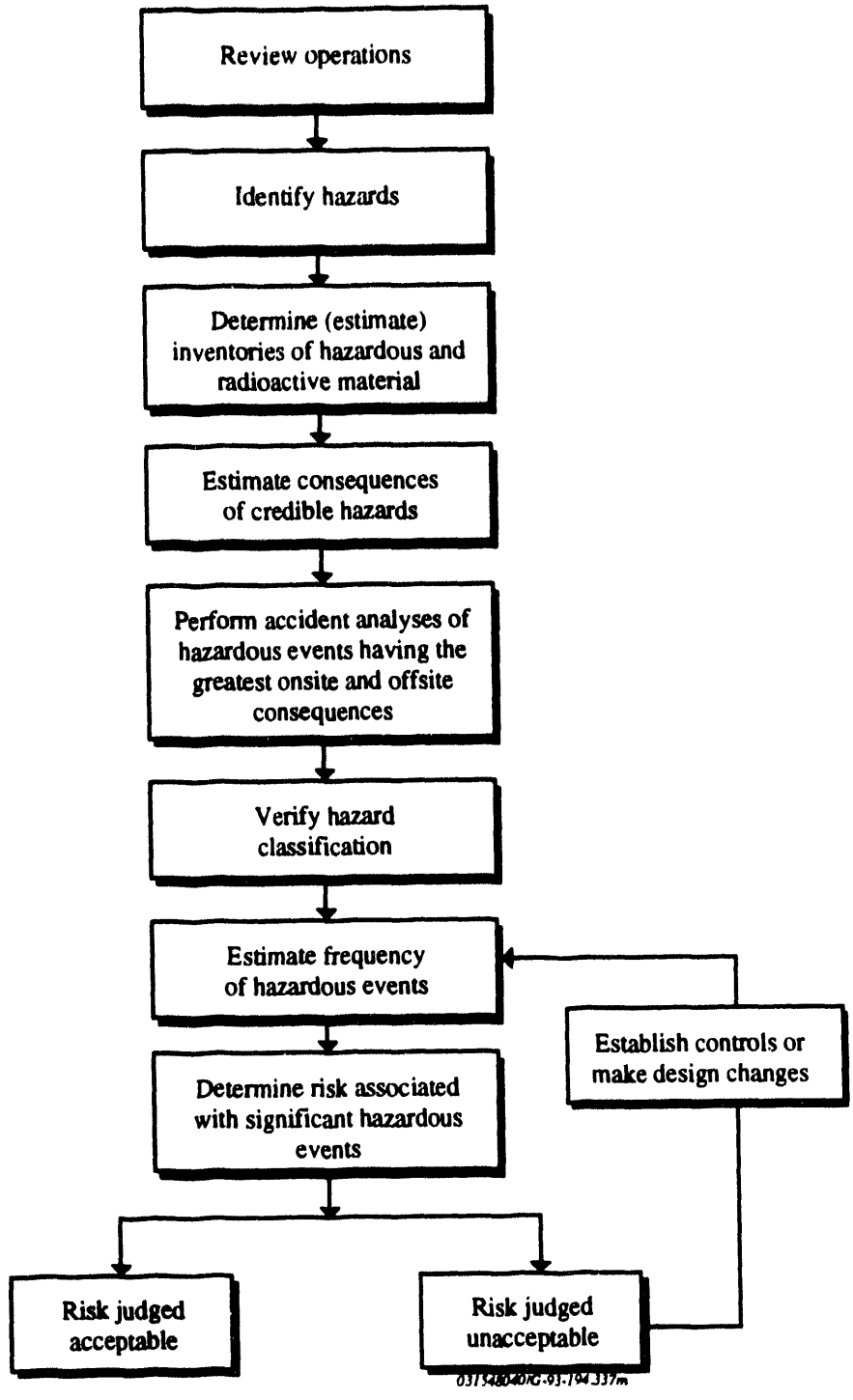


Figure 5-1. Hazard Analysis Process

Table 5-1. Potential Hazard Sources

Electric Sources

- High voltage and current sources
- Transformers
- Batteries
- Static electricity

Motion Sources

- Shears, sharp edges, pinch points, machinery
- Vehicles/forklifts & trucks
- Mass in motion

Gravity-Mass Source

- Falling
- Falling objects
- Lifting
- Tripping, slipping
- Earthquakes

Pressure Sources

- Chemical reactions
- Noise
- Confined gases
- Extreme wind

Chemical Sources

- Corrosive materials
- Flammable materials
- Toxic materials
- Reactive materials
- Carcinogenic materials
- Oxygen deficiency

Heat Sources

- Electrical
- Melter
- Natural gas
- Friction
- Chemical reactions
- Spontaneous combustion

Cold Sources

- Ice, snow

Radiant Sources

- Radioactive materials
- Rf fields
- Infrared sources
- Ultraviolet

analysis are provided in **Table 5-2**. Events which would result in potentially serious on- or offsite consequences are identified. The analyses include events initiated by natural phenomena, human error, vehicular accident, explosions, and equipment failures, that could result in adverse on- and offsite consequences due to a fire, explosion, or other mechanism. A qualitative estimate of the probability of occurrence of each hazard is provided together with an appropriate qualitative estimate of the severity of the events. The frequency of industrial accidents is determined from safety statistics compiled by the National Safety Council (1990). These are combined to provide a qualitative risk level for such a facility. These levels are applied in accordance with the method detailed by Hallinan (1988) and are not significantly different from those contained in Pacific Northwest Laboratory Manual PNL-MA-44, *Safety Analysis*; LA-10294-MS (Elder *et. al.* 1986); and in the *Technical Guidance for Hazards Analysis* (EPA, FEMA & DOT 1987). The probability and consequence level definitions of Hallinan (1988) are detailed in **Tables 5-3 and 5-4**. The risk levels are determined by application of the Risk Matrix developed by Hallinan (1988), provided in **Figure 5-2**.

New criteria are specified in the draft DOE-STD-SAFT-1900 (DOE 1993e) which are significantly different from the criteria used in the other referenced qualitative hazard analysis methods and are not adopted in this PHA. The draft Standard changes the designations of both event frequencies and consequences and presents a different risk table. For example, in the draft Standard events with a frequency of 10^{-4} to 10^{-2} are designated as being of a "Medium" frequency, rather than "Low" as in the method used herein, and a "Medium" consequence is one in which a serious injury to a worker could occur within the facility rather than a serious injury to a worker outside the facility. In the draft standard a Medium frequency event, such as a fire, and a Medium consequence, a serious worker injury, would result in a "Serious" classification which could be classified as an unacceptable risk and require extensive analysis and mitigative safety systems. If the draft standard were to be adopted by DOE, extensive revision of this and other safety analyses would be required.

Table 5-2. Hazards Characterization: Vitrification Processes

Hazard Event	Causes	Preventive Features		Method of Detection	Mitigative Features		Potential Impact	Risk Determination
		Design	Administrative		Design	Administrative		
Fire	Incompatible chemicals in melter; ignition of combustibles in storage; natural gas leak; personnel error; electrical fault.	Approved combustible material storage containers; facility designed to exceed UBC; electrical system compliance with NEC.	Facility safety procedures; Quality Assurance Plan; employee training; workplace fire inspections; ignition source limitation.	Personnel observation; smoke or heat detectors.	Automatic fire sprinkler systems; fire extinguishers; local fire department; exterior fire hydrants.	Facility safety procedures; employee training.	Facility damage; personnel injury; potential release of hazardous and radioactive materials to the environment.	Probability Low Consequence Moderate Risk Low
Hazardous Materials Exposure	Vehicle impact; container drop; container failure; personnel error; fire; system leakage; chemical reaction; system leakage or failure.	Approved hazardous material storage containers; DOE 6430.1A/ASME Code process vessels and equipment; ventilation and offgas treatment systems.	Facility safety procedures; personnel training; Quality Assurance Plan; workplace air sampling; signs and postings.	Personnel observation; change of process system indicators; ventilation or building air monitoring.	Ventilation and offgas treatment systems; drain systems; secondary containments; protective clothing.	Facility safety procedures.	Facility personnel exposure to hazardous materials; potential release of hazardous materials to the environment.	Probability High Consequence Extremely Low Risk Low
Ionizing Radiation Exposure	Vehicle impact; container drop; container failure; personnel error; fire; system leakage; chemical reaction; system leakage or failure.	Approved radioactive material storage containers; DOE 6430.1A/ASME Code process vessels and equipment; shielding; ventilation and offgas treatment systems; workplace air sampling; area radiation monitoring.	Facility safety procedures; personnel training; Quality Assurance Plan; signs and postings.	Personnel observation; change of process system indicators; ventilation and building air monitoring indication; area monitor indication.	Ventilation and offgas treatment systems; drain systems; secondary containments; protective clothing.	Facility safety procedures.	Facility personnel exposure to radioactive material; potential release of radioactive material to the environment.	Probability High Consequence Extremely Low Risk Low

Table. 5-2 Hazards Characterization: Vitrification Processes (Continued)

Hazard Event	Causes	Preventive Features		Method of Detection	Mitigative Features		Potential Impact	Risk Determination
		Design	Administrative		Design	Administrative		
High Voltage Hazard	Vehicle impact; personnel error; equipment failure.	Enclosures for high voltage equipment; NEC compliance; circuit breakers; grounded conduits; process system electrical indicators.	Facility safety procedures; employee training; protective shoes and mats; Quality Assurance Plan; signs, tags, and postings.	Personnel detection; electrical system fault indication; circuit breaker trip; detection of electrical fire.	Circuit breakers.	Facility safety procedures.	Personnel injury; equipment damage; facility damage.	Probability Extremely Low Consequence Moderate Risk Negligible
Industrial Hazards (mass-in-motion)	Forklift operation; roll-up doors; crane operation; rotating machinery; fall from height; dropped object.	Machinery meets applicable ANSI standards; machine guarding; hand rails; load-rated floor; seismic restraints; audible and visual crane alarms; audible and visual forklift alarms.	Facility safety procedures; Quality Assurance Plan; employee training; preventive maintenance; forklift and crane operator certifications; signs and postings; personal protective equipment (harness, hard hats).	Personnel observation.	None identified.	Facility safety procedures; employee training.	Personnel injury; equipment damage; facility damage.	Probability Low to Moderate Consequence Moderate to Low Risk Low
Natural Phenomena	Earthquake - container failure, building collapse; tornado - airborne missile, building/system damage; flood - electrical short, storage container failure.	Facility designed to UBC and DOE 6430.1A criteria.	Facility safety procedures; Quality Assurance Plan; personnel training.	Personnel observation; Report of inclement weather.	None identified.	Facility safety procedures; personnel training.	Personnel injury; equipment damage; facility damage; potential release of hazardous and radioactive material to the environment.	Probability Extremely Low to Moderate Consequence Moderate to Negligible Risk Negligible to Low

Table. 5-2 Hazards Characterization: Vitrification Processes (Continued)

Hazard Event	Causes	Preventive Features		Method of Detection	Mitigative Features		Potential Impact	Risk Determination
		Design	Administrative		Design	Administrative		
Aircraft Impact	Aircraft crash into facility - system damage/failure; fire; explosion	Facility designed to UBC and DOE 6430.1A criteria.	Facility safety procedures; Quality Assurance Plan; personnel training.	Personnel observation	None identified	Facility safety procedures; personnel training	Personnel injury; equipment damage; facility damage; potential release of hazardous and radioactive material to the environment.	Probability Extremely Low to Low Consequence High to Moderate Risk Low
Explosion	Incompatible chemicals in melter; uncontrolled chemical reaction in melter; pressurized gas or system failure; buildup of explosive gas; natural gas leak.	Facility designed to DOE 6430.1A, ASME code; combustible gas detection.	Facility safety procedures; Quality Assurance Plan; personnel training.	Personnel observation; process indicator changes.	Shielding; venting.	Facility safety procedures; personnel training.	Personnel injury; equipment damage; facility damage; potential release of radioactive and hazardous material to the environment.	Probability Low Consequence Moderate Risk Low
Thermal Sources (Heat and Cold)	Container failure; process system leakage/failure.	Facility designed to DOE 6430.1A, ASME code; access restrictions; insulation.	Facility safety procedures; employee training; signs, tags, and postings.	Personnel observation; process system indicator changes.	Personal protective equipment.	Facility safety procedures; personnel training.	Personnel injury.	Probability Moderate Consequence Low Risk Low

Table 5-3. Probability Levels.

Probability Level			Estimate Range of Occurrence Rate per Year
Category	Symbol	Description	
Incredible	A	Probability of occurrence is so small that a reasonable scenario is not conceivable. These events are not considered in design or accident analysis.	$<10^{-6}$
Extremely Low	B	Probability of occurrence is extremely unlikely or event is not expected to occur during the life of the facility or operation.	$>10^{-6}$ and $<10^{-4}$
Low	C	Probability of occurrence is unlikely, or event is not expected to occur but may occur during the life of the facility or operation.	$>10^{-4}$ and $<10^{-2}$
Moderate	D	Event is likely to occur during the facility or operation lifetime.	$>10^{-2}$ and $<10^{-1}$
High	E	Event is likely to occur several times during the facility or operation lifetime.	$>10^{-1}$

Table 5-4. Consequence Levels.

Consequence level[a]	Category	Maximum Consequences
1	High	Serious impact on-site or off-site. May cause death or loss of the facility/operation. Major impact on the environment.
2	Moderate	Major impact on-site and/or minor impact off-site. May cause severe injury or severe occupational illness to personnel or major damage to a facility/operation or minor impact to the environment. Capable of returning to operation.
3	Low	Minor on-site with no off-site impact. May cause minor injury or minor occupational illness, or minor impact on the environment.
4	Extremely Low	Will not result in a significant injury, occupational illness, or impact on the environment.

[a] Worker consequence levels addressed in this table are for workers outside the immediate area in which an accident occurs.

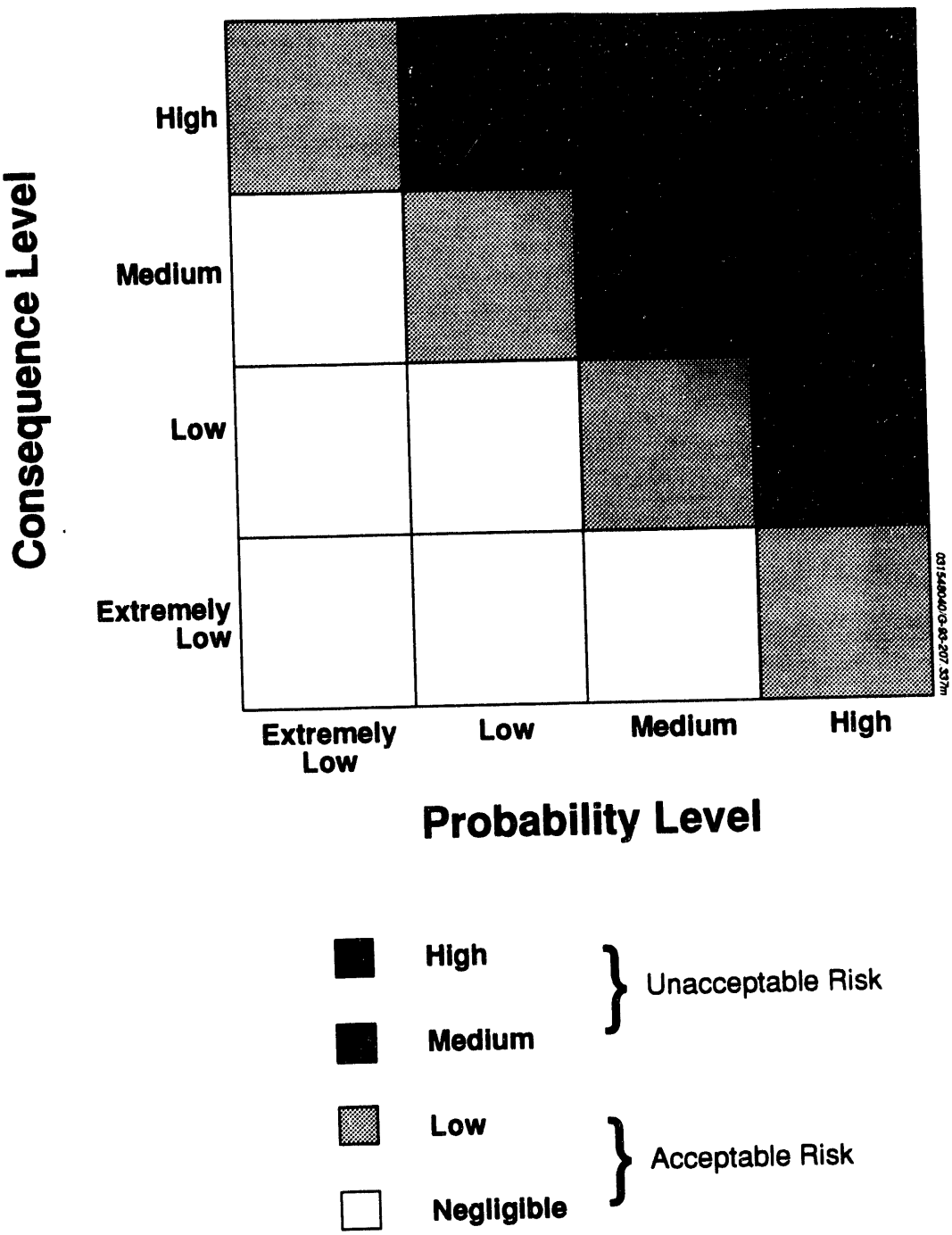


Figure 5-2. Risk Matrix

5.2 INVENTORIES

Radioactive Material

In accordance with the guidance of DOE-STD-1027-92 (DOE 1992b), a preliminary assessment of facility hazard requires the identification of the inventory of radioactive material and a comparison to the Threshold Quantities provided in the Standard.

A wide range of potential radioisotopes may be found in mixed waste but most exist at low concentrations. Mixed waste containing fissile transuranic isotopes may be treated in the facility although it is expected that these materials will meet the "less than 100 nCi/g" standard for handling as low-level wastes in accordance with DOE Order 5820.2A (DOE 1988b) and, therefore, there will be no possibility of a nuclear criticality at the facility. Should enriched uranium or fissile transuranic wastes be processed at a vitrification facility, inventory limits in accordance with the standards of ANSI/ANS-8.15-1981 (ANSI 1981) and ANSI/ANS-.8.1-1983 (ANSI 1983) shall be established so that nuclear criticality will not be possible. Facility maximum inventory limits shall be established in facility safety procedures for all classes of radioisotopes to support maintenance of the ultimate facility hazard classification and assure the prevention of unreviewed safety questions (USQs) in accordance with the requirements of DOE Order 5480.21 (DOE 1991d).

An inventory determination is performed by estimating the total quantity of each class of radionuclide allowable in the facility mixed waste inventory based on the DOE-STD-1027-92, Table A.1, Threshold Quantities. The sum of the ratios of the total inventory of each radionuclide to the Table A.1 thresholds are then calculated. Representative and conservative radioisotopes are chosen in the broad categories of activation and fission products, iodines, natural actinides, and transuranics. These choices reflect both the lowest or one of the lowest Threshold Quantities in the DOE Standard and isotopes typically found in mixed waste. The results are provided for a vitrification facility which is operated as an Exempt facility (that is, a facility which has radiological hazards, but does not meet the criteria for consideration as a "nuclear" facility and is exempt from the requirements of DOE 5480.23), a Category 3 facility, or a Category 2 facility, in accordance with the guidance of DOE-STD-1027-92. The ultimate classification depends on the inventories of radioactive materials in the wastes being processed. The maximum inventory for an Exempt facility is estimated in **Table 5-5**. The maximum inventory for a Category 3 facility is estimated in **Table 5-6**. A facility which would have an inventory in excess of the Category 3 estimated limits of Table 5-6 would be considered Category 2.

Table 5-5 Proposed Maximum Radionuclide Inventory for an Exempt (Below Category 3) Facility

Nuclide[a]	Maximum Inventory (Ci)[b]	Category 3 Threshold Quantity (Ci)[c]	Inventory to Threshold Quantity Ratio[d]
Tritium (^{3}H)	100	1,000	0.1
^{14}C	4	420	0.01
Activation Products (^{60}Co)	28	280	0.1
Fission Products ($^{90}Sr/Y$)	1.6	16	0.1
Iodines (^{125}I)	0.05	0.56	0.1
Thorium (^{232}Th)	0.01	0.1	0.1
Uranium (^{238}U)	0.4	4.2	0.1
Transuranics (^{239}Pu)	0.05	0.52	0.1
Sum of Ratios			**0.71**

[a] The nuclides indicated are examples chosen as representative of a particular class of nuclides.

[b] The maximum inventory quantities postulated are the maximum total quantities of those classes of isotopes which would be allowed into a vitrification facility and include all wastes, in-process materials, and process by-products.

[c] The Threshold Quantities are as indicated in DOE-STD-1027-92 (DOE 1992b).

[d] The ratios of the maximum inventory quantities to the Category 3 Threshold Quantities are summed, in accordance with the guidance in DOE-STD-1297-92, and are found to be less than 1.0. This demonstrates that the potential hazard from the maximum inventory of radioactive material will not be sufficient to warrant classification as Category 3.

Table 5-6 Proposed Maximum Radionuclide Inventory for a Category 3 Facility

Nuclide[a]	Maximum Inventory (Ci)[b]	Category 2 Threshold Quantity (Ci)[c]	Inventory to Threshold Quantity Ratio[d]
Tritium (^{3}H)	30,000	300,000	0.1
^{14}C	14,000	1,400,000	0.01
Activation Products (^{60}Co)	19,000	190,000	0.1
Fission Products ($^{90}Sr/Y$)	2,200	22,000	0.1
Iodines (^{125}I)	240	2,400	0.1
Thorium (^{232}Th)	1.8	18	0.1
Uranium (^{238}U)	24	240	0.1
Transuranics (^{239}Pu)	5.6	56	0.1
Sum of Ratios			**0.71**

[a] The nuclides indicated are examples chosen as representative of a particular class of nuclides.

[b] The maximum inventory quantities postulated are the maximum total quantities of those classes of isotopes which would be allowed into a vitrification facility and include all wastes, in-process materials, and process by-products.

[c] The Threshold Quantities are as indicated in DOE-STD-1027-92 (DOE 1992b).

[d] The ratios of the maximum inventory quantities to the Category 2 Threshold Quantities are summed, in accordance with the guidance in DOE-STD-1027-92, and are found to be less than 1.0. This demonstrates that the potential hazard from the maximum inventory of radioactive material will not be sufficient to warrant classification as Category 2.

The sum of the ratios of the total inventory of each radionuclide to the DOE-STD-1027-92, Table A.1, Threshold Quantities is calculated in Tables 5-5 and 5-6 and is less than one in order to provide a margin of safety and preclude approach to any technical safety limit. It should be noted that the vitrification facility or segment of an integrated mixed waste treatment facility should not, at any time, be expected to contain a significant fraction of the maximum inventories. This will maintain a margin of safety, maintain the conservatism of this analysis, and assure that there will be no significant potential for the occurrence of an USQ.

Hazardous Material

The preliminary assessment of facility hazard is performed in accordance with the requirements of DOE Order 5481.1B (DOE 1986) by examining the range of hazardous materials found in mixed waste and the process reagents and by-products. The hazard classification system contained in DOE Order 5481.1B for facilities containing hazardous (chemical) materials is not yet provided with specific guidance on the evaluation of hazards and consequences, as is contained in DOE-STD-1027-92 (DOE 1992b) for radioactive materials. The Order provides general, qualitative classifications for DOE hazardous facilities similar but not identical to those in DOE Order 5480.23 and DOE-STD-1027-92:

- Low hazard - those which present minor onsite and negligible offsite impacts
- Moderate hazard - those which present considerable potential onsite impacts, but at most minor offsite impacts
- High hazard - those with the potential for onsite or offsite impacts to large numbers of persons or major impacts on the environment.

However, the proposed DOE Standard DOE-STD-SAFT-0019 (DOE 1993e) proposes that the following criteria be used:

- High consequence - > ERPG-2 at the site boundary or > ERPG-3 at 600 m or prompt death in facility
- Medium consequence- Serious injury in facility
- Low consequence - < High to the public and < Medium to workers

The draft guidance is significantly different from that in the existing DOE Order and other hazard analysis methods in that serious consequences to workers within the facility are considered and could result in the facility being classified as moderate or high hazard. The draft guidance is not used in this analysis and the adoption of the draft guidance would necessitate the revision of this PHA.

Hazardous materials, for the purpose of this PHA, are considered to be those chemicals which could present a significant hazard to on- or offsite personnel if they were released in sufficient quantity and are those materials which have been designated by the Department of Labor (DOL), Occupational Safety and Health Administration (OSHA), as highly hazardous in 29 CFR 1910.119 (DOL 1993) and by the Environmental Protection Agency (EPA) as extremely hazardous substances in 40 CFR 355 (EPA 1993).

The total quantity of a specific hazardous material in mixed wastes which could be treated by vitrification are estimated below. The maximum amounts of in-process hazardous by-products are estimated. The primary hazardous constituents are identified. These are compared to the referenced industry standards.

The hazardous constituents and quantities of mixed waste generated and stored at the various DOE facilities have not been fully characterized. The range of hazardous constituents which may be incorporated in waste which may be brought into a vitrification facility will likely include all the EPA waste codes except the "K" code (Musgrave 1993). Waste codes D, F, P, and U represent the following waste categories:

D Codes: Hazardous wastes that show toxicity characteristic, and are subject to Land Disposal Restrictions (LDR) - including **D004-D043**

F Codes: Hazardous wastes from non-specific sources - including **F001-F039**

P Codes: Hazardous wastes from discarded commercial chemical products, off-specification species, container residues and spill residues thereof - including **U001-U359** (40 CFR 261.33)

U Codes: Hazardous wastes from discarded commercial chemical products, off-specification species, container residues, and spill residues thereof - including **P023-P122** (40 CFR 261.33).

Thompson (1992), under contract to the Mixed Waste Treatment Project (MWTP) to prepare Functional and Operational Requirements (F&OR), has identified mixed waste generated and stored by DOE facilities, using data derived from the following three sources:

- *Waste Management Information System*
- *Integrated Database*
- *National Report on Prohibited Wastes.*

Thompson used the data to categorize DOE mixed waste in five major treatment groups and assigned treatment line/waste codes to these five groups. Pertinent data for these groups include the information summarized in **Table 5-7**.

Table 5-7. DOE Mixed Waste Composition by Type

Waste Code	Waste Description	Density** kg/m^3	Mass Generation Rate kg/y	Volume Storage Rate m^3/y
100	Aqueous liquids	1,049	104,910	100
200	Organic liquids	882	52,890	60
300	Wet solids	1,276	957,230	750
400	Homogeneous dry solid	1,181	88,570	75
500	Heterogeneous dry solid*	1,336	308,560	250
TOTALS			**1,512,250**	**1,160**

* This represents the average of the small and large heterogeneous dry solids.
**The average density was 1.25 E3 kg/m^3.

Specific components of the five groups which may be contaminated with hazardous constituents from some or all of the EPA waste codes are listed below.

- Aqueous waste may contain the following:
  - aqueous liquids
  - heavy metal solutions
  - salt solutions
  - slurries
  - trace organics

- Organic liquids may contain the following:
  - organic liquids and sludges
  - solvents
  - scintillation cocktails
  - mercury-contaminated liquids
  - PCB-contaminated liquids

- Wet solids may contain the following:
  - adsorbed/absorbed liquids
  - sludges
  - resins
  - cemented sludges

- Homogeneous solids may consist of the following:
  - dry homogeneous solids
  - grouts
  - ashes and paint chips
  - concrete or asphalt
  - bricks, soils, and salts
  - pyrophorics

- Heterogeneous dry solids may consist of the following:
  - equipment
  - gloveboxes
  - leaded gloves and aprons
  - construction debris
  - general metals and metallic equipment
  - wood
  - dry solids which can be sorted

- filters
- glass
- combustible materials
- miscellaneous waste combinations.

Bechtel Corporation (1992), under contract to MWTP to prepare a cost estimate report, used the same grouping (aqueous liquids, organic liquids, wet solids, homogeneous dry solids, and heterogeneous dry solids) of mixed waste in their study on mixed waste to be treated.

From a list of 125 waste descriptions compiled from the Waste Management Information System for DOE mixed waste, the wastes were organized by Bechtel into the following nine major classes:

Class	Waste Description
1000	Aqueous liquids and slurries
2000	Organic liquids
3000	Solid process residues
4000	Soils
5000	Debris wastes
6000	Special wastes
7000	Inherently hazardous wastes
8000	Unknown
9000	Treated wastes

Examples of waste belonging to each class are provided in "Waste Stream Definition" (Mayberry 1993). Hazardous characteristics of these waste streams include *ignitability*, *corrosivity*, *reactivity*, and *toxicity* and are exemplified by non-halogenated solvents, acids and bases, cyanides, and halogenated/heavy metals, respectively. From these, standardized surrogate waste streams are being developed for testing under the MWIP (Mayberry et al. 1994). These surrogate streams as detailed by Mayberry et al. are shown in **Table 5-8.**

The primary contaminants in these surrogates are halogenated and non-halogenated solvents and metals. From these twelve mixed waste surrogates will be selected the standard wastes for testing by vitrification . No specific information could be obtained on the actual surrogate waste streams to be tested by vitrification processes. However, the melter processes are amenable to treating metals and ashes and sludges from other processes. Therefore, four waste streams were selected from Table 5-8 as potential surrogate waste streams for treatment by vitrification processes and these are detailed in **Table 5-9.** These four waste streams are ash; high organic content sludge; cement, sludges, ashes, solids; and heterogeneous debris. Specific hazardous chemical

Table 5-8. Mixed Waste Treatment Project Waste Stream Categories Selected for Surrogate Formulations

Item	Code No.	Waste Name	Waste Description	Potential Hazards		Typical Hazardous Constituents
				Hazard Class	EPA Codes	
1	1300	Neutral aqueous wastes	Aqueous solutions or slurries with pH values between 2 and 12.5	Toxicity	F001, F003, F006, D004-D011	Volatile and semi-volatile organics; ash; scale; metals; salts
2	2110	Aqueous halogenated organic liquids	Aqueous solution with between 1% and 99% organic liquids	Toxicity	F001, F002, F005, D004, D006-D010	Halogenated and non-halogenated organics.
3	3111	Ash	Bottom and fly ash and residue from incineration of radioactive waste	Toxicity	F001-F003 F005 D004-D011	Halogenated and non-halogenated solvents; heavy metals
4	3113 3114	Absorbed aqueous and organic liquids	Vermiculite clay or diatomaceous earth material contaminated with aqueous and organic liquids	Toxicity	F001-F003 F005 D004-D005 D007-D009 D011	Halogenated and non-halogenated solvents; heavy metals
5	3122	High organic content sludges	Halogenated or non-halogenated sludges with >1% organics	Toxicity	F001-F004 D004-D011	Halogenated and non-halogenated solvents; heavy metals
6	3140	Cement sludges, ashes, and solids	Sludges mixed with solidifying agents such as cement	Toxicity	F001-F004 D004-D011	Halogenated and non-halogenated solvents; heavy metals
7	3151 3152	Chloride, sulfate and nitrate salts	Evaporated or process salts, predominately nitrate salts	Toxicity	D005-D008	Chloride, sulfate, and nitrate salts; metals
8	3200	Organic matrix solids	Organic solids which would leave only moderate ash residue	Toxicity Ignitability	Not identified	Activated carbon, cellulose, organic resin; metal salts; trace organics
9	5400	Heterogeneous debris	Mixtures of metals and non-metals, combustibles, soils, and process residue	Toxicity Ignitability	F001-F005 D004-D011	Halogenated and non-halogenated solvents; metals
10	5440	Bulk combustibles	50% to 95% combustibles	Toxicity Ignitability	F001-F003 F005 D004 D006-D011	Carbon, cellulose, PVC, rubber, metals, organics.
11	6100	Lab Packs	Lab chemicals, packing material	Toxicity Ignitability Corrosivity Reactivity	D001-D008 D010-D017	Carbon, polyethylene metals, organics.
12	7200	Lead Shapes	Bulk lead	Toxicity	Not identified	Lead, metals, organics.

Table 5-9 Content of Selected Surrogate Waste Streams

Waste Stream	Code No.	Chemical	Quantity (kg)/drum
Ash	3111	Carbon	31
		Vermiculite	47
		Fly ash	86
		Coal bottom ash cinders	86
		Chromium	0.88
		Nickel	1.0
		Lead	1.2
		Cadmium	1.1
		Naphthalene	1.0
		1,2 dichlorobenze	0.78
		Chlorobenzene	0.78
High Organic Content Sludge	3122	Carbon	26
		Water	52
		Perlite	26
		Iron oxide	26
		Calcium sulfate	26
		Aluminum Oxide	13
		Ethylene glycol	38
		Mineral oil	31
		Chromium	0.44
		Nickel	0.50
		Lead	0.60
		Cadmium	0.55
		Naphthalene	7.8
		1,2 dichlorobenzene	5.2
		Chlorobenzene	5.2
Cement, Sludges, Ashes, Solids	3140	Carbon	26
		Water	130
		Perlite	26
		Fly ash	26
		Concrete	26
		Calcium sulfate	7.8
		Iron oxide	7.8
		Aluminum oxide	3.9
		Chromium	0.44
		Nickel	0.50
		Lead	0.60
		Cadmium	0.55
		Naphthalene	1.0
		1,2 dichlorobenzene	0.78
		Chlorobenzene	0.78

Table 5-9 Hazardous Material Content of Surrogate Waste Streams (Cont.)

Waste Stream	Code No.	Chemical	Quantity (kg)/drum
Heterogeneous Debris	5400	Carbon	13
		Water	38
		Wood	26
		PVC	26
		Neoprene	26
		Mild steel	26
		Glass beads	26
		Concrete	21
		Alumina crucibles	26
		Diatomaceous earth	26
		Chromium	0.44
		Nickel	0.50
		Lead	0.60
		Cadmium	0.55
		Naphthalene	1.0
		1,2 dichlorobenzene	0.78
		Chlorobenzene	0.78

* Of the materials listed in the surrogate waste streams, only cresols are considered highly hazardous substances in 40 CFR 355.

constituents associated with these waste streams are provided in Table 5-9. The hazards associated with these are analyzed in Section 5.3.

The calculations of the maximum quantities of each chemical in each waste stream were performed based on an average total weight of each drum of 260 kg and on the chemical weight percentage from Mayberry et al. (1994). The product of these factors expressed in kilograms, yielded the quantities of the materials and hazardous chemicals in these four waste streams. These quantities of hazardous materials were used to estimate the hazard from wastes being treated by vitrification processes.

The quantities of hazardous byproducts produced by vitrification processes could also be important to the safety of the process. The following are postulated as the primary byproducts of treatment of mixed wastes by vitrification processes as determined from the Pacific Northwest Laboratory (1992), *Preliminary Safety Evaluation Document for the Hazardous Waste Treatment Facility*, DOE/SR (1993), Richards and Bennett (1990) and SAIC (1993):

- From Organic Contaminants in Wastes
  - Carbon dioxide (CO_2)
  - Water vapor (H_2O))
  - Hydrochloric acid (HCl)
  - Hydrofluoric acid (HF)
  - Hydrobromic acid (HBr)

- From Inorganic Contaminants in Waste
  - Oxides of nitrogen (NO_X)
  - Oxides of sulfur (SO_X)
  - Oxides of carbon (CO_X)
  - Hydrochloric acid (HCl)
  - Hydrofluoric acid (HF)
  - Particulates
  - Volatile Metals (Be, Cd, Hg, etc.)

DOE/SR (1993) determined the mass of $NO_X$and SO_X from the processing of 650,000 gallons of mixed waste sludge and found that projected emissions from their vitrification process would result in approximately 27 tons/y of NO_X and negligible amounts of SO_X . Emission of particulates, metals, and radioactive materials were also estimated as being negligible and controllable using HEPA filtration. The offgas scrubber would be expected to remove any significant quantities of acid. Emissions of NO_X and an evaluation of possible best available control technologies for the Hanford Waste Vitrification Plant was performed by SAIC (1992) and found to be within EPA limits.

The "Initial Alternative MWTP Flowsheet" memo (Gillins 1993) provides the breakdown, by element, of the different waste categories reported in the Functional and Operation Requirement (F&OR) documents (Thompson 1992) and the *MWTP Process Systems and Facilities Design Study and Cost Estimate* for LLNL (Bechtel 1992).

A wide range of hazardous materials are found in mixed waste but most exist only at low concentrations as reflected in Table 5-9. Although some waste streams, such as organic liquids, may have high concentrations of hazardous materials, this waste stream constitutes only 3% of DOE mixed waste. It is also not credible that many waste streams, such as organic liquids, could be treated by vitrification. The Threshold Quantities, contained in 29 CFR 1910.119, are those amounts of specific hazardous materials which, if they are contained in a process stream, tank, or container, require specific safety procedures, hazard analyses, and emergency action plans under OSHA regulations. The Threshold Planning Quantities, contained in 40 CFR 355, are those amounts of specific hazardous materials which, if they are contained in a facility, require specific emergency plans under EPA regulations. The Threshold Quantities in both regulations typically indicate amounts between 100 and 10,000 pounds as the limit for each of the materials. Of the hazardous materials in Table 5-9 only cadmium, if it is considered to be in oxide form, is on the 40 CFR 355 and 29 CFR 1910.119 highly hazardous material lists.

The Threshold Quantity from 40 CFR 355 for cadmium oxide is 10,000 pounds; the Threshold Quantity of HCl is 500 pounds; the Threshold Quantity of nitric oxide (considering all NO_X as nitric oxide) is 100 pounds; and the Threshold Quantity of SO_X (considering all SO_X as sulfur dioxide) is 500 pounds.

Assuming a maximum inventory of approximately 100 drums of waste and considering the entire inventory of cadmium in those drums, there would be an insufficient quantity to approach the Threshold Quantities for hazardous materials in the wastes. The quantities of gaseous oxides and acids within the system at any one time would also be small compared to the annual emissions referenced above (DOE/SR 1993; SAIC 1992) but have not yet been evaluated for a future mixed low-level waste vitrification unit. Based on this initial inventory screening, a vitrification facility would therefore be considered a low hazard facility as only negligible offsite impact appears possible.

It is noted that, this preliminary assessment should not be considered exhaustive as many different types of hazardous contaminants may be found in mixed wastes considered for treatment by vitrification processes. However, most mixed waste contains hazardous materials as only a small percentage of the total mass of the waste, as reflected in Table 5-9. It is expected that a vitrification facility is not likely, at any time, to contain any significant fraction of a Threshold Quantity of any specific hazardous material.

The quantities of hazardous materials typically found in mixed wastes, as indicated above, indicate that a vitrification facility would present a hazard only to personnel in the facility and would, therefore, be a Low Hazard facility in accordance with the requirements of DOE Order 5481.1B. Should a future vitrification facility treat waste streams with larger quantities of highly hazardous materials, such that considerable hazard to onsite personnel could exist, the facility classification would be Moderate Hazard. Should a future vitrification facility treat waste streams with quantities equal to or in excess of the 29 and 40 CFR Threshold Quantities, the facility could present a hazard to large numbers of on- and offsite personnel and would be considered a High Hazard facility. Facility maximum inventory limits shall be established in facility safety procedures for all hazardous materials brought into the facility to support maintenance of the facility hazard classification eventually selected. The consequences of potential accidents involving the identified hazardous materials are addressed further in Section 5.3.

5.3 BOUNDING ANALYSES OF POTENTIAL ACCIDENTS

This hazards analysis characterizes potential hazardous conditions present in a vitrification facility in terms of energy sources, hazardous and radioactive materials, and natural phenomena. A summary of potential hazardous events is presented in Table 5-2 and includes events involving container failure, personnel error, fire, uncontrolled chemical reaction, vehicle accidents, and hazardous and radioactive material releases. Natural phenomena including seismic activity, lightning, rain, and extreme wind, that could affect facility operations, are identified. It is noted that there will be no criticality hazard in a vitrification facility which treats low-level mixed wastes; although some waste contaminated with transuranic isotopes may be treated at the facility, it is

expected that such waste will be limited, as detailed in Section 5.2, at least to the criteria established in DOE-STD-1027-92 (DOE 1992b), ANSI/ANS-8.15-1981 (ANSI 1981), and ANSI/ANS-8.1-1983 (ANSI 1983).

The hazards inherent in a vitrification facility are assessed in this Section in three broad categories: operational and equipment hazards; radiological hazards; and hazardous material hazards. The potential accident scenarios involve only credible events, as defined in DOE Order 6430.1A (DOE 1989a), which have an estimated probability of occurrence of 10^{-6} or greater. They provide details on the postulated sequence of events, an estimate of the likelihood of the event, and estimates of consequences. Where appropriate, credit is taken for preventive features of the facility design, that is, those controls that keep an event from happening by reducing the event frequency. Passive design features that will remain intact during an accident (for example, building walls) are considered in the accident scenarios. Active design features (for example, building ventilation) are considered in accident scenarios only if they increase the potential accident consequences. No credit is taken for mitigative features, that is, those controls that reduce the consequence level of an event.

Conservative atmospheric transport methods are used to estimate the on- and offsite concentrations of hazardous and radioactive materials following release. Airborne concentrations of radioactive materials were calculated using HOTSPOT (Homann 1991). Airborne concentrations of hazardous materials were calculated using airborne dispersion, χ/Q, values calculated using the method of Hanna *et al.* (1982). Appendix A contains the calculations from the computer-based model.

In the following analyses, only radioactive and hazardous material releases were identified as having the potential to impact offsite members of the public or the environment. Industrial and operational accidents involving vitrification processes could credibly result in severe injury or death of a worker in the facility, but no potential effects outside the facility were identified other than the potential release of radioactive and hazardous materials. These events could be initiated by a number of credible causes. Therefore, a bounding estimate is performed to verify the hazard classifications which resulted from the examination of inventories. The actual cause of the postulated hazardous and radioactive material release event is not then relevant because more than one credible cause may be postulated.

For the purpose of this hazards analysis, the maximal amounts of radioactive material which could be in storage are determined based on proposed inventory limits. The maximum inventory of radioactive materials are postulated for the facility and the effects of an accident involving these materials are analyzed. The resulting doses to on- and offsite personnel are compared to the dose equivalent criteria in the DOE-STD-1027-92 (DOE 1992b) and DOE Order

5400.5 (DOE 1990) to verify facility classification for radiological consequences. The maximum inventory of hazardous materials could not be postulated for the facility but the effects of accidents involving the assumed inventory of 100 drums, from Section 5.2, are analyzed. Exposures of on- and offsite personnel are assessed with respect to the limits provided by various industrial standards including those of American Conference of Governmental Industrial Hygienists (ACGIH), American Industrial Hygiene Association (AIHA), and National Institute for Occupational Safety and Health (NIOSH) (ACGIH 1990; AIHA 1989; NIOSH 1990).

Accidents are analyzed and maximum source terms are determined in accordance with accepted industry guidance including *A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities* (Elder *et al.* 1986), *Nuclear Fuel Cycle Facility Accident Analysis Handbook* (Ayer *et al.* 1988), and DOE-STD-1027-92 (DOE 1992b).

Accident effects within the facility are estimated at 30 m from the source in accordance with the guidance of DOE-STD-1027-92 (DOE 1992b). The exposure of the maximally exposed onsite receptor outside the facility is calculated at 100 m in accordance with the guidance of DOE-STD-1027-92. The exposure to offsite receptors is calculated to the maximally exposed individual at 300 m in accordance with the guidance of DOE-STD-1027-92. In all cases, the meteorological parameters assume "D" class stability, 4.5 m/s wind speed, ground level releases, and non-buoyant plumes, in accordance with the Standard recommendation. (The draft DOE Standard DOE-STD-SAFT-0019 (DOE 1993e) proposes a method that uses meteorological parameters assuming "F" class stability, and 1 m/s wind speed which is not consistent with the DOE-STD-1027-92 approach and is not used for this analysis as DOE-STD-SAFT-0019 has been issued only in draft.) The accident scenarios assume that site personnel and members of the public will be at the on- and offsite location with the highest airborne concentration of radioactive and hazardous material for the entire accident duration. This assumption provides conservative estimates of the maximum possible exposure of site personnel and members of the public.

5.3.1 Operational and Equipment Assessment

This section provides a qualitative analysis of potential vitrification facility operational and equipment accidents to identify those features which are important to safety within the facility. No operational events or equipment failures were identified which could affect personnel outside the facility other than through release of hazardous and radioactive material. Potential accidents involving the release of radioactive and hazardous materials are analyzed in subsections 5.3.2 and 5.3.3. Information on the potential hazards associated with the vitrification are taken from the Savannah River Laboratory (1988), *Process Hazards Review 672-T Integrated DWPF Melter Facility*, the Pacific Northwest Laboratory (1992), *Preliminary Safety Evaluation Document for the Hazardous Waste Treatment Facility*, and the draft *Defense Waste Processing Facility Safety*

Analysis Report (SRS 1993). The probability estimates of industrial accidents were developed from a database of DOE accidents and industrial safety statistics developed by the National Safety Council (1990) and assume a facility staff of 20 individuals.

Electrical

The vitrification melters are provided with high voltage, high current power supplies. Various other systems and components are provided with standard electrical power at lower current and voltage. Component failures and personnel errors can result in equipment damage and potential personnel injury or death. As vitrification processes are a new application of an existing technology, the probability and consequences of electrical accidents are not expected to be different from other similar industrial applications. The probability of moderate and high consequence events (severe injury or death or loss of facility operation) is expected to be extremely low (10^{-4} to 10^{-6}). The probability of low consequence events (minor injury or equipment damage) is expected to be medium to low (10^{-1} to 10^{-4}).

Natural and Compressed Gases

Natural gas and compressed gases may be used in vitrification processes as a process start-up heat source and calibration gases for instrumentation, respectively. All compressed gases are expected to be inert or inert with a small percentage of carbon monoxide, nitric oxide, carbon dioxide, or oxygen. Natural and compressed gases used in vitrification processes are considered to pose similar hazards to those from routine industrial gas use. Natural gas could present a fire hazard and an asphyxiation hazard if allowed to accumulate in a confined space by a leak or improper alignment. Compressed gas cylinders also pose a missile hazard if ruptured. All compressed gas use would be performed in compliance with OSHA regulations and Compressed Gas Association standards. The probability of moderate and high consequence events (severe injury or death) is expected to be extremely low (10^{-4} to 10^{-6}). The probability of low consequence events (minor injury or equipment damage) is expected to be moderate to low (10^{-1} to 10^{-4}).

Fire

The potential for fire in a vitrification facility appeared to be low as waste will be contained in approved containers and process systems would be expected to incorporate redundant fire protection features. Fire hazards in a vitrification facility are considered to be lower than fire hazards in other industrial incineration operations. Such a facility will be constructed to DOE 6430.1A fire protection criteria appropriate to the hazard classification of the facility and to NFPA codes. The systems are constructed of noncombustible materials. The start-up natural gas burner would be equipped with Underwriters Laboratory and Factory Mutual approved safety systems to prevent the release of uncombusted natural gas. The probability of moderate and high consequence

events (severe injury or death or facility destruction) is expected to be extremely low (10^{-4} to 10^{-6}). The probability of low consequence events (minor injury or equipment damage) is expected to be low (10^{-2} to 10^{-4}).

Spills of Glass

The potential for a failure of the melt chamber or spill during glass removal is credible. Glass is drained from the melt chamber via a weir or tap and mechanical failures could result in a spill. It is expected that such a spill would be contained by a secondary containment surrounding the system. The walls or bottom of the melt chamber could also fail due to corrosion of metal walls or burn-through of the refractory liner by a broken rod electrode. The waste/glass melt environment has been demonstrated to be extremely corrosive and the probability of failure of metal electrodes is high. Industrial accidents in large glass melters have occurred due to burn-through of vessel walls from broken rod electrodes (Peters 1994) and resulted in the release of the glass inventory to the process area and subsequent facility fire. A future vitrification facility should consider installation of a secondary containment surrounding the entire vitrification system sufficient to contain the entire glass melt inventory. The consequences of a major glass spill and subsequent facility fire are limited by the consequences of the fire analyzed in 5.3.2 and 5.3.3.

The probability of moderate and high consequence events (severe injury or death or facility destruction is expected to be low (10^{-2} to 10^{-4}). The probability of low consequence events (minor injury or equipment damage) is expected to be moderate to high ($>10^{-1}$ to 10^{-2}).

Explosion

The potential for explosion in the vitrification systems is credible due to the wide range of chemicals that may be present in the waste and the water used to cool the systems. Explosions could occur in the melter feed tank, the primary process vessel, the offgas system, or any secondary combustion chamber due to the accumulation of explosive gas mixtures. Steam explosions in the glass melter are also credible in the event of the introduction of water into the process vessel if there is a salt layer on top of the melt. The potential for such an event is reduced by the inherent operational mode of the vitrification systems at reduced pressure and in a predominantly inert atmosphere. The potential for explosion in the facility appeared to be low as waste will be contained in DOT specification containers and the natural gas portion of the process system would incorporate explosion prevention features. Explosion hazards in a vitrification facility are considered to pose lesser hazards than those from other industrial incineration operations. Such a facility will be constructed to DOE 6430.1A criteria appropriate to the hazard classification of the facility. Explosion relief features may be incorporated into vitrification systems. The probability of moderate and high consequence events (severe injury or death or

facility destruction) is expected to be extremely low (10^{-4} to 10^{-6}). The probability of low consequence events (minor injury or equipment damage) is expected to be low (10^{-2} to 10^{-4}).

Industrial Safety Hazards

The potential for routine industrial hazards, (such as burn, trip, fall, lifting, and rotating equipment hazards) appeared to be comparable to or lower than other similar industrial facilities. Vitrification facilities are mechanically simple processes with few moving parts. Motor driven mechanisms would be enclosed or guarded to meet OSHA regulations. The probability of moderate and high consequence events (severe injury or death) is expected to be low (10^{-2} to 10^{-4}). The probability of low consequence events (minor injury or equipment damage) is expected to be high(> 10^{-1}).

Hazardous Chemical and Radiation Exposure

A vitrification facility will contain radioactive and hazardous material at low concentrations on otherwise inert material in waste which is packaged in DOT specification containers. Therefore, direct contact of workers with these hazardous and radioactive constituents will be infrequent. The possibility of spills will be present and appropriate spill response procedures will be necessary. Worker radiation exposures will be controlled in accordance with 10 CFR 835 (DOE 1994) regulations and minimized in accordance with DOE "as low as reasonably achievable" (ALARA) policy. Worker hazardous chemical exposures will be controlled in accordance with DOE Order 5480.10 (DOE 1985) requirements. The probability of moderate and high consequence events (severe injury or death) is expected to be extremely low (10^{-4} to 10^{-6}). The probability of low consequence events (minor unplanned exposures) is expected to be high (> 10^{-1}).

5.3.2 Radiological Assessment

The radiological assessment calculates doses to the maximally exposed individuals in terms of 50-y, whole body, committed effective dose equivalent (CEDE). CEDEs are determined in accordance with the International Commission on Radiological Protection (ICRP) Publication 30 methodology (ICRP 1979) and DOE Orders 5400.5 (DOE 1990) and 5480.11 (DOE 1989b).

Calculated CEDEs are not reflective of those which would actually be received by an individual during an accident, but are conservative estimates of the dose to a worker and to a member of the general public under accident conditions. These estimates are used to verify facility hazard classification. The duration of exposure is assumed to be equal to the duration of the release. (The actual duration of any worst-case accident is, therefore, not relevant to the dose calculation as the source term will be directly proportional to the receptor intake which is in turn directly proportional to the CEDE.)

Sealed radioactive sources and check sources may be used in a vitrification facility. Sealed sources and check sources are constructed and distributed in accordance with USNRC requirements in 10 CFR 30 through 34 (NRC 1993) and ANSI standards (ANSI 1977) to pose minimal hazards. Specifically licensed sealed sources are constructed to withstand accident environments. The analyses of this section assume any significant sealed source will withstand accident conditions and they are excluded from the inventory of material at risk in accordance with DOE-STD-1027-92 guidance.

The on- and offsite CEDEs were calculated at 30 m, 100 m, and 300 m. Representative and limiting isotopes are chosen for the dose calculations as representative of those which are found in mixed wastes. The limits specified in DOE-STD-1027-92 (DOE 1992b) are an onsite CEDE of 1 rem (or more) at 100 m as the Category 2 criterion and 10 rem (or more) at 30 m over a 24 hour period as the Category 3 criteria.

Any number of accidents are possible in a vitrification facility and will result in a range of consequences: spills of containers of waste, leaks from treatment systems, fires involving limited quantities of combustible waste, leaks from the process systems, and small explosions which would be contained by the building structure. In order to envelope the consequences of all the possible scenarios, a generalized release of radioactive material is postulated to occur within the building. This worst-case accident for a vitrification facility could be a fire or explosion which is assumed to involve the maximum building inventory of radioactive material. The potentially contaminated effluent from the event leaks from the building through a door, the ventilation system, or an opening in the building side or roof and is released to the environment.

The material-at-risk is defined by the facility inventory as detailed in subsection 5.2, above. The release fractions are as recommended in DOE-STD-1027-92 (DOE 1992b). No credit is taken for plume rise, although some of the accidents could result in a buoyant release, which would reduce the resultant on- and offsite CEDEs. The results from the computer-based HOTSPOT model (Homann 1991) are provided in Appendix A. The maximum potential onsite CEDE are presented in **Tables 5-10 and 5-11**.

Table 5-10. Radioactive Material Category 3 Release Factors, Source Terms, and Doses

Nuclide	Release Fraction	Source Term (Ci)	Dose at 30m (rem)	Dose at 100m (rem)	Dose at 300m (rem)
Tritium (^{3}H)	1.0	100	0.04	0.0047	0.00059
^{14}C	0.01	0.04	0.00036	0.000042	0.0000052
Activation Products (^{60}Co)	0.001	0.028	0.0089	0.0021	0.00013
Fission Products ($^{90}Sr/Y$)	0.001	0.0016	0.018	0.001	0.00026
Iodines (^{125}I)	0.5	0.025	0.0026	0.0003	0.000037
Thorium (^{232}Th)	0.001	0.00001	0.047	0.0054	0.00068
Uranium (^{238}U)	0.001	0.0004	0.2	0.024	0.003
Transuranics (^{239}Pu)	0.001	0.00005	0.07	0.0082	0.001
Total			**0.39**	**0.046**	**0.0056**

Table 5-11. Radioactive Material Category 2 Release Factors, Source Terms, and Doses

Nuclide	Release Fraction	Source Term (Ci)	Dose at 30m (rem)	Dose at 100m (rem)	Dose at 300m (rem)
Tritium (^{3}H)	1.0	30,000	12	1.4	0.18
^{14}C	0.01	140	1.3	0.15	0.018
Activation Products (^{60}Co)	0.001	19	12	1.4	0.18
Fission Products ($^{90}Sr/Y$)	0.001	2.2	12	1.4	0.018
Iodines (^{125}I)	0.5	130	12	1.5	0.18
Thorium (^{232}Th)	0.001	0.0018	8.4	0.98	0.12
Uranium (^{238}U)	0.001	0.024	12	1.4	0.18
Transuranics (^{239}Pu)	0.001	0.0056	7.9	0.91	0.11
Total			**78**	**9.1**	**0.99**

5.3.3 Hazardous Material Assessment

The hazardous material accident scenarios calculate exposures to onsite personnel and members of the public. Calculated airborne concentrations of hazardous materials are not reflective of those which would actually be experienced by an individual during an accident, but are conservative estimates of the theoretical maximum exposures of a worker and of a member of the general public. These estimates are used to verify facility hazard classification.

The onsite airborne concentrations of hazardous materials were calculated at 30 m and 100 m and the off-site concentrations were calculated at 300 m. These maximum airborne concentrations were then compared to the various industrial and governmental standards provided by OSHA, EPA, AIHA, ACGIH, and NIOSH. The OSHA, ACGIH, and NIOSH set standards for controlling exposures of worker to hazardous materials, thus these standards are not directly

applicable to exposures of members of the public. The AIHA sets standards for public exposures called Emergency Response Planning Guides (ERPGs). Very few ERPG concentration values have been set by AIHA, thus these are of only limited utility. The currently identified highly hazardous materials from 29 CFR 1910.119 and 40 CFR 355 together with the more numerous AIHA, ACGIH, and NIOSH standards are provided for reference in tabular form in Appendix B. The definitions of industrial hygiene and emergency preparedness terms from AIHA, ACGIH, NIOSH, and OSHA standards are contained in Appendix C.

The unique hazardous materials that may be part of the mixed waste streams treated by a vitrification facility cannot be defined at this time. Surrogate materials for a few waste streams for the demonstration of vitrification processes are catalogued in Section 5.2. These materials are considered representative and are used to assess consequences of accidents involving stored waste. As noted previously, hazardous materials are typically minor contaminants in mixed waste streams, such that this approach is considered representative. The process by-products, detailed in Section 5.2, are used to assess the consequences from these sources.

The conclusion from subsection 5.2 is verified by summing the total inventory of hazardous materials in 100 mixed waste drums and the maximum quantities of process by-products resulting from a weeks activity of a vitrification facility, applying appropriate release and dispersion factors (Elder *et al.* 1986; Ayer 1988), and calculating the resultant on- and offsite airborne concentrations by application of the appropriate χ/Q values, 0.017 s/m^3 at 30 m, 0.0016 s/m^3 at 100 m, and 0.0002 s/m^3 at 300 m.

The hazardous by-products of vitrification (NO_x, SO_x, and HCl) are subject to leakage due to equipment failure, leakage due to personnel error, and damage to the system and release of the material due to fires, uncontrolled chemical reactions, vehicular accidents, and falls of heavy objects.

To bound the possible consequences of accidents involving mixed waste containers, a fire involving the entire 100 drum waste inventory was postulated. The fire is assumed to burn for 1 hour and to consume the entire waste inventory. A release fraction of 0.01 is applied to all metals and a release fraction of 0.001 is applied to all combustible organics.

During normal operation, the vitrification unit converts the hazardous organic constituents of mixed waste to carbon dioxide and water, thus reducing their hazardous potential. Metals and inert materials are converted to slag and remain in the process vessel. Some volatile metals are carried over into the secondary chamber, are oxidized upon contact with air, condensed in the quench, and are removed from the off-gas stream in the filter system. Halogens are converted to their complementary acid and neutralized and removed by the scrubber. Leaks or equipment

failures in the process systems could release acids, gases, molten glass, or particulate metal oxides into the facility, but no significant release mechanism from the facility could be identified. Thus, no accidents were identified which could increase the release fractions of hazardous materials over those used in the analysis. Spills of mixed waste are possible, but would have consequences only within the facility and would pose lesser hazards to personnel outside the facility than those analyzed.

No plume rise is postulated in the scenarios although releases of heated gas or vapor and fires would result in significant plume rise and lower down-wind concentrations. If plume rise was taken into account, the on- and offsite consequences would be less than those estimated.

The results of the waste fire scenario are presented in **Table 5-12.** All airborne concentrations of hazardous materials were less than their respective industrial and governmental standards provided by OSHA, EPA, AIHA, ACGIH, and NIOSH.

Table 5-12. Waste Fire Accident Results

Material	Amount (kg)	Release Fraction	Source Term (g)	Concentration in mg/m^3 at 30 m	Concentration in mg/m^3 at 100 m	Concentration in mg/m^3 at 300 m	Standard mg/m^3
Chromium	55	0.01	550	2.6	0.24	0.030	500 (IDLH) 0.5 (TLV)
Nickel	63	0.01	630	3.0	0.28	0.035	0.05 (TLV) 50 (LOC)
Lead	75	0.01	750	3.5	0.33	0.042	0.05 (PEL)
Cadmium	69	0.01	690	3.3	0.31	0.038	0.05 (TLV) 40 (IDLH) 4 (LOC)
Naphthalene	270	0.001	270	1.3	0.12	0.015	50 (TLV)
1,2 dichloro benzene	190	0.001	190	0.90	0.084	0.011	301 (TLV-C)
chlorobenzene	190	0.001	190	0.90	0.084	0.011	46 (TLV)

5.4 CONSEQUENCE ANALYSIS AND PRELIMINARY HAZARD CLASSIFICATION

The consequences of the accident scenarios compare hypothetical exposures and effects to DOE requirements (DOE 1992b) and accepted industry standards (ACGIH, 1990; AIHA, 1989; NIOSH 1990). Qualitative estimates of the probability of accidents and their maximum expected consequences are provided. The probability estimates are based on engineering judgment and industrial data. In addition, the design bases specified in UCRL-15910 (Kennedy *et al.* 1990) for external phenomena such as earthquakes, extreme winds, and rain are considered in determining the probability of such events. The probability and consequence of each event are evaluated to establish hazard-specific probability and consequence levels.

5.4.1 Consequences of Radiological Assessments

For an Exempt facility, the maximum potential onsite CEDEs will be less than the Category 3 values calculated in Section 5.3. These are the following: 0.39 rem at 30 m, 46 mrem at 100 m, and 5.6 mrem at 300 m. The doses associated with a vitrification facility operated as Category 3 would be between these values and the Category 2 threshold values calculated in Section 5.3. These are the following: up to 78 rem at 30 m, 9.1 rem at 100 m, and 0.99 rem at 300 m. The onsite dose equivalent at 30 m would be more than the DOE standard of 10 rem for a Category 3 facility so that mitigative measures would be indicated to reduce the exposure or to limit the inventory if the facility were to be operated as Category 3. The onsite dose equivalent at 100 m is more than the DOE standard of 1 rem for a Category 2 facility. No DOE offsite accidental dose standards exist, however, the offsite dose is minimal in comparison to current NRC offsite accidental dose standards (NRC 1993).

5.4.2 Consequences of Hazardous Material Assessments

The results of the Section 5.3 accident analyses indicate that maximal releases of hazardous materials from stored waste and the process systems could have impacts only onsite. Although onsite concentrations at 30 and 100 m for chromium, nickel, lead, and cadmium could exceed continuous occupational exposure limits (TLVs and PELs); no significant health effects would be expected from these exposures. Existing short-term hazard limits (IDLHs and LOCs) would not be exceeded either on- or offsite. No significant effects were identified to offsite members of the public or the environment.

5.4.3 Conclusions

The radiological assessments indicate that a vitrification facility may be an Exempt (non-nuclear), a Category 3, or a Category 2 facility based on the maximum inventory of radioactive material selected. It will have minimal impacts to offsite personnel and the environment in all cases. The calculated impacts would result in no significant injury or risk of illness and only minor impact to the environment. The probability of occurrence of the worst-case accidents are estimated to be low (10^{-2} to 10^{-4}/y).

The hazardous materials assessment indicates that a vitrification facility would be low hazard with respect to hazardous materials. It would have minimal impacts to offsite personnel and the environment. The probability of occurrence of the worst-case accident is estimated to be low (10^{-2} to 10^{-4}/y).

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APPENDIX A

HOTSPOT CALCULATIONS

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : H-3 Inhalation Class : D
HalfLife : 12.350 years
SOURCE TERM : 1.0E+02 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 4.7E-03 rem

Plume Centerline

D = 0.10 km		D = 0.20 km		D = 0.50 km	
DEP = 1.5E+03 uCi/m^2		DEP = 4.0E+02 uCi/m^2		DEP = 7.3E+01 uCi/m^2	
CHI = 1.5E-01 (Ci-s)/m^3		CHI = 4.0E-02 (Ci-s)/m^3		CHI = 7.3E-03 (Ci-s)/m^3	
50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
SKIN	4.7E-03 rem	SKIN	1.3E-03 rem	SKIN	2.3E-04 rem
THYROID	4.7E-03 rem	THYROID	1.3E-03 rem	THYROID	2.3E-04 rem
LUNG	4.7E-03 rem	LUNG	1.3E-03 rem	LUNG	2.3E-04 rem
SURFACE BONE	4.7E-03 rem	SURFACE BONE	1.3E-03 rem	SURFACE BONE	2.3E-04 rem
LIVER	4.7E-03 rem	LIVER	1.3E-03 rem	LIVER	2.3E-04 rem
SPLEEN	4.7E-03 rem	SPLEEN	1.3E-03 rem	SPLEEN	2.3E-04 rem
GONADS	4.7E-03 rem	GONADS	1.3E-03 rem	GONADS	2.3E-04 rem
EFFECTIVE DOSE EQUIVALENT	4.7E-03 rem	EFFECTIVE DOSE EQUIVALENT	1.3E-03 rem	EFFECTIVE DOSE EQUIVALENT	2.3E-04 rem

Plume Centerline

D = 1.00 km		D = 2.00 km		D = 5.00 km	
DEP = 2.2E+01 uCi/m^2		DEP = 6.9E+00 uCi/m^2		DEP = 1.7E+00 uCi/m^2	
CHI = 2.2E-03 (Ci-s)/m^3		CHI = 6.9E-04 (Ci-s)/m^3		CHI = 1.7E-04 (Ci-s)/m^3	
50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
SKIN	6.9E-05 rem	SKIN	2.2E-05 rem	SKIN	5.3E-06 rem
THYROID	6.9E-05 rem	THYROID	2.2E-05 rem	THYROID	5.3E-06 rem
LUNG	6.9E-05 rem	LUNG	2.2E-05 rem	LUNG	5.3E-06 rem
SURFACE BONE	6.9E-05 rem	SURFACE BONE	2.2E-05 rem	SURFACE BONE	5.3E-06 rem
LIVER	6.9E-05 rem	LIVER	2.2E-05 rem	LIVER	5.3E-06 rem
SPLEEN	6.9E-05 rem	SPLEEN	2.2E-05 rem	SPLEEN	5.3E-06 rem
GONADS	6.9E-05 rem	GONADS	2.2E-05 rem	GONADS	5.3E-06 rem
EFFECTIVE DOSE EQUIVALENT	6.9E-05 rem	EFFECTIVE DOSE EQUIVALENT	2.2E-05 rem	EFFECTIVE DOSE EQUIVALENT	5.3E-06 rem

Plume Centerline

D = 10.00 km		D = 20.00 km		D = 50.00 km	
DEP = 6.3E-01 uCi/m^2		DEP = 2.4E-01 uCi/m^2		DEP = 7.0E-02 uCi/m^2	
CHI = 6.3E-05 (Ci-s)/m^3		CHI = 2.4E-05 (Ci-s)/m^3		CHI = 7.0E-06 (Ci-s)/m^3	
50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
SKIN	2.0E-06 rem	SKIN	7.6E-07 rem	SKIN	2.2E-07 rem
THYROID	2.0E-06 rem	THYROID	7.6E-07 rem	THYROID	2.2E-07 rem
LUNG	2.0E-06 rem	LUNG	7.6E-07 rem	LUNG	2.2E-07 rem
SURFACE BONE	2.0E-06 rem	SURFACE BONE	7.6E-07 rem	SURFACE BONE	2.2E-07 rem
LIVER	2.0E-06 rem	LIVER	7.6E-07 rem	LIVER	2.2E-07 rem
SPLEEN	2.0E-06 rem	SPLEEN	7.6E-07 rem	SPLEEN	2.2E-07 rem
GONADS	2.0E-06 rem	GONADS	7.6E-07 rem	GONADS	2.2E-07 rem
EFFECTIVE DOSE EQUIVALENT	2.0E-06 rem	EFFECTIVE DOSE EQUIVALENT	7.6E-07 rem	EFFECTIVE DOSE EQUIVALENT	2.2E-07 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : C-14 Inhalation Class : D
HalfLife : 5.7E+03 Years
SOURCE TERM : 4.0E-02 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 4.2E-05 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 5.9E-01 uCi/m^2	DEP = 1.6E-01 uCi/m^2	DEP = 2.9E-02 uCi/m^2
CHI = 5.9E-05 (Ci-s)/m^3	CHI = 1.6E-05 (Ci-s)/m^3	CHI = 2.9E-06 (Ci-s)/m^3

50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
THYROID	4.2E-05 rem	THYROID	1.1E-05 rem	THYROID	2.0E-06 rem
LUNG	4.2E-05 rem	LUNG	1.1E-05 rem	LUNG	2.0E-06 rem
SURFACE BONE	4.2E-05 rem	SURFACE BONE	1.1E-05 rem	SURFACE BONE	2.0E-06 rem
RED MARROW	4.2E-05 rem	RED MARROW	1.1E-05 rem	RED MARROW	2.0E-06 rem
GONADS	4.2E-05 rem	GONADS	1.1E-05 rem	GONADS	2.0E-06 rem
EFFECTIVE DOSE EQUIVALENT	4.2E-05 rem	EFFECTIVE DOSE EQUIVALENT	1.1E-05 rem	EFFECTIVE DOSE EQUIVALENT	2.0E-06 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 8.7E-03 uCi/m^2	DEP = 2.8E-03 uCi/m^2	DEP = 6.7E-04 uCi/m^2
CHI = 8.7E-07 (Ci-s)/m^3	CHI = 2.8E-07 (Ci-s)/m^3	CHI = 6.7E-08 (Ci-s)/m^3

50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
THYROID	6.1E-07 rem	THYROID	1.9E-07 rem	THYROID	4.7E-08 rem
LUNG	6.1E-07 rem	LUNG	1.9E-07 rem	LUNG	4.7E-08 rem
SURFACE BONE	6.1E-07 rem	SURFACE BONE	1.9E-07 rem	SURFACE BONE	4.7E-08 rem
RED MARROW	6.1E-07 rem	RED MARROW	1.9E-07 rem	RED MARROW	4.7E-08 rem
GONADS	6.1E-07 rem	GONADS	1.9E-07 rem	GONADS	4.7E-08 rem
EFFECTIVE DOSE EQUIVALENT	6.1E-07 rem	EFFECTIVE DOSE EQUIVALENT	1.9E-07 rem	EFFECTIVE DOSE EQUIVALENT	4.7E-08 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 2.5E-04 uCi/m^2	DEP = 9.6E-05 uCi/m^2	DEP = 2.8E-05 uCi/m^2
CHI = 2.5E-08 (Ci-s)/m^3	CHI = 9.6E-09 (Ci-s)/m^3	CHI = 2.8E-09 (Ci-s)/m^3

50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
THYROID	1.8E-08 rem	THYROID	6.7E-09 rem	THYROID	2.0E-09 rem
LUNG	1.8E-08 rem	LUNG	6.7E-09 rem	LUNG	2.0E-09 rem
SURFACE BONE	1.8E-08 rem	SURFACE BONE	6.7E-09 rem	SURFACE BONE	2.0E-09 rem
RED MARROW	1.8E-08 rem	RED MARROW	6.7E-09 rem	RED MARROW	2.0E-09 rem
GONADS	1.8E-08 rem	GONADS	6.7E-09 rem	GONADS	2.0E-09 rem
EFFECTIVE DOSE EQUIVALENT	1.8E-08 rem	EFFECTIVE DOSE EQUIVALENT	6.7E-09 rem	EFFECTIVE DOSE EQUIVALENT	2.0E-09 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : CO-60 Inhalation Class : Y
HalfLife : 5.271 years
SOURCE TERM : 2.8E-02 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 2.1E-03 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 4.2E-01 uCi/m^2	DEP = 1.1E-01 uCi/m^2	DEP = 2.0E-02 uCi/m^2
CHI = 4.2E-05 (Ci-s)/m^3	CHI = 1.1E-05 (Ci-s)/m^3	CHI = 2.0E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.8E-02 rem	LUNG 4.8E-03 rem	LUNG 8.8E-04 rem
EFFECTIVE DOSE EQUIVALENT 2.1E-03 rem	EFFECTIVE DOSE EQUIVALENT 5.6E-04 rem	EFFECTIVE DOSE EQUIVALENT 1.0E-04 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 6.1E-03 uCi/m^2	DEP = 1.9E-03 uCi/m^2	DEP = 4.7E-04 uCi/m^2
CHI = 6.1E-07 (Ci-s)/m^3	CHI = 1.9E-07 (Ci-s)/m^3	CHI = 4.7E-08 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 2.6E-04 rem	LUNG 8.4E-05 rem	LUNG 2.0E-05 rem
EFFECTIVE DOSE EQUIVALENT 3.0E-05 rem	EFFECTIVE DOSE EQUIVALENT 9.7E-06 rem	EFFECTIVE DOSE EQUIVALENT 2.4E-06 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.8E-04 uCi/m^2	DEP = 6.7E-05 uCi/m^2	DEP = 2.0E-05 uCi/m^2
CHI = 1.8E-08 (Ci-s)/m^3	CHI = 6.7E-09 (Ci-s)/m^3	CHI = 2.0E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 7.6E-06 rem	LUNG 2.9E-06 rem	LUNG 8.5E-07 rem
EFFECTIVE DOSE EQUIVALENT 8.8E-07 rem	EFFECTIVE DOSE EQUIVALENT 3.3E-07 rem	EFFECTIVE DOSE EQUIVALENT 9.8E-08 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : SR-90 Inhalation Class : Y
HalfLife : 29.120 years
SOURCE TERM : 1.6E-03 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 1.0E-03 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 2.4E-02 uCi/m^2	DEP = 6.4E-03 uCi/m^2	DEP = 1.2E-03 uCi/m^2
CHI = 2.4E-06 (Ci-s)/m^3	CHI = 6.4E-07 (Ci-s)/m^3	CHI = 1.2E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 8.7E-03 rem	LUNG 2.3E-03 rem	LUNG 4.3E-04 rem
EFFECTIVE DOSE EQUIVALENT 1.0E-03 rem	EFFECTIVE DOSE EQUIVALENT 2.8E-04 rem	EFFECTIVE DOSE EQUIVALENT 5.1E-05 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 3.5E-04 uCi/m^2	DEP = 1.1E-04 uCi/m^2	DEP = 2.7E-05 uCi/m^2
CHI = 3.5E-08 (Ci-s)/m^3	CHI = 1.1E-08 (Ci-s)/m^3	CHI = 2.7E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.3E-04 rem	LUNG 4.0E-05 rem	LUNG 9.9E-06 rem
EFFECTIVE DOSE EQUIVALENT 1.5E-05 rem	EFFECTIVE DOSE EQUIVALENT 4.8E-06 rem	EFFECTIVE DOSE EQUIVALENT 1.2E-06 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.0E-05 uCi/m^2	DEP = 3.8E-06 uCi/m^2	DEP = 1.1E-06 uCi/m^2
CHI = 1.0E-09 (Ci-s)/m^3	CHI = 3.8E-10 (Ci-s)/m^3	CHI = 1.1E-10 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 3.7E-06 rem	LUNG 1.4E-06 rem	LUNG 4.1E-07 rem
EFFECTIVE DOSE EQUIVALENT 4.3E-07 rem	EFFECTIVE DOSE EQUIVALENT 1.7E-07 rem	EFFECTIVE DOSE EQUIVALENT 4.8E-08 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : I-125 Inhalation Class : D
HalfLife : 60.182 days
SOURCE TERM : 2.5E-02 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 3.0E-04 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 3.7E-01 uCi/m^2	DEP = 9.9E-02 uCi/m^2	DEP = 1.8E-02 uCi/m^2
CHI = 3.7E-05 (Ci-s)/m^3	CHI = 9.9E-06 (Ci-s)/m^3	CHI = 1.8E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
THYROID 1.0E-02 rem	THYROID 2.7E-03 rem	THYROID 4.9E-04 rem
EFFECTIVE DOSE EQUIVALENT 3.0E-04 rem	EFFECTIVE DOSE EQUIVALENT 7.9E-05 rem	EFFECTIVE DOSE EQUIVALENT 1.5E-05 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 5.4E-03 uCi/m^2	DEP = 1.7E-03 uCi/m^2	DEP = 4.2E-04 uCi/m^2
CHI = 5.4E-07 (Ci-s)/m^3	CHI = 1.7E-07 (Ci-s)/m^3	CHI = 4.2E-08 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
THYROID 1.5E-04 rem	THYROID 4.7E-05 rem	THYROID 1.1E-05 rem
EFFECTIVE DOSE EQUIVALENT 4.3E-06 rem	EFFECTIVE DOSE EQUIVALENT 1.4E-06 rem	EFFECTIVE DOSE EQUIVALENT 3.4E-07 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.6E-04 uCi/m^2	DEP = 6.0E-05 uCi/m^2	DEP = 1.7E-05 uCi/m^2
CHI = 1.6E-08 (Ci-s)/m^3	CHI = 6.0E-09 (Ci-s)/m^3	CHI = 1.7E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
THYROID 4.2E-06 rem	THYROID 1.6E-06 rem	THYROID 4.7E-07 rem
EFFECTIVE DOSE EQUIVALENT 1.3E-07 rem	EFFECTIVE DOSE EQUIVALENT 4.8E-08 rem	EFFECTIVE DOSE EQUIVALENT 1.4E-08 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : TH-232 Inhalation Class : Y
HalfLife : 1.4E+10 Years
SOURCE TERM : 1.0E-05 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 5.5E-03 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 1.5E-04 uCi/m^2	DEP = 4.0E-05 uCi/m^2	DEP = 7.3E-06 uCi/m^2
CHI = 1.5E-08 (Ci-s)/m^3	CHI = 4.0E-09 (Ci-s)/m^3	CHI = 7.3E-10 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.7E-02 rem	LUNG 4.6E-03 rem	LUNG 8.5E-04 rem
SURFACE BONE 9.4E-02 rem	SURFACE BONE 2.5E-02 rem	SURFACE BONE 4.6E-03 rem
RED MARROW 7.4E-03 rem	RED MARROW 2.0E-03 rem	RED MARROW 3.6E-04 rem
EFFECTIVE DOSE EQUIVALENT 5.4E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.5E-03 rem	EFFECTIVE DOSE EQUIVALENT 2.7E-04 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 2.2E-06 uCi/m^2	DEP = 6.9E-07 uCi/m^2	DEP = 1.7E-07 uCi/m^2
CHI = 2.2E-10 (Ci-s)/m^3	CHI = 6.9E-11 (Ci-s)/m^3	CHI = 1.7E-11 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 2.5E-04 rem	LUNG 8.0E-05 rem	LUNG 2.0E-05 rem
SURFACE BONE 1.4E-03 rem	SURFACE BONE 4.4E-04 rem	SURFACE BONE 1.1E-04 rem
RED MARROW 1.1E-04 rem	RED MARROW 3.4E-05 rem	RED MARROW 8.4E-06 rem
EFFECTIVE DOSE EQUIVALENT 8.0E-05 rem	EFFECTIVE DOSE EQUIVALENT 2.5E-05 rem	EFFECTIVE DOSE EQUIVALENT 6.2E-06 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 6.3E-08 uCi/m^2	DEP = 2.4E-08 uCi/m^2	DEP = 7.0E-09 uCi/m^2
CHI = 6.3E-12 (Ci-s)/m^3	CHI = 2.4E-12 (Ci-s)/m^3	CHI = 7.0E-13 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 7.3E-06 rem	LUNG 2.8E-06 rem	LUNG 8.1E-07 rem
SURFACE BONE 4.0E-05 rem	SURFACE BONE 1.5E-05 rem	SURFACE BONE 4.4E-06 rem
RED MARROW 3.1E-06 rem	RED MARROW 1.2E-06 rem	RED MARROW 3.5E-07 rem
EFFECTIVE DOSE EQUIVALENT 2.3E-06 rem	EFFECTIVE DOSE EQUIVALENT 8.8E-07 rem	EFFECTIVE DOSE EQUIVALENT 2.6E-07 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : U-238 Inhalation Class : Y
HalfLife : 4.5E+09 Years
SOURCE TERM : 4.0E-04 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 0.024 rem
Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 5.9E-03 uCi/m^2	DEP = 1.6E-03 uCi/m^2	DEP = 2.9E-04 uCi/m^2
CHI = 5.9E-07 (Ci-s)/m^3	CHI = 1.6E-07 (Ci-s)/m^3	CHI = 2.9E-08 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 2.0E-01 rem	LUNG 5.3E-02 rem	LUNG 9.7E-03 rem
EFFECTIVE DOSE EQUIVALENT 2.4E-02 rem	EFFECTIVE DOSE EQUIVALENT 6.4E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.2E-03 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 8.7E-05 uCi/m^2	DEP = 2.8E-05 uCi/m^2	DEP = 6.7E-06 uCi/m^2
CHI = 8.7E-09 (Ci-s)/m^3	CHI = 2.8E-09 (Ci-s)/m^3	CHI = 6.7E-10 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 2.9E-03 rem	LUNG 9.2E-04 rem	LUNG 2.2E-04 rem
EFFECTIVE DOSE EQUIVALENT 3.5E-04 rem	EFFECTIVE DOSE EQUIVALENT 1.1E-04 rem	EFFECTIVE DOSE EQUIVALENT 2.7E-05 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 2.5E-06 uCi/m^2	DEP = 9.6E-07 uCi/m^2	DEP = 2.8E-07 uCi/m^2
CHI = 2.5E-10 (Ci-s)/m^3	CHI = 9.6E-11 (Ci-s)/m^3	CHI = 2.8E-11 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 8.4E-05 rem	LUNG 3.2E-05 rem	LUNG 9.3E-06 rem
EFFECTIVE DOSE EQUIVALENT 1.0E-05 rem	EFFECTIVE DOSE EQUIVALENT 3.8E-06 rem	EFFECTIVE DOSE EQUIVALENT 1.1E-06 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : PU-239 Inhalation Class : Y
HalfLife : 2.4E+04 Years
SOURCE TERM : 5.0E-05 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 8.2E-03 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 7.4E-04 uCi/m^2	DEP = 2.0E-04 uCi/m^2	DEP = 3.7E-05 uCi/m^2
CHI = 7.4E-08 (Ci-s)/m^3	CHI = 2.0E-08 (Ci-s)/m^3	CHI = 3.7E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 3.0E-02 rem	LUNG 7.9E-03 rem	LUNG 1.5E-03 rem
SURFACE BONE 8.7E-02 rem	SURFACE BONE 2.3E-02 rem	SURFACE BONE 4.3E-03 rem
RED MARROW 6.9E-03 rem	RED MARROW 1.9E-03 rem	RED MARROW 3.4E-04 rem
LIVER 1.9E-02 rem	LIVER 5.2E-03 rem	LIVER 9.5E-04 rem
EFFECTIVE DOSE EQUIVALENT 8.2E-03 rem	EFFECTIVE DOSE EQUIVALENT 2.2E-03 rem	EFFECTIVE DOSE EQUIVALENT 4.0E-04 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 1.1E-05 uCi/m^2	DEP = 3.5E-06 uCi/m^2	DEP = 8.4E-07 uCi/m^2
CHI = 1.1E-09 (Ci-s)/m^3	CHI = 3.5E-10 (Ci-s)/m^3	CHI = 8.4E-11 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 4.3E-04 rem	LUNG 1.4E-04 rem	LUNG 3.4E-05 rem
SURFACE BONE 1.3E-03 rem	SURFACE BONE 4.0E-04 rem	SURFACE BONE 9.8E-05 rem
RED MARROW 1.0E-04 rem	RED MARROW 3.2E-05 rem	RED MARROW 7.8E-06 rem
LIVER 2.8E-04 rem	LIVER 9.0E-05 rem	LIVER 2.2E-05 rem
EFFECTIVE DOSE EQUIVALENT 1.2E-04 rem	EFFECTIVE DOSE EQUIVALENT 3.8E-05 rem	EFFECTIVE DOSE EQUIVALENT 9.2E-06 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 3.1E-07 uCi/m^2	DEP = 1.2E-07 uCi/m^2	DEP = 3.5E-08 uCi/m^2
CHI = 3.1E-11 (Ci-s)/m^3	CHI = 1.2E-11 (Ci-s)/m^3	CHI = 3.5E-12 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.3E-05 rem	LUNG 4.8E-06 rem	LUNG 1.4E-06 rem
SURFACE BONE 3.7E-05 rem	SURFACE BONE 1.4E-05 rem	SURFACE BONE 4.1E-06 rem
RED MARROW 2.9E-06 rem	RED MARROW 1.1E-06 rem	RED MARROW 3.3E-07 rem
LIVER 8.2E-06 rem	LIVER 3.1E-06 rem	LIVER 9.1E-07 rem
EFFECTIVE DOSE EQUIVALENT 3.4E-06 rem	EFFECTIVE DOSE EQUIVALENT 1.3E-06 rem	EFFECTIVE DOSE EQUIVALENT 3.8E-07 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : H-3 Inhalation Class : D
HalfLife : 12.350 years
SOURCE TERM : 3.0E+04 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 1.4 rem

Plume Centerline

D = 0.10 km		D = 0.20 km		D = 0.50 km	
DEP = 4.5E+05 uCi/m^2		DEP = 1.2E+05 uCi/m^2		DEP = 2.2E+04 uCi/m^2	
CHI = 4.5E+01 (Ci-s)/m^3		CHI = 1.2E+01 (Ci-s)/m^3		CHI = 2.2E+00 (Ci-s)/m^3	
50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
SKIN	1.4E+00 rem	SKIN	3.8E-01 rem	SKIN	6.9E-02 rem
THYROID	1.4E+00 rem	THYROID	3.8E-01 rem	THYROID	6.9E-02 rem
LUNG	1.4E+00 rem	LUNG	3.8E-01 rem	LUNG	6.9E-02 rem
SURFACE BONE	1.4E+00 rem	SURFACE BONE	3.8E-01 rem	SURFACE BONE	6.9E-02 rem
LIVER	1.4E+00 rem	LIVER	3.8E-01 rem	LIVER	6.9E-02 rem
SPLEEN	1.4E+00 rem	SPLEEN	3.8E-01 rem	SPLEEN	6.9E-02 rem
GONADS	1.4E+00 rem	GONADS	3.8E-01 rem	GONADS	6.9E-02 rem
EFFECTIVE DOSE EQUIVALENT	1.4E+00 rem	EFFECTIVE DOSE EQUIVALENT	3.8E-01 rem	EFFECTIVE DOSE EQUIVALENT	6.9E-02 rem

Plume Centerline

D = 1.00 km		D = 2.00 km		D = 5.00 km	
DEP = 6.5E+03 uCi/m^2		DEP = 2.1E+03 uCi/m^2		DEP = 5.0E+02 uCi/m^2	
CHI = 6.5E-01 (Ci-s)/m^3		CHI = 2.1E-01 (Ci-s)/m^3		CHI = 5.0E-02 (Ci-s)/m^3	
50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
SKIN	2.1E-02 rem	SKIN	6.6E-03 rem	SKIN	1.6E-03 rem
THYROID	2.1E-02 rem	THYROID	6.6E-03 rem	THYROID	1.6E-03 rem
LUNG	2.1E-02 rem	LUNG	6.6E-03 rem	LUNG	1.6E-03 rem
SURFACE BONE	2.1E-02 rem	SURFACE BONE	6.6E-03 rem	SURFACE BONE	1.6E-03 rem
LIVER	2.1E-02 rem	LIVER	6.6E-03 rem	LIVER	1.6E-03 rem
SPLEEN	2.1E-02 rem	SPLEEN	6.6E-03 rem	SPLEEN	1.6E-03 rem
GONADS	2.1E-02 rem	GONADS	6.6E-03 rem	GONADS	1.6E-03 rem
EFFECTIVE DOSE EQUIVALENT	2.1E-02 rem	EFFECTIVE DOSE EQUIVALENT	6.6E-03 rem	EFFECTIVE DOSE EQUIVALENT	1.6E-03 rem

Plume Centerline

D = 10.00 km		D = 20.00 km		D = 50.00 km	
DEP = 1.9E+02 uCi/m^2		DEP = 7.2E+01 uCi/m^2		DEP = 2.1E+01 uCi/m^2	
CHI = 1.9E-02 (Ci-s)/m^3		CHI = 7.2E-03 (Ci-s)/m^3		CHI = 2.1E-03 (Ci-s)/m^3	
50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
SKIN	6.0E-04 rem	SKIN	2.3E-04 rem	SKIN	6.6E-05 rem
THYROID	6.0E-04 rem	THYROID	2.3E-04 rem	THYROID	6.6E-05 rem
LUNG	6.0E-04 rem	LUNG	2.3E-04 rem	LUNG	6.6E-05 rem
SURFACE BONE	6.0E-04 rem	SURFACE BONE	2.3E-04 rem	SURFACE BONE	6.6E-05 rem
LIVER	6.0E-04 rem	LIVER	2.3E-04 rem	LIVER	6.6E-05 rem
SPLEEN	6.0E-04 rem	SPLEEN	2.3E-04 rem	SPLEEN	6.6E-05 rem
GONADS	6.0E-04 rem	GONADS	2.3E-04 rem	GONADS	6.6E-05 rem
EFFECTIVE DOSE EQUIVALENT	6.0E-04 rem	EFFECTIVE DOSE EQUIVALENT	2.3E-04 rem	EFFECTIVE DOSE EQUIVALENT	6.6E-05 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : C-14 Inhalation Class : D
HalfLife : 5.7E+03 Years
SOURCE TERM : 1.4E+02 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 0.146 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 2.1E+03 uCi/m^2	DEP = 5.6E+02 uCi/m^2	DEP = 1.0E+02 uCi/m^2
CHI = 2.1E-01 (Ci-s)/m^3	CHI = 5.6E-02 (Ci-s)/m^3	CHI = 1.0E-02 (Ci-s)/m^3

50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
THYROID	1.5E-01 rem	THYROID	3.9E-02 rem	THYROID	7.1E-03 rem
LUNG	1.5E-01 rem	LUNG	3.9E-02 rem	LUNG	7.1E-03 rem
SURFACE BONE	1.5E-01 rem	SURFACE BONE	3.9E-02 rem	SURFACE BONE	7.1E-03 rem
RED MARROW	1.5E-01 rem	RED MARROW	3.9E-02 rem	RED MARROW	7.1E-03 rem
GONADS	1.5E-01 rem	GONADS	3.9E-02 rem	GONADS	7.1E-03 rem
EFFECTIVE DOSE EQUIVALENT	1.5E-01 rem	EFFECTIVE DOSE EQUIVALENT	3.9E-02 rem	EFFECTIVE DOSE EQUIVALENT	7.1E-03 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 3.0E+01 uCi/m^2	DEP = 9.7E+00 uCi/m^2	DEP = 2.4E+00 uCi/m^2
CHI = 3.0E-03 (Ci-s)/m^3	CHI = 9.7E-04 (Ci-s)/m^3	CHI = 2.4E-04 (Ci-s)/m^3

50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
THYROID	2.1E-03 rem	THYROID	6.8E-04 rem	THYROID	1.6E-04 rem
LUNG	2.1E-03 rem	LUNG	6.8E-04 rem	LUNG	1.6E-04 rem
SURFACE BONE	2.1E-03 rem	SURFACE BONE	6.8E-04 rem	SURFACE BONE	1.6E-04 rem
RED MARROW	2.1E-03 rem	RED MARROW	6.8E-04 rem	RED MARROW	1.6E-04 rem
GONADS	2.1E-03 rem	GONADS	6.8E-04 rem	GONADS	1.6E-04 rem
EFFECTIVE DOSE EQUIVALENT	2.1E-03 rem	EFFECTIVE DOSE EQUIVALENT	6.8E-04 rem	EFFECTIVE DOSE EQUIVALENT	1.6E-04 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 8.8E-01 uCi/m^2	DEP = 3.4E-01 uCi/m^2	DEP = 9.8E-02 uCi/m^2
CHI = 8.8E-05 (Ci-s)/m^3	CHI = 3.4E-05 (Ci-s)/m^3	CHI = 9.8E-06 (Ci-s)/m^3

50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:		50-YR DOSE COMMITMENT:	
THYROID	6.1E-05 rem	THYROID	2.3E-05 rem	THYROID	6.8E-06 rem
LUNG	6.1E-05 rem	LUNG	2.3E-05 rem	LUNG	6.8E-06 rem
SURFACE BONE	6.1E-05 rem	SURFACE BONE	2.3E-05 rem	SURFACE BONE	6.8E-06 rem
RED MARROW	6.1E-05 rem	RED MARROW	2.3E-05 rem	RED MARROW	6.8E-06 rem
GONADS	6.1E-05 rem	GONADS	2.3E-05 rem	GONADS	6.8E-06 rem
EFFECTIVE DOSE EQUIVALENT	6.1E-05 rem	EFFECTIVE DOSE EQUIVALENT	2.3E-05 rem	EFFECTIVE DOSE EQUIVALENT	6.8E-06 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : CO-60 Inhalation Class : Y
HalfLife : 5.271 years
SOURCE TERM : 1.9E+01 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 1.4 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 2.8E+02 uCi/m^2	DEP = 7.6E+01 uCi/m^2	DEP = 1.4E+01 uCi/m^2
CHI = 2.8E-02 (Ci-s)/m^3	CHI = 7.6E-03 (Ci-s)/m^3	CHI = 1.4E-03 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.2E+01 rem	LUNG 3.3E+00 rem	LUNG 6.0E-01 rem
EFFECTIVE DOSE EQUIVALENT 1.4E+00 rem	EFFECTIVE DOSE EQUIVALENT 3.8E-01 rem	EFFECTIVE DOSE EQUIVALENT 6.9E-02 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 4.1E+00 uCi/m^2	DEP = 1.3E+00 uCi/m^2	DEP = 3.2E-01 uCi/m^2
CHI = 4.1E-04 (Ci-s)/m^3	CHI = 1.3E-04 (Ci-s)/m^3	CHI = 3.2E-05 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.8E-01 rem	LUNG 5.7E-02 rem	LUNG 1.4E-02 rem
EFFECTIVE DOSE EQUIVALENT 2.1E-02 rem	EFFECTIVE DOSE EQUIVALENT 6.6E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.6E-03 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.2E-01 uCi/m^2	DEP = 4.6E-02 uCi/m^2	DEP = 1.3E-02 uCi/m^2
CHI = 1.2E-05 (Ci-s)/m^3	CHI = 4.6E-06 (Ci-s)/m^3	CHI = 1.3E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 5.2E-03 rem	LUNG 2.0E-03 rem	LUNG 5.7E-04 rem
EFFECTIVE DOSE EQUIVALENT 6.0E-04 rem	EFFECTIVE DOSE EQUIVALENT 2.3E-04 rem	EFFECTIVE DOSE EQUIVALENT 6.6E-05 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : SR-90 Inhalation Class : Y
HalfLife : 29.120 years
SOURCE TERM : 2.2E+00 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 1.4 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 3.3E+01 uCi/m^2	DEP = 8.7E+00 uCi/m^2	DEP = 1.6E+00 uCi/m^2
CHI = 3.3E-03 (Ci-s)/m^3	CHI = 8.7E-04 (Ci-s)/m^3	CHI = 1.6E-04 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.2E+01 rem	LUNG 3.2E+00 rem	LUNG 5.9E-01 rem
EFFECTIVE DOSE EQUIVALENT 1.4E+00 rem	EFFECTIVE DOSE EQUIVALENT 3.8E-01 rem	EFFECTIVE DOSE EQUIVALENT 7.0E-02 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 4.8E-01 uCi/m^2	DEP = 1.5E-01 uCi/m^2	DEP = 3.7E-02 uCi/m^2
CHI = 4.8E-05 (Ci-s)/m^3	CHI = 1.5E-05 (Ci-s)/m^3	CHI = 3.7E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.8E-01 rem	LUNG 5.6E-02 rem	LUNG 1.4E-02 rem
EFFECTIVE DOSE EQUIVALENT 2.1E-02 rem	EFFECTIVE DOSE EQUIVALENT 6.6E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.6E-03 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.4E-02 uCi/m^2	DEP = 5.3E-03 uCi/m^2	DEP = 1.5E-03 uCi/m^2
CHI = 1.4E-06 (Ci-s)/m^3	CHI = 5.3E-07 (Ci-s)/m^3	CHI = 1.5E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 5.1E-03 rem	LUNG 1.9E-03 rem	LUNG 5.6E-04 rem
EFFECTIVE DOSE EQUIVALENT 6.0E-04 rem	EFFECTIVE DOSE EQUIVALENT 2.3E-04 rem	EFFECTIVE DOSE EQUIVALENT 6.7E-05 rem

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 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  I-125 Inhalation Class : D
 HalfLife     : 60.182 days
SOURCE TERM       :  1.3E+02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >    1.5 rem
Plume Centerline

D  =  0.10 km             D  =  0.20 km             D  =  0.50 km
DEP =  1.9E+03 uCi/m^2    DEP =  5.0E+02 uCi/m^2    DEP =  9.1E+01 uCi/m^2
CHI =  1.9E-01 (Ci-s)/m^3 CHI =  5.0E-02 (Ci-s)/m^3 CHI =  9.1E-03 (Ci-s)/m^3

50-YR DOSE COMMITMENT:    50-YR DOSE COMMITMENT:    50-YR DOSE COMMITMENT:
--------------------      --------------------      --------------------
THYROID       5.0E+01 rem THYROID       1.3E+01 rem THYROID       2.5E+00 rem
EFFECTIVE DOSE            EFFECTIVE DOSE            EFFECTIVE DOSE
EQUIVALENT    1.5E+00 rem EQUIVALENT    4.0E-01 rem EQUIVALENT    7.3E-02 rem

Plume Centerline

D  =  1.00 km             D  =  2.00 km             D  =  5.00 km
DEP =  2.7E+01 uCi/m^2    DEP =  8.6E+00 uCi/m^2    DEP =  2.1E+00 uCi/m^2
CHI =  2.7E-03 (Ci-s)/m^3 CHI =  8.6E-04 (Ci-s)/m^3 CHI =  2.1E-04 (Ci-s)/m^3

50-YR DOSE COMMITMENT:    50-YR DOSE COMMITMENT:    50-YR DOSE COMMITMENT:
--------------------      --------------------      --------------------
THYROID       7.3E-01 rem THYROID       2.3E-01 rem THYROID       5.7E-02 rem
EFFECTIVE DOSE            EFFECTIVE DOSE            EFFECTIVE DOSE
EQUIVALENT    2.2E-02 rem EQUIVALENT    6.9E-03 rem EQUIVALENT    1.7E-03 rem

Plume Centerline

D  = 10.00 km             D  = 20.00 km             D  = 50.00 km
DEP =  7.8E-01 uCi/m^2    DEP =  3.0E-01 uCi/m^2    DEP =  8.7E-02 uCi/m^2
CHI =  7.8E-05 (Ci-s)/m^3 CHI =  3.0E-05 (Ci-s)/m^3 CHI =  8.7E-06 (Ci-s)/m^3

50-YR DOSE COMMITMENT:    50-YR DOSE COMMITMENT:    50-YR DOSE COMMITMENT:
--------------------      --------------------      --------------------
THYROID       2.1E-02 rem THYROID       8.1E-03 rem THYROID       2.4E-03 rem
EFFECTIVE DOSE            EFFECTIVE DOSE            EFFECTIVE DOSE
EQUIVALENT    6.3E-04 rem EQUIVALENT    2.4E-04 rem EQUIVALENT    7.0E-05 rem
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HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : TH-232 Inhalation Class : Y
HalfLife : 1.4E+10 Years
SOURCE TERM : 1.8E-03 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 0.981 rem

Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 2.7E-02 uCi/m^2	DEP = 7.2E-03 uCi/m^2	DEP = 1.3E-03 uCi/m^2
CHI = 2.7E-06 (Ci-s)/m^3	CHI = 7.2E-07 (Ci-s)/m^3	CHI = 1.3E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 3.1E+00 rem	LUNG 8.3E-01 rem	LUNG 1.5E-01 rem
SURFACE BONE 1.7E+01 rem	SURFACE BONE 4.5E+00 rem	SURFACE BONE 8.3E-01 rem
RED MARROW 1.3E+00 rem	RED MARROW 3.6E-01 rem	RED MARROW 6.6E-02 rem
EFFECTIVE DOSE EQUIVALENT 9.8E-01 rem	EFFECTIVE DOSE EQUIVALENT 2.6E-01 rem	EFFECTIVE DOSE EQUIVALENT 4.8E-02 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 3.9E-04 uCi/m^2	DEP = 1.2E-04 uCi/m^2	DEP = 3.0E-05 uCi/m^2
CHI = 3.9E-08 (Ci-s)/m^3	CHI = 1.2E-08 (Ci-s)/m^3	CHI = 3.0E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 4.6E-02 rem	LUNG 1.4E-02 rem	LUNG 3.5E-03 rem
SURFACE BONE 2.5E-01 rem	SURFACE BONE 7.9E-02 rem	SURFACE BONE 1.9E-02 rem
RED MARROW 2.0E-02 rem	RED MARROW 6.2E-03 rem	RED MARROW 1.5E-03 rem
EFFECTIVE DOSE EQUIVALENT 1.4E-02 rem	EFFECTIVE DOSE EQUIVALENT 4.6E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.1E-03 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.1E-05 uCi/m^2	DEP = 4.3E-06 uCi/m^2	DEP = 1.3E-06 uCi/m^2
CHI = 1.1E-09 (Ci-s)/m^3	CHI = 4.3E-10 (Ci-s)/m^3	CHI = 1.3E-10 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.3E-03 rem	LUNG 5.0E-04 rem	LUNG 1.5E-04 rem
SURFACE BONE 7.1E-03 rem	SURFACE BONE 2.7E-03 rem	SURFACE BONE 8.0E-04 rem
RED MARROW 5.6E-04 rem	RED MARROW 2.2E-04 rem	RED MARROW 6.3E-05 rem
EFFECTIVE DOSE EQUIVALENT 4.1E-04 rem	EFFECTIVE DOSE EQUIVALENT 1.6E-04 rem	EFFECTIVE DOSE EQUIVALENT 4.6E-05 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : U-238 Inhalation Class : Y
HalfLife : 4.5E+09 Years
SOURCE TERM : 2.4E-02 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 1.4 rem
Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 3.6E-01 uCi/m^2	DEP = 9.5E-02 uCi/m^2	DEP = 1.8E-02 uCi/m^2
CHI = 3.6E-05 (Ci-s)/m^3	CHI = 9.5E-06 (Ci-s)/m^3	CHI = 1.8E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.2E+01 rem	LUNG 3.2E+00 rem	LUNG 5.8E-01 rem
EFFECTIVE DOSE EQUIVALENT 1.4E+00 rem	EFFECTIVE DOSE EQUIVALENT 3.8E-01 rem	EFFECTIVE DOSE EQUIVALENT 7.0E-02 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 5.2E-03 uCi/m^2	DEP = 1.7E-03 uCi/m^2	DEP = 4.0E-04 uCi/m^2
CHI = 5.2E-07 (Ci-s)/m^3	CHI = 1.7E-07 (Ci-s)/m^3	CHI = 4.0E-08 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.7E-01 rem	LUNG 5.5E-02 rem	LUNG 1.3E-02 rem
EFFECTIVE DOSE EQUIVALENT 2.1E-02 rem	EFFECTIVE DOSE EQUIVALENT 6.6E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.6E-03 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 1.5E-04 uCi/m^2	DEP = 5.7E-05 uCi/m^2	DEP = 1.7E-05 uCi/m^2
CHI = 1.5E-08 (Ci-s)/m^3	CHI = 5.7E-09 (Ci-s)/m^3	CHI = 1.7E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 5.0E-03 rem	LUNG 1.9E-03 rem	LUNG 5.6E-04 rem
EFFECTIVE DOSE EQUIVALENT 6.0E-04 rem	EFFECTIVE DOSE EQUIVALENT 2.3E-04 rem	EFFECTIVE DOSE EQUIVALENT 6.7E-05 rem

HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE : PU-239 Inhalation Class : Y
HalfLife : 2.4E+04 Years
SOURCE TERM : 5.6E-03 Ci
RELEASE FRACTION : 1.0E+00
FILTER EFFICIENCY: 0.000000 %
EFFECTIVE RELEASE HEIGHT : 1.00 m
WIND SPEED (h = 2 m) : 4.5 m/s
STABILITY CLASS : D DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 1.0 m INVERSION LAYER HEIGHT : 5000.0 m
SAMPLE TIME : 10.000 min
MAXIMUM DOSE DISTANCE : < 0.10 km MAXIMUM CEDE : > 0.916 rem
Plume Centerline

D = 0.10 km	D = 0.20 km	D = 0.50 km
DEP = 8.3E-02 uCi/m^2	DEP = 2.2E-02 uCi/m^2	DEP = 4.1E-03 uCi/m^2
CHI = 8.3E-06 (Ci-s)/m^3	CHI = 2.2E-06 (Ci-s)/m^3	CHI = 4.1E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 3.3E+00 rem	LUNG 8.9E-01 rem	LUNG 1.6E-01 rem
SURFACE BONE 9.7E+00 rem	SURFACE BONE 2.6E+00 rem	SURFACE BONE 4.8E-01 rem
RED MARROW 7.8E-01 rem	RED MARROW 2.1E-01 rem	RED MARROW 3.8E-02 rem
LIVER 2.2E+00 rem	LIVER 5.8E-01 rem	LIVER 1.1E-01 rem
EFFECTIVE DOSE EQUIVALENT 9.1E-01 rem	EFFECTIVE DOSE EQUIVALENT 2.4E-01 rem	EFFECTIVE DOSE EQUIVALENT 4.5E-02 rem

Plume Centerline

D = 1.00 km	D = 2.00 km	D = 5.00 km
DEP = 1.2E-03 uCi/m^2	DEP = 3.9E-04 uCi/m^2	DEP = 9.4E-05 uCi/m^2
CHI = 1.2E-07 (Ci-s)/m^3	CHI = 3.9E-08 (Ci-s)/m^3	CHI = 9.4E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 4.9E-02 rem	LUNG 1.5E-02 rem	LUNG 3.8E-03 rem
SURFACE BONE 1.4E-01 rem	SURFACE BONE 4.5E-02 rem	SURFACE BONE 1.1E-02 rem
RED MARROW 1.1E-02 rem	RED MARROW 3.6E-03 rem	RED MARROW 8.8E-04 rem
LIVER 3.2E-02 rem	LIVER 1.0E-02 rem	LIVER 2.4E-03 rem
EFFECTIVE DOSE EQUIVALENT 1.3E-02 rem	EFFECTIVE DOSE EQUIVALENT 4.2E-03 rem	EFFECTIVE DOSE EQUIVALENT 1.0E-03 rem

Plume Centerline

D = 10.00 km	D = 20.00 km	D = 50.00 km
DEP = 3.5E-05 uCi/m^2	DEP = 1.3E-05 uCi/m^2	DEP = 3.9E-06 uCi/m^2
CHI = 3.5E-09 (Ci-s)/m^3	CHI = 1.3E-09 (Ci-s)/m^3	CHI = 3.9E-10 (Ci-s)/m^3
50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:	50-YR DOSE COMMITMENT:
LUNG 1.4E-03 rem	LUNG 5.4E-04 rem	LUNG 1.6E-04 rem
SURFACE BONE 4.1E-03 rem	SURFACE BONE 1.6E-03 rem	SURFACE BONE 4.6E-04 rem
RED MARROW 3.3E-04 rem	RED MARROW 1.3E-04 rem	RED MARROW 3.6E-05 rem
LIVER 9.1E-04 rem	LIVER 3.5E-04 rem	LIVER 1.0E-04 rem
EFFECTIVE DOSE EQUIVALENT 3.9E-04 rem	EFFECTIVE DOSE EQUIVALENT 1.5E-04 rem	EFFECTIVE DOSE EQUIVALENT 4.3E-05 rem

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 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  H-3 Inhalation Class : D
 HalfLife     : 12.350 years
SOURCE TERM      :  1.0E+02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE    : >  4.7E-03 rem
D = 0.03 km
DEP =  1.3E+04 uCi/m^2
CHI =  1.3E+00 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááá
SKIN           4.0E-02 rem
THYROID        4.0E-02 rem
LUNG           4.0E-02 rem
SURFACE BONE   4.0E-02 rem
LIVER          4.0E-02 rem
SPLEEN         4.0E-02 rem
GONADS         4.0E-02 rem
EFFECTIVE DOSE
EQUIVALENT     4.0E-02 rem


D = 0.30 km
DEP =  1.9E+02 uCi/m^2
CHI =  1.9E-02 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááá
SKIN           5.9E-04 rem
THYROID        5.9E-04 rem
LUNG           5.9E-04 rem
SURFACE BONE   5.9E-04 rem
LIVER          5.9E-04 rem
SPLEEN         5.9E-04 rem
GONADS         5.9E-04 rem
EFFECTIVE DOSE
EQUIVALENT     5.9E-04 rem


 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  C-14 Inhalation Class : D
 HalfLife     :  5.7E+03 Years
SOURCE TERM      :  4.0E-02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE    : >  4.2E-05 rem
Plume Centerline
```

```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  C-14 Inhalation Class : D
 HalfLife     :  5.7E+03 Years
SOURCE TERM      :  4.0E-02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  4.2E-05 rem
D = 0.03 km
DEP =  5.1E+00 uCi/m^2
CHI =  5.1E-04 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁ
THYROID        3.6E-04 rem
LUNG           3.6E-04 rem
SURFACE BONE   3.6E-04 rem
RED MARROW     3.6E-04 rem
GONADS         3.6E-04 rem
EFFECTIVE DOSE
EQUIVALENT     3.6E-04 rem


D = 0.30 km
DEP =  7.4E-02 uCi/m^2
CHI =  7.4E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁ
THYROID        5.2E-06 rem
LUNG           5.2E-06 rem
SURFACE BONE   5.2E-06 rem
RED MARROW     5.2E-06 rem
GONADS         5.2E-06 rem
EFFECTIVE DOSE
EQUIVALENT     5.2E-06 rem


 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  SR-90 Inhalation Class : Y
 HalfLife     : 29.120 years
SOURCE TERM      :  1.6E-03 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  1.0E-03 rem
D = 0.03 km
DEP =  2.0E-01 uCi/m^2
CHI =  2.0E-05 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁ
LUNG           7.5E-02 rem
EFFECTIVE DOSE
EQUIVALENT     8.9E-03 rem

D = 0.30 km
DEP =  3.0E-03 uCi/m^2
CHI =  3.0E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁ
LUNG           1.1E-03 rem
EFFECTIVE DOSE
EQUIVALENT     1.3E-04 rem
```

```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  CO-60 Inhalation Class : Y
 HalfLife     :  5.271 years
SOURCE TERM       :  2.8E-02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :      1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE    : >  2.1E-03 rem
D = 0.03 km
DEP =  3.6E+00 uCi/m^2
CHI =  3.6E-04 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁ
LUNG           1.5E-01 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-02 rem


D = 0.30 km
DEP =  5.2E-02 uCi/m^2
CHI =  5.2E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁÁ
LUNG           2.3E-03 rem
EFFECTIVE DOSE
EQUIVALENT     2.6E-04 rem
```

```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  I-125 Inhalation Class : D
 HalfLife     : 60.182 days
SOURCE TERM       :  2.5E-02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  3.0E-04 rem
D = 0.03 km
DEP =  3.2E+00 uCi/m^2
CHI =  3.2E-04 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááá
THYROID       8.6E-02 rem
EFFECTIVE DOSE
EQUIVALENT    2.6E-03 rem


D = 0.30 km
DEP =  4.7E-02 uCi/m^2
CHI =  4.7E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááá
THYROID       1.3E-03 rem
EFFECTIVE DOSE
EQUIVALENT    3.7E-05 rem



 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  TH-232 Inhalation Class : Y
 HalfLife     :  1.4E+10 Years
SOURCE TERM       :  1.0E-05 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  5.5E-03 rem
D = 0.03 km
DEP =  1.3E-03 uCi/m^2
CHI =  1.3E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááá
LUNG          1.5E-01 rem
SURFACE BONE  8.1E-01 rem
RED MARROW    6.4E-02 rem
EFFECTIVE DOSE
EQUIVALENT    4.7E-02 rem


D = 0.30 km
DEP =  1.9E-05 uCi/m^2
CHI =  1.9E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááá
LUNG          2.2E-03 rem
SURFACE BONE  1.2E-02 rem
RED MARROW    9.3E-04 rem
EFFECTIVE DOSE
EQUIVALENT    6.8E-04 rem
```

```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  U-238 Inhalation Class : Y
 HalfLife     :  4.5E+09 Years
SOURCE TERM       :  4.0E-04 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  0.024 rem
D = 0.03 km
DEP =  5.1E-02 uCi/m^2
CHI =  5.1E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááááá
LUNG           1.7E+00 rem
EFFECTIVE DOSE
EQUIVALENT     2.0E-01 rem


D = 0.30 km
DEP =  7.4E-04 uCi/m^2
CHI =  7.4E-08 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááááá
LUNG           2.5E-02 rem
EFFECTIVE DOSE
EQUIVALENT     3.0E-03 rem



 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  PU-239 Inhalation Class : Y
 HalfLife     :  2.4E+04 Years
SOURCE TERM       :  5.0E-05 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  8.2E-03 rem
D = 0.03 km
DEP =  6.4E-03 uCi/m^2
CHI =  6.4E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááááá
LUNG           2.6E-01 rem
SURFACE BONE   7.4E-01 rem
RED MARROW     6.0E-02 rem
LIVER          1.7E-01 rem
EFFECTIVE DOSE
EQUIVALENT     7.0E-02 rem

D = 0.30 km
DEP =  9.3E-05 uCi/m^2
CHI =  9.3E-09 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
áááááááááááááááááááááááááá
LUNG           3.7E-03 rem
SURFACE BONE   1.1E-02 rem
RED MARROW     8.7E-04 rem
LIVER          2.4E-03 rem
EFFECTIVE DOSE
EQUIVALENT     1.0E-03 rem
```

```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  H-3 Inhalation Class : D
 HalfLife     : 12.350 years
SOURCE TERM      :  3.0E+04 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >    1.4 rem
D = 0.03 km
DEP =  3.8E+06 uCi/m^2
CHI =  3.8E+02 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
SKIN           1.2E+01 rem
THYROID        1.2E+01 rem
LUNG           1.2E+01 rem
SURFACE BONE   1.2E+01 rem
LIVER          1.2E+01 rem
SPLEEN         1.2E+01 rem
GONADS         1.2E+01 rem
EFFECTIVE DOSE
EQUIVALENT     1.2E+01 rem


D = 0.30 km
DEP =  5.6E+04 uCi/m^2
CHI =  5.6E+00 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
SKIN           1.8E-01 rem
THYROID        1.8E-01 rem
LUNG           1.8E-01 rem
SURFACE BONE   1.8E-01 rem
LIVER          1.8E-01 rem
SPLEEN         1.8E-01 rem
GONADS         1.8E-01 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-01 rem
```

```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  C-14 Inhalation Class : D
 HalfLife     :  5.7E+03 Years
SOURCE TERM       :  1.4E+02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  0.146 rem
D = 0.03 km
DEP =  1.8E+04 uCi/m^2
CHI =  1.8E+00 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
THYROID        1.3E+00 rem
LUNG           1.3E+00 rem
SURFACE BONE   1.3E+00 rem
RED MARROW     1.3E+00 rem
GONADS         1.3E+00 rem
EFFECTIVE DOSE
EQUIVALENT     1.3E+00 rem


D = 0.30 km
DEP =  2.6E+02 uCi/m^2
CHI =  2.6E-02 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
THYROID        1.8E-02 rem
LUNG           1.8E-02 rem
SURFACE BONE   1.8E-02 rem
RED MARROW     1.8E-02 rem
GONADS         1.8E-02 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-02 rem



 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  CO-60 Inhalation Class : Y
 HalfLife     :  5.271 years
SOURCE TERM       :  1.9E+01 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :     1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >    1.4 rem
D = 0.03 km
DEP =  2.4E+03 uCi/m^2
CHI =  2.4E-01 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           1.1E+02 rem
EFFECTIVE DOSE
EQUIVALENT     1.2E+01 rem

D = 0.30 km
DEP =  3.5E+01 uCi/m^2
CHI =  3.5E-03 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           1.5E+00 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-01 rem
```

```
HOTSPOT 5.5 GENERAL PLUME
RADIONUCLIDE :  SR-90 Inhalation Class : Y
HalfLife     : 29.120 years
SOURCE TERM      :  2.2E+00 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :      1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >    1.4 rem
D = 0.03 km
DEP =  2.8E+02 uCi/m^2
CHI =  2.8E-02 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           1.0E+02 rem
EFFECTIVE DOSE
EQUIVALENT     1.2E+01 rem


D = 0.30 km
DEP =  4.1E+00 uCi/m^2
CHI =  4.1E-04 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           1.5E+00 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-01 rem


 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  I-125 Inhalation Class : D
 HalfLife     : 60.182 days
SOURCE TERM      :  1.2E+02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :      1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >    1.4 rem
D = 0.03 km
DEP =  1.5E+04 uCi/m^2
CHI =  1.5E+00 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
THYROID        4.1E+02 rem
EFFECTIVE DOSE
EQUIVALENT     1.2E+01 rem


D = 0.30 km
DEP =  2.2E+02 uCi/m^2
CHI =  2.2E-02 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
THYROID        6.0E+00 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-01 rem
```

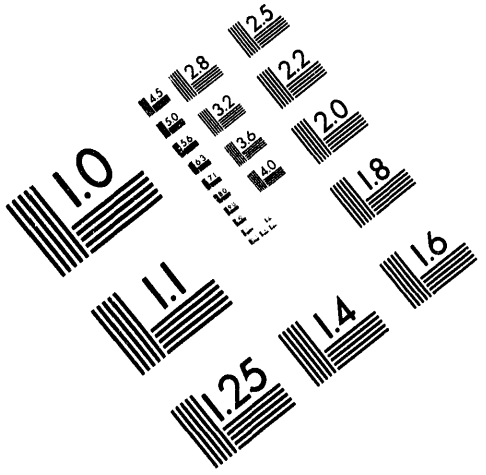
```
 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  TH-232 Inhalation Class : Y
 HalfLife     :  1.4E+10 Years
SOURCE TERM       :  1.8E-03 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :      1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  0.981 rem
D = 0.03 km
DEP =  2.3E-01 uCi/m^2
CHI =  2.3E-05 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           2.7E+01 rem
SURFACE BONE   1.5E+02 rem
RED MARROW     1.1E+01 rem
EFFECTIVE DOSE
EQUIVALENT     8.4E+00 rem


D = 0.30 km
DEP =  3.3E-03 uCi/m^2
CHI =  3.3E-07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           3.9E-01 rem
SURFACE BONE   2.1E+00 rem
RED MARROW     1.7E-01 rem
EFFECTIVE DOSE
EQUIVALENT     1.2E-01 rem



 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  U-238 Inhalation Class : Y
 HalfLife     :  4.5E+09 Years
SOURCE TERM       :  2.4E-02 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :      1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >    1.4 rem
D = 0.03 km
DEP =  3.1E+00 uCi/m^2
CHI =  3.1E-04 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           1.0E+02 rem
EFFECTIVE DOSE
EQUIVALENT     1.2E+01 rem


D = 0.30 km
DEP =  4.5E-02 uCi/m^2
CHI =  4.5E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           1.5E+00 rem
EFFECTIVE DOSE
EQUIVALENT     1.8E-01 rem
```



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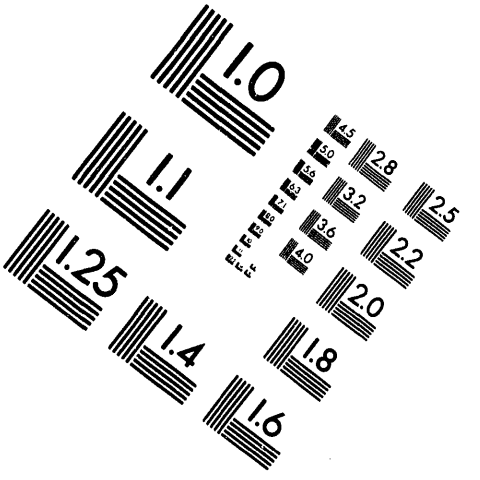

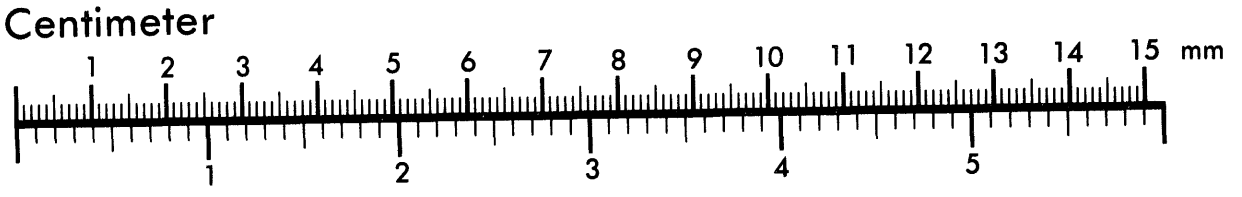

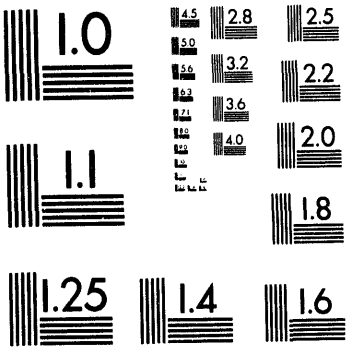

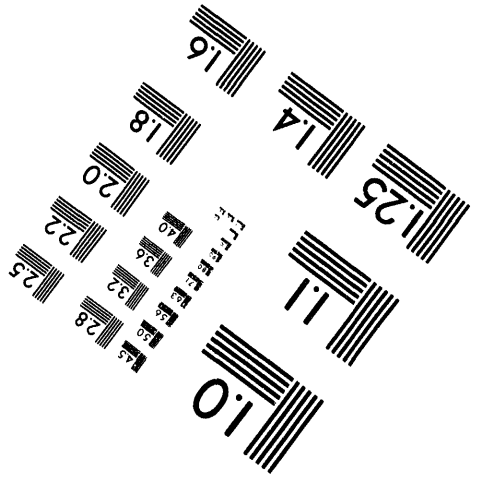

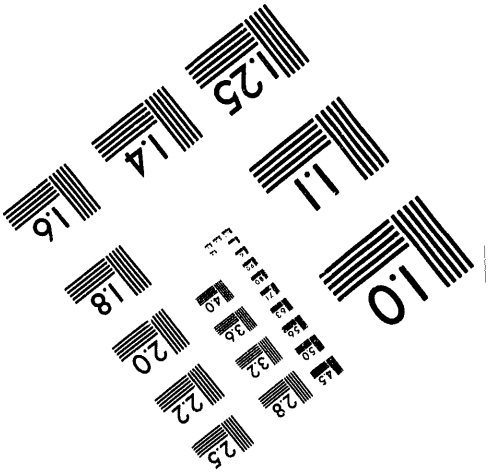

2 of 2

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 HOTSPOT 5.5 GENERAL PLUME
 RADIONUCLIDE :  PU-239 Inhalation Class : Y
 HalfLife     :  2.4E+04 Years
SOURCE TERM       :  5.6E-03 Ci
RELEASE FRACTION :  1.0E+00
FILTER EFFICIENCY:  0.000000 %
 EFFECTIVE RELEASE HEIGHT :      1.00 m
 WIND SPEED (h = 2 m)     : 4.5 m/s
 STABILITY CLASS          : D   DEPOSITION VELOCITY      :   1.00 cm/s
 RECEPTOR HEIGHT          : 1.0 m    INVERSION LAYER HEIGHT   : 5000.0 m
 SAMPLE TIME              :   10.000 min
 MAXIMUM DOSE DISTANCE    : <   0.10 km    MAXIMUM CEDE   : >  0.916 rem
D = 0.03 km
DEP =  7.2E-01 uCi/m^2
CHI =  7.2E-05 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           2.9E+01 rem
SURFACE BONE   8.3E+01 rem
RED MARROW     6.7E+00 rem
LIVER          1.9E+01 rem
EFFECTIVE DOSE
EQUIVALENT     7.9E+00 rem


D = 0.30 km
DEP =  1.0E-02 uCi/m^2
CHI =  1.0E-06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:
ááááááááááááááááááááááááá
LUNG           4.2E-01 rem
SURFACE BONE   1.2E+00 rem
RED MARROW     9.7E-02 rem
LIVER          2.7E-01 rem
EFFECTIVE DOSE
EQUIVALENT     1.1E-01 rem
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APPENDIX B

CHEMICAL DATA

CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Acetaldehyde*	Liquid	0.001	180			270	18300
Acetone	Liquid	0.5				2380	48000
Acetone cyanohydrin**	Liquid	0.001			12		
Acetone thiosemicarbazide**	Solid	0.001			1000		
Acetonitrile**	Liquid	0.001	67			101	6840
Acrolein*	Liquid	0.001		7	1.1	0.69	11.7
Acrylamide**	Solid	0.001	0.03		110		
Acrylonitrile**	Liquid	0.001	4.3		110		1105
Acrylyl chloride**	Liquid	0.5			0.9		
Adiponitrile**	Liquid	0.001			17		
Aldicarb**	Solid	0.001			0.3		
Aldrin**	Solid	0.001	0.25		10		100
Allyl alcohol**	Liquid	0.001	4.8		36	9.5	363
Allyl chloride*	Liquid	0.001	3			6	954
Allylamine*	Liquid	0.5			3.2		
Alkylaluminums*	Liquid	0.001	2				
Aluminun phosphide**	Solid	0.001			20		
Aminopterin**	Solid	0.001			25		
Amiton**	Liquid	0.001			3.3		
Amiton Oxalate**	Solid	0.001			3		
Ammonia, anhydrous*	Gas	1		710	35	24	355
Ammonia solutions (>44% Wt)*	Liquid	0.5	17		35	24	355
Ammonium perchlorate*	Solid	0.001					
Ammonium permanganate*	Solid	0.001				5	
Amphetamine**	Liquid	0.001			20		
Aniline**	Liquid	0.001	7.6		38		387
Aniline, 2,4,6-trimethyl**	Liquid	0.001			2.9		
Antimony	Solid	0.001	0.5				80
Antimony pentafluoride**	Liquid	0.001	0.5		2.7		80
Antimycin A**	Liquid	0.001			1.8		
ANTU**	Solid	0.001	0.3		10		100
Aroclor 1254 (PCB)	Liquid	0.001	0.5				5
Arsenic	Solid	0.001	0.01		0.002		100
Arsenic pentoxide**	Solid	0.001			8		
Arsenous oxide**	Solid	0.001			1.4		
Arsenous trichloride**	Solid	0.001			10		
Arsine*	Gas	1			1.9		19.4
Azinphos-ethyl**	Solid	0.001			3.9		
Azinphos-methyl**	Solid	0.001	2		0.7	5	
Barium	Solid	0.001	0.5				1100
Benzene	Liquid	0.001	32		28		9750
Benzenamine, 3-(trifluoromethyl)**	Liquid	0.001			4.4		
Benzene, 1-(chloromethyl)-4-nitro**	Solid	0.001			28		
Benzenearsonic acid**	Solid	0.001			0.27		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Benzimidazole, 4,5-dichloro-2-(trfluoromethyl)**	Solid	0.001			13		
Benzotrichloride**	Liquid	0.001			0.7		
Benzyl chloride**	Liquid	0.001	5.2		5.2		52.6
Benzyl cyanide**	Liquid	0.001			4.3		
Beryllium	Solid	0.001	0.002				10
Bis (chloromethyl) ether BCME*	Liquid	0.001	0.0047		0.25		
Bis (chloromethyl) ketone**	Solid	0.001	0.66		0.27		
Bitoscanate**	Solid	0.001			20		
Boron trichloride*	Gas	1			10		
Boron trifluoride*	Gas	1			28		282
Bromine*	Liquid	0.5	0.66		6.5	2	66.4
Bromine chloride*							
Bromine pentafluoride*	Liquid	0.5	0.72				
Bromine trifluoride*	Liquid	0.5					24.9
Bromadiolone *	Solid	0.001					
Bromoform	Liquid	0.001	5.2				
Butyl hydroperoxide*							
Butyl perbenzoate*							
Cadmium	Solid	0.001	0.005				50
Cadmium oxide**	Solid	0.001	0.005		4		50
Cadmium chloride	Solid	0.001	0.002		0.01		
Cadmium stearate**	Solid	0.001			1.3		
Calcium arsenate**	Solid	0.001			10		
Camphechlor**	Solid	0.001			20		
Cantharidin**	Solid	0.001			4.3		
Carbachol chloride**	Solid	0.001			15		
Carbofuran**	Solid	0.001	0.1		0.43		
Carbon disulfide**	Liquid	0.001	31		160		1580
Carbon tetrachloride	Liquid	0.001	12.6				2817
Carbophenothion**	Liquid	0.001			6.8		
Chlordane**	Liquid	0.001	0.5		50		500
Chlorfenvinfos**	Liquid	0.001			10		
Chlorine*	Gas	1		59	7.3	2.9	88.5
Chlorine dioxide*	Gas	1	0.28			0.83	28
Chlorine pentrafluoride*	Gas	1	2.5				
Chlorine trifluoride*	Gas	1	0.38				77
Chloroacetaldehyde	Liquid	0.001			69		326
Chlormephos**	Liquid	0.001			7		
Chlormequat chloride**	Solid	0.001			7		
Chloroacetic acid**	Solid	0.001			1.8		
Chlorobenzene	Liquid	0.001	46				11232
Chlorodiethylaluminum*	Liquid	0.001	2				
1-Chloro-2,4-dinitrobenzene*	Solid	0.001					
Chloroethanol**	Liquid	0.001			3.3		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Chloroethyl chloroformate**	Liquid	0.001			20		
Chloroform**	Liquid	0.001	9.78				4960
Chloromethane	Gas	1	1030				
Chloromethyl ether**	Liquid	0.001	0.005		0.25		
Chloromethyl methyl ether*	Liquid	0.001			1.8	3.35	
Chlorophacione**	Solid	0.001			1		
Chloropicrin*	Liquid	0.001	0.67	20.5			27.3
Chloropicrin & Methyl bromide*	Liquid	0.001					
Chloropicrin & Methyl chloride*	Liquid	0.001					
Chloroxuron**	Solid	0.001			10		
Chlorothiophos**	Liquid	0.001			7.8		
Chromic chloride**	Solid	0.001			0.05		
Chromium	Solid	0.001	0.5				
Cobalt	Solid	0.001	0.05		2		20
Cobalt carbonyl**	Solid	0.001	0.1		0.27		
Colchicine**	Solid	0.001			0.9		
Copper	Solid	0.001	1				
Coumaphos**	Solid	0.001			3		
Coumatetralyl**	Solid	0.001			16.5		
Cresol, o-**	Solid	0.001	22		110		1125
Crimidine**	Solid	0.001			1.2		
Crotonaldehyde**	Liquid	0.001		145.5	40		1164
Cumene hydroperoxide*	Liquid	0.001					
Cyanide	Gas	1	5				50
Cyanogen*	Liquid	0.001	21				
Cyanogen bromide**	Solid	0.001			44		
Cyanogen chloride*	Gas	1				0.75	
Cyanuric fluoride*	Liquid	0.001	2.5				
Cyanogen iodide**	Solid	0.001			180		
Cyanophos**	Liquid	0.001			25		
Cyanuric fluoride**	Liquid	0.001			0.17		
Cyclohexane	Liquid	0.001	100				35000
Cycloheximide**	Solid	0.001			2		
Cyclohexylamine**	Liquid	0.01	41		160		
Cyclopentane	Liquid	0.5	1720		110		
Decaborane**	Solid	0.001	0.25		10	0.75	100
Demeton**	Liquid	0.001	0.11		2		20
Demeton-S-methyl**	Liquid	0.001			5		
Diacetyl peroxide*	Liquid	0.001					
Dialifor**	Solid	0.001			5		
Diazomethane*	Gas	1	0.34				35
Dibenzoyl peroxide*	Solid	0.001	5				
Diborane*	Gas	1			5		46
Dibutyl peroxide*							

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Dichloro Acetylene*	Liquid	0.001				0.39	
1,2-Dichlorobenzene	Liquid	0.001	301			675	6110
1,1-Dichloroethane	Liquid	0.001	400			1010	16,480
1,2-Dichloroethane	Liquid	0.001	4			8	4110
1,1-Dichloroethylene	Liquid	0.001	20			79	
1,2-Dichloroethylene	Liquid	0.001	790				16120
1,2-Dichloropropane	Liquid	0.001	347			508	9400
Cis 1,3-Dichloropropene	Liquid	0.001	4.5				
Trans 1,3-Dichloropropene	Liquid	0.001	4.5				
Dichloroethyl ether	Liquid	0.001	29		150	58	1485
Dichloromethylphenylsilane**	Liquid	0.001			20		
Dichlorosilane*							
Dichlorvos	Liquid	0.001	0.9		20		200
Dicrotophos	Liquid	0.001	0.25		0.9		
Diepoxybutane**	Liquid	0.001			3.5		
Diethyl chlorophosphate**	Liquid	0.001			8		
Diethylcarbamazine citrate**	Solid	0.001			3		
Diethylzinc*	Liquid	0.001					
Digitoxin**	Solid	0.001			0.18		
Diglycidyl ether**	Liquid	0.001	0.53		45		135.3
Digoxin**	Solid	0.001			0.2		
Diisopropyl peroxydicarbonate*							
Diketene	Liquid	0.001		175			
Dilaluroyl peroxide*							
Dimefox**	Liquid	0.001			1		
Dimethoate**	Solid	0.001			30		
Dimethylamine, anhydrous*	Gas	1	9.2	920		27.6	3740
Dimethyldichlorosilane*	Liquid	0.001					
Dimethylhydrazine, 1,1-*	Liquid	0.01	1.2		12		125
Dimethyl phosphorochloridothioate**	Liquid	0.001			3.2		
Dimethyl sulfate**	Liquid	0.001	0.52		5		52.4
Dimethyldichlorosilane**	Liquid	0.01			3		
Dimethyl-p-phenylenediamine**	Solid	0.001			0.13		
Dimetilan**	Solid	0.001			25		
2,4-Dinitroaniline*	Solid	0.001					
Dinitrocresol**	Solid	0.001	0.2		0.5		5
Dinoseb**	Solid	0.001			4.5		
Dinoterb**	Solid	0.001			25		
Dioxathion**	Liquid	0.001	0.2		3.4		
Diphacinone**	Solid	0.001			0.9		
Disphosphoramide, octamethyl**	Liquid	0.001			0.8		
Disulfoton**	Liquid	0.001	0.1		2		
Dithiazanine iodide**	Solid	0.001			20		
Dithiobiuret**	Solid	0.001			5		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Emetine, dihydrochloride**	Solid	0.001			0.01		
Endosulfan**	Solid	0.001	0.1		0.8		
Endothion**	Solid	0.001			17		
Endrin**	Solid	0.001	0.1		20		2000
Epichlorohydrin**	Liquid	0.001	7.6		38		962
EPN**	Solid	0.001	0.5		5		50
Ergocalciferol**	Solid	0.001			40		
Ergotamine tartrate**	Solid	0.001			10		
Ethanesulfonyl chloride, 2-chloro**	Liquid	0.001			25		
Ethanol, 1,2-dichloro-, acetate**	Liquid	0.001			11		
Ethion**	Liquid	0.001	0.4		13		
Ethoprophos**	Liquid	0.001			26		
Ethylbenzene	Liquid	0.001	434			543	8820
Ethylbis (2-chloroethyl) amine**	Liquid	0.001			7.5		
Ethyl ether	Liquid	0.001	1210			1520	
Ethylene fluorohydrin**	Liquid	0.001			0.07		
Ethyl nitrate*	Liquid	0.001					
Ethylamine*	Gas	1	18				7840
Ethylene dichloride	Liquid	0.001	40		8		4110
Ethylene fluorohydrin*	Liquid	0.001					
Ethylene oxide*	Gas	0.01	1.8		140		1464
Ethylenediamine**	Liquid	0.001	25		490		5000
Ethyleneimine*	Liquid	0.001	0.88		4		179
Ethylthiocyanate**	Liquid	0.001			0.2		
Fenamiphos**	Solid	0.001	0.1		0.9		
Fenitrothion**	Liquid	0.001			3.8		
Fensulfothion**	Liquid	0.001	0.1		2		
Fluenetil**	Solid	0.001			6		
Fluorine*	Gas	1			39	3.1	142.8
Fluoroacetamide**	Solid	0.001			5.8		
Fluoroacetic acid**	Solid	0.001			0.47		
Fluoroacetyl chloride**	Liquid	0.001			10		
Fluorouracil**	Solid	0.001			19		
Fonofos**	Liquid	0.001	0.1		1.3		
Formaldehyde*	Gas	1	0.3	30.67	12		36.7
Formaldehyde*	Liquid	0.001	0.3		12	2.5	36.7
Formaldehyde cyanohydrin**	Liquid	0.001			6		
Formetanate hydrochloride**	Solid	0.001			18		
Formic acid	Liquid	0.001	9.4		19		57.3
Formothion**	Liquid	0.001			0.27		
Formparanate**	Solid	0.001			7.2		
Fosthietan**	Liquid	0.001			4.7		
Freon 113	Liquid	0.001	7600			9500	35055
Fuberidazole**	Solid	0.001			3.3		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Furan*	Liquid	0.001			1.2		
Gallium trichloride**	Solid	0.001			32		
Hexachlorobutadiene	Liquid	0.001	0.21	315			
Hexachlorocyclopentadiene**	Liquid	0.001	0.11		0.2		
Hexamethylenediamine, N,N'-dibutyl**	Liquid	0.001			2.2		
Hexachloronapthalene	Solid	0.001	0.2		0.2		2
Hexafluoracetone*	Gas	1	0.68				
Hydrochloric acid, Anhydrous*	Liquid	0.001				7.5	152
Hydrofluoric acid, Anhydrous*	Liquid	0.001	2.5			5	25
Hydrazine**	Liquid	0.001	0.13		10		106.4
Hydrocyanic acid**	Gas	1			5.5		
Hydrogen bromide*	Gas	1				10	168
Hydrogen chloride*	Gas	1		150	15		152
Hydrogen cyanide, Anhydrous*	Liquid	0.5				5	56
Hydrogen fluoride*	Gas	1		43.3	1.6		24.9
Hydrogen peroxide (Conc > 52%)*	Liquid	0.001	1.4		10		105.8
Hydrogen selenide*	Gas	1	0.16		0.66		6.7
Hydrogen sulfide*	Gas	1	14		42	21	426
Hydroquinone**	Solid	0.001	2		20		
Hydroxylamine*	Solid	0.001					
Iron pentacarbonyl*	Liquid	0.001	0.23		0.8	0.45	
Isobenzan**	Solid	0.001			1		
Isobutyl nitrile**	Liquid	0.001			25		
Isocyanic acid, 3,4-dichlorphenyl ester**	Solid	0.001			14		
Isodrin**	Solid	0.001			7		
Isofluorphate**	Liquid	0.001			3.6		
Isophorone diisocyanate**	Solid	0.001	0.045		1.23		
Isopropyl chloroformate**	Liquid	0.001			100		
Isoproplymethylpyrazolyl dimethylcarbamate**	Liquid	0.001			5.6		
Isopropylamine*	Liquid	0.001	12			24	9840
Ketene*	Gas	1	0.86			2.6	
Lactonitrile**	Liquid	0.001			18		
Lead	Solid	0.001	0.05				
Leptophos**	Solid	0.001			30		
Lewisite**	Liquid	0.001			4.7		
Lindane**	Solid	0.001	0.5		100		1000
Lithium hydride**	Solid	0.001	0.025		5		55
Malonitrile**	Solid	0.001			19		
Manganese	Solid	0.001	1			3	
Manganese, tricarbonyl methycyclopentadienyl**	Liquid	0.001	1		0.6	3	
Mechlorethamine**	Liquid	0.001			29		
Mephosfolan**	Liquid	0.001			9		
Mercuric acetate**	Solid	0.001	0.01		24		
Mercuric chloride**	Solid	0.001			30		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Mercuric oxide**	Solid	0.001			16		
Mercurous nitrate	Solid	0.001	0.05		0.1		
Mercury alkyl compounds	Solid	0.001	0.01		30	0.03	
Mercury oxycyanide	Solid	0.001	0.01				
Mercury vapor	Liquid	0.01					28
Methacrolein diacetate**	Liquid	0.001			44		
Methacrylic anhydride**	Liquid	0.001			4.5		
Methacrylaldehyde*	Liquid	0.001					358
Methacrylonitrile**	Liquid	0.001			3		
Methacryloyl chloride*	Liquid	0.001			0.6		
Methacryloyloxyethyl isocyanate*	Liquid	0.001			0.27		
Methamidophos**	Solid	0.001			7.5		
Methanesulfonyl fluoride**	Liquid	0.001			14		
Methyl acrylonitrile*	Liquid	0.001	2.7				
Methanol	Liquid	0.001	262			328	33250
Methidathion**	Solid	0.001			20		
Methiocarb**	Solid	0.001			15		
Methomyl**	Solid	0.001	2.5		10		
Methoxyethylmercuric acetate**	Solid	0.001			25		
Methyl 2-chloroacrylate**	Liquid	0.001			5		
Methylamine, anhydrous*	Gas	1	6.4			19	129
Methyl bromide*	Gas	1	19		780		7900
Methyl chloride*	Gas	1	103			207	21000
Methyl chloroformate*	Liquid	0.001			1.8		
Methyl disulfide	Liquid	0.001			0.1		
Methyl isothiocyanate**	Solid	0.001					
Methyl ethyl ketone	Liquid	0.001	590			885	9000
Methyl ethyl ketone peroxide*	Liquid	0.001				1.5	
Methyl fluoracetate*	Liquid	0.001					
Methyl fluorosulfate*							
Methyl hydrazine*	Liquid	0.001	0.38		0.94		96
Methyl iodide*	Liquid	0.001	10				
Methyl isocyanate*	Liquid	0.5	0.047		4.7		47.4
Methyl mercaptan*	Gas	1	0.98	196	79		800
Methyl phenkapton**	Liquid	0.001			11		
Methyl phosphonic dichloride**	Solid	0.001			1.4		
Methyl thiocyanate**	Liquid	0.001			85		
Methyl vinyl ketone*	Liquid	0.01			0.07		
Methylene chloride	Liquid	0.5	174		3530		17650
Methyltrichlorosilane*	Liquid	0.001			1.8		
Methylmercuric dicyanamide**	Solid	0.001			20		
Methytrichlorosilane**	Liquid	0.001			1.8		
Metolcarb**	Solid	0.001			4.8		
Mevinphos**	Liquid	0.001			4		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Mexacarbate**	Solid	0.001			14		
Mitomycin C**	Solid	0.001			23		
Molybdenum	Solid	0.001	10				
Monocrotophos**	Solid	0.001	0.25		0.63		
Muscimol**	Solid	0.001			17		
Mustard Gas**	Liquid	0.001			1		
Naphthalene	Solid	0.001	50			75	2500
Nickel	Solid	0.001			50		
Nickel carbonyl*	Liquid	0.5	0.12		0.35		49.7
Nicotine**	Liquid	0.001	0.5		3.5		35
Nicotine sulfate**	Solid	0.001			9		
Nitric acid*	Liquid	0.001	5.2		26	10	262
Nitric oxide*	Gas	1			30		125
Nitroaniline*	Solid	0.001	3				300
Nitrobenzene**	Liquid	0.001	5		100		1024
Nitrocyclohexane**	Liquid	0.001			1.5		
Nitromethane*	Liquid	0.001	250				2540
Nitrogen dioxide*	Liq/Gas	1	5.6		9.4	9.4	95.5
Nitrogen oxides (NO, N2O4, N2O3)*	Gas	1	30				125
Nitrogen trifluoride*	Gas	1	29		29		5900
Nitropropane-2	Liquid	0.001	36				8510
Nitrosodimethylamine**	Liquid	0.001			19		
Norbormide**	Solid	0.001			3.8		
Oleum*	Liquid	0.001	1		8	3	80
Osmium tetroxide*	Solid	0.001	1.6		0.1	0.0047	1
Ouabain**	Solid	0.001			8.3		
Oxamyl**	Solid	0.001			1.7		
Oxetane, 3,3-bis (chloromethyl)**	Liquid	0.001			2		
Oxydisulfoton**	Liquid	0.001			3.5		
Oxygen difluoride*	Gas	1	0.11				1.12
Ozone*	Gas	1	0.22		2	0.6	20
P-dichlorobenzene	Solid	0.001	451			661	6000
Paraquat**	Solid	0.001	0.1		0.15		1.5
Paraquat methosulfate**	Solid	0.001			0.5		
Parathion**	Liquid	0.001	0.1		2		20
Parathion methyl**	Solid	0.001			0.34		
Paris Green**	Solid	0.001			22		
Pentaborane*	Liquid	0.01	0.013		0.8	0.039	7.9
Pentadecylamine**	Solid	0.001			2		
Peracetic acid*	Liquid	0.001			4.5		
Perchloric acid*	Liquid	0.001					
Perchloromethyl mercaptan*	Liquid	0.001	0.76		7.6		77.3
Perchloryl fluoride*	Gas	1	13			25	1582
Perfluoroisobutylene	Gas	1		2.46			

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Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Peroxyacetic acid*	Liquid	0.001			4.5		
Phenol**	Solid	0.001	19		39		960
Phenol, 2,2'-thiobis (4-chloro-6-methyl)**	Solid	0.001			1.3		
Phenol, 3- (1-methylethyl)-, methylcarbamate**	Solid	0.001			16		
Phenoxarsine, 10,10'-oxydi**	Solid	0.001			14		
Phenyl dichloroarsine**	Liquid	0.001			4		
Phenylhydrazine hydrochloride**	Solid	0.001			250		
Phenylmercury acetate**	Solid	0.001			22		
Phenylsilitrane**	Solid	0.001			1		
Phenylthiourma**	Solid	0.001			3		
Phorate**	Liquid	0.001	0.05		0.1	0.2	
Phosacetim**	Solid	0.001			3.7		
Phosfolan**	Solid	0.001			9		
Phosgene*	Gas	1	0.4	4	0.8		8.2
Phosmet**	Solid	0.001			0.54		
Phosphamidon**	Liquid	0.001			0.3		
Phosphine*	Gas	1			28	1.4	282
Phosphoric acid	Liquid	0.001	1			3	10000
Phosphorus**	Solid	0.5	0.1		3		
Phosphorus oxychloride*	Liquid	0.001	0.63		3		
Phosphorus pentachloride**	Solid	0.001	0.85		20		200
Phosphorus pentoxide**	Solid	0.001		100	0.6		
Phosphorus trichloride*	Liquid	0.01	1.1		28	2.8	285.5
Phosphoryl chloride*	Liquid	0.001	0.6				
Physostigmine**	Solid	0.001			4.5		
Physostigmine, salicylate (1:1)**	Solid	0.001			2.5		
Picrotoxin**	Solid	0.001			15		
Piperidine**	Liquid	0.001			22		
Platinum (sol. cpds.)	Solid	0.001					
Platinum metal	Solid	0.001					
Potassium arsenite**	Solid	0.001			14		
Potassium cyanide**	Solid	0.001			5		
Potassium silver cyanide**	Solid	0.001			20		
Promecarb**	Solid	0.001			16		
Propargyl bromide*	Liquid	0.001			0.03		
Propiolactone-beta**	Liquid	0.001	1.5		1.5		
Propionitrile**	Liquid	0.001			3.7		
Propionitrile, 3-chloro**	Liquid	0.001			9		
Propiophenone, 4-amino**	Solid	0.001			5.6		
Propyl chloroformate**	Liquid	0.001			10		
Propyl nitrate*	Liquid	0.001	107			172	8740
Propyleneimine**	Liquid	0.001	4.7		120		1185
Propylene oxide**	Liquid	0.5	48		480		4840
Prothoate**	Solid	0.001			1.7		

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CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Pyrene**	Solid	0.001			1.7		
Pyridine, 2-methyl-5-vinyl**	Liquid	0.001			1.9		
Pyridine, 4-amino**	Solid	0.001			20		
Pyridine, 4-nitro, 1-oxide**	Solid	0.001			80		
Pyriminil**	Solid	0.001			6.2		
Salcomine**	Solid	0.001			39		
Sarin*	Liquid	0.001			0.05		
Selenious acid**	Solid	0.001			250		
Selenium hexafluoride*	Gas	1	0.16				40
Selenium oxychloride**	Liquid	0.001			10		
Semicarbazide hydrochloride**	Solid	0.001			100		
Silane, (4-aminobutyl) diethoxymethyl**	Liquid	0.001			45		
Silver, metal	Solid	0.001	0.1				
Silver, soluble compounds	Solid	0.001	0.01				
Sodium arsenate**	Solid	0.001			130		
Sodium arsenite**	Solid	0.001			10		
Sodium azide**	Solid	0.001			20	0.29	
Sodium cacodylates**	Solid	0.001			4		
Sodium cyanide**	Solid	0.001			5		
Sodium fluoroactate**	Solid	0.001	0.05		0.5	0.15	5
Sodium hydroxide	Liquid	0.001	2				250
Sodium selenate**	Solid	0.001			1.6		
Sodium selenite**	Solid	0.001			2.3		
Sodium tellurite**	Solid	0.001			20		
Stannane, acetoxytriphenyl**	Solid	0.001			20		
Stibine*	Gas	1	0.51				207
Styrene	Liquid	0.001	215			425	21650
Strychnine**	Solid	0.001	0.15		0.3		3
Strychnine sulfate**	Solid	0.001			5		
Sulfotep**	Liquid	0.001	0.2		3.5		
Sulfoxide, 3-chloropropyl octyl**	Liquid	0.001			8		
Sulfur dioxide*	Gas	1		39	26	13	266
Sulfur pentafluoride*	Gas	1				0.1	10.6
Sulfur tetrafluoride*	Gas	1			9.2	0.44	
Sulfur trioxide*	Solid	0.5			3		
Sulfuric acid**	Liquid	0.001	1	30	8	3	80
Sulfuric anhydride*	Solid	0.001					
Tabun**	Liquid	0.001			0.15		
Tellurium**	Solid	0.001	0.1		20		
Tellurium hexafluoride*	Gas	1	0.2		1		10
1,1,2,2-Tetrachloroethane	Liquid	0.001	7				1050
Tetrachloroethylene (Perchloroethylene)	Liquid	0.001	170			1357	3445
TEPP (tetraethyl dithiopyrophosphate)**	Liquid	0.001	0.047		1		10
Terbufos**	Liquid	0.001			1		

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Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Tetraethyl lead**	Liquid	0.001	0.1		4		40
Tetraethyl tin**	Liquid	0.001			7		
Tetrafluorethylene*	Gas	1					
Tetrafluorohydrazine*	Gas	1	29			45	
Tetramethyl lead*	Liquid	0.001	0.15		4		40
Tetranitromethane**	Liquid	0.001			8		
Thallium (sol. cpds.)	Solid	0.001					20
Thallic oxide	Solid	0.001	0.1		2		
Thallous carbonate**	Solid	0.001	0.1		2		
Thallous chloride**	Solid	0.001	0.1		2		
Thallous Malonate**	Solid	0.001			2		
Thallous sulfate**	Solid	0.001	0.1		2		
Thallium sulfate**	Solid	0.001	0.1		2		
Thiocarbazide**	Solid	0.001			100		
Thiofanox**	Solid	0.001			8.5		
Thionazin**	Liquid	0.001			3.5		
Thionyl chloride*	Liquid	0.001				4.9	
Thiophenol**	Liquid	0.001			1.4		
Thiosemicarbazide**	Solid	0.001			9.2		
Thiourea, (2-chlorophenyl)**	Solid	0.001			4.6		
Thiourea, (2-methylphenyl)**	Solid	0.001			50		
Titanium tetrachloride**	Liquid	0.001	0.05		1		
Toluene	Liquid	0.001	377			565	7660
Toluene 2, 4-diisocyanate**	Liquid	0.001	0.036		7	0.14	72.4
Toluene 2,6-diisocyanate**	Liquid	0.001			0.9		
Trans-1,4-dichlorobutane**	Liquid	0.001			4.4		
Triamiphos**	Solid	0.001			10		
Triazofos**	Liquid	0.001			2.8		
Trichloroacetyl chloride**	Liquid	0.001			4.5		
Trichloro (chloromethyl) silane*	Liquid	0.001			0.3		
Trichloro (dichlorophenyl) silane*	Liquid	0.001			8		
Trichloroethylsilane**	Liquid	0.001			3		
1,1,1-Trichloroethane (Methyl chloroform)	Liquid	0.001	1900			2450	5550
1,1,2-Trichloroethane	Liquid	0.001	55				2775
Trichloroethylene (TCE)	Liquid	0.001	269			1080	5460
Trichlorofluoromethane	Liquid	0.001	5620				57100
Trichlorosilane*	Liquid	0.001					
Trifluorochloroethylene*	Gas	1	5				
Trichloronate**	Liquid	0.001			10		
Trichlorophenylsilane**	Liquid	0.001			3.3		
Triethoxysilane**	Liquid	0.001			5		
Trimethylchlorosilane**	Liquid	0.001			50		
Trimethylolpropane phosphite**	Solid	0.001			2.5		
Trimethyltin chloride**	Solid	0.001			20		

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CHEMICAL DATA

Chemical	Physical State	Release Factor	TLV (mg/m3)	ERPG-3 (mg/m3)	LOC (mg/m3)	STEL (mg/m3)	IDLH (mg/m3)
Triphenyltin chloride**	Solid	0.001			20		
Trimethoxysilane*	Liquid	0.001					625
Tris (2-chloroethyl) amine**	Liquid	0.001			0.8		
Valinomycin**	Solid	0.001			2.5		
Vanadium, as V2O5, pentoxide**	Solid	0.001	0.05		7		70
Vinyl acetate monomer**	Liquid	0.01	35		54		
Vinyl chloride	Gas	1	2.6			13	
Warfarin**	Solid	0.001	0.1		20		350
Warfarin sodium**	Solid	0.001			9		
Xylene	Liquid	0.001	435			655	4410
Xylene dichloride**	Solid	0.001			2		
Zinc, ZnO	Solid	0.001	5			10	
Zinc phosphide**	Solid	0.001			12		

* = Contained in Appendix A to 29 CFR 1910.119 , ** = Contained in Appendix A to 40 CFR 355

APPENDIX C

DEFINITIONS FROM AIHA, OSHA, ACGIH, EPA AND NIOSH

AIHA EMERGENCY RESPONSE PLANNING GUIDELINES (ERPGs) FOR ON-SITE AND OFF-SITE EXPOSURES TO ACUTELY HAZARDOUS MATERIALS

The American Industrial Hygiene Association (AIHA) has established ERPGs for 12 compounds. ERPGs are emergency exposure limits based on insignificant, reversible, and irreversible health effects. Three levels of ERPGs have been established by AIHA:

1. ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or without perceiving a clearly defined objectionable odor.

Comment: These exposures are considered to have insignificant health consequences. Off-site airborne concentrations at or below ERPG-1 correspond to low consequence.

2. ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

Comment: On-site airborne (worker) concentrations at 100 or above ERPG-2 correspond to moderate consequences.

3. ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

Comment: Exposures at or above the ERPG-3 level off-site correspond to a high consequence level.

DEFINITIONS FOR AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH

TLV

Threshold limit values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance, or other forms of stress may form the basis for others.

For some substances, e.g., irritant gases, only one category, the TLV-Ceiling, may be relevant. For other substances, either two or three categories may be relevant, depending upon their physiological action. It is important to observe that if any one of these three TLVs is exceeded, a potential hazard from that substance is presumed to exist.

TLV TWA

The Threshold Limit Value-Time Weighed Average is the TWA concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers maybe repeatedly exposed, day after day, without adverse effect.

STEL

A STEL is defined as a 15-minute TWA exposure which should not be exceeded at any time during a work day, even if the eight-hour-TWA is within the TLV. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

DEFINITION FROM NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH

NIOSH

IDLH — The Immediately Dangerous to Life or Health level represents a maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

DEFINITION FROM THE ENVIRONMENTAL PROTECTION AGENCY

EPA/FEMA/DOT

LOC — Level of Concern concentrations are set by EPA/FEMA/DOT in their *Technical Guidance for Hazards Analysis* (EPA 1987) and are defined as those concentrations of an extremely hazardous substance in the air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time. Although this definition is comparable to that for the NIOSH IDLH, with the exception that the EPA indicates the possibility of irreversible health effects above these levels whereas the NIOSH indicates no irreversible health effects below IDLH levels, EPA typically sets LOC concentrations at one-tenth of the IDLH level. Therefore, in some instances, the LOC values may be considered overly conservative.

OSHA DEFINITIONS (29 CFR 1910.1000) FROM AIR CONTAMINANT STANDARDS

Permissible Exposure Limit (PEL): An employee's exposure in any 8-hour work shift of a 40-hour work week, shall not exceed the 8-hour time weighted average given for that material in the Z-1 Table unless otherwise noted; a (C) designation denotes a ceiling limit.

Acceptable Ceiling Concentration: An employee's exposure to a material listed in Table Z-2 shall not exceed at any time during an 8-hour sift the acceptable ceiling concentration limit given for the material, except for a time period, and up to a concentration not exceeding the maximum duration and concentration allowed in the column under "acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift."

Time Weighted Average (TWA) is the employee's average airborne exposure in any 8-hour work shift of a 40- hour work week which shall not be exceeded.

Short-term Exposure Limit (STEL) is the employee's 15-minute time weighted average exposure which shall not be exceeded any time during a work day unless another time limit is specified in parenthetical notation below the limit. If another time period is specified, the time weighted average exposure over that time limit shall not be exceeded at any time during the working day.

Ceiling/"C": An employee's exposure to chemicals preceded by a "C" shall at no time exceed the ceiling value given for that material. A ceiling value is the employee's exposure which shall not be exceeded during any part of the work day. If instantaneous monitoring is not feasible, the ceiling shall be assessed as a 15-minute time-weighed-average exposure which shall not be exceeded at any time over a working day.

DATE
FILMED
9/7/94

END