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INCINERATION OF LOW-LEVEL RADIOACTIVE AND MIXED WASTES:

WASTE HANDLING AND OPERATIONAL ISSUES

Prepared for

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EXECUTIVE SUMMARY

As part of a major effort to bring its facilities into compliance with environmental regulations, the U.S. Department of Energy (DOE) is investigating options for managing low-level radioactive and mixed waste (LLR/MW). The U.S. Environmental Protection Agency (EPA), Office of Radiation and Indoor Air, in collaboration with DOE, Office of Environmental Restoration, is assessing incineration as a treatment alternative for LLR/MW produced during the remediation/restoration of contaminated sites. The overall purpose of this examination is to identify and evaluate the fundamental technical and operational issues associated with the effective, economical, and safe use of incineration for treating both the hazardous and radioactive constituents of these wastes, while minimizing potential risks to human health, welfare, and the environment.

This document represents one component of this effort, focusing on technological and operational issues associated with incineration. Other components of the EPA and DOE effort focus on regulation and policy issues surrounding incineration, waste inventories and incinerator capacity, comparative risks associated with incineration and other treatment technologies, and the feasibility of innovative emission control technologies.

This report presents the results of a survey of DOE and commercial incinerators currently operating or "on stand-by" that may play a role in the treatment of low-level and mixed wastes from remediation and restoration activities. Using this information, the report identifies and discusses current operational and technological issues

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LIST OF EXHIBITS

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ACRONYMS

AEA	Atomic Energy Act of 1954
ANL	Argonne National Laboratory
APC	Air Pollution Control
BDAT	Best Demonstrated Available Technology
BGI	Beta/Gamma Incinerator
BIF	Boiler and Industrial Furnace
CAA	Clean Air Act (1991)
CA	Controlled Air (at LLNL)
CAI	Controlled Air Incinerator (at LANL)
CEM	Continuous Emission Monitor(ing)
CFR	Code of Federal Regulations
CIF	Consolidated Incineration Facility (at SRS)
DAW	Dry Active Waste (DOE)
DHEC	Department of Health and Environmental Control (South Carolina)
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DRE	Destruction Removal Efficiency (RCRA)
DSSI	Diversified Scientific Services, Inc.
DWPF	Defense Waste Processing Facility
DWTF	Decontamination and Waste Treatment Facility
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FBU	Fluidized Bed Unit (at RFP)
FFCA	Federal Facilities Compliance Act of 1992
FRP	Fiber Reinforced Plastic
FTIR	Fourier Transform Infrared (spectroscopy)
GC	Gas Chromatograph(y)
GC-MS	Gas Chromatograph/Mass Spectrograph
HAZWRAP	Hazardous Waste Remediation Action Program
HC	Hydrocarbons
HEPA	High-Efficiency Particulate Air (filter)
HSWA	Hazardous and Solid Waste Amendments of 1984
HWMF	Hazardous Waste Management Facility
HWT&P	Hazardous Waste Treatment and Processing
ICRP	International Commission on Radiological Protection
ID	Induced Draft (fan)
IDLH	Immediately Dangerous to Life and Health
INEL	Idaho National Engineering Laboratory

ACRONYMS (Continued)

INPO	(Incinerator operator training program referenced by Scientific Ecology Group, SEG)
K-25	Area at DOE's Oak Ridge Plant which contains former Gas Diffusion Plant
IWPF	Idaho Waste Processing Facility
LANL	Los Alamos National Laboratory
LDR	Land Disposal Restriction
LHNF	Low-hazard Nuclear Facility
LLD	Lower Limits of Detection
LLNL	Lawrence Livermore National Laboratory
LLR/MW	Low-level Radioactive and Mixed Waste
LLW	Low-level (radioactive) Waste
MPC	Maximum Permissible Concentrations
MW	Mixed Waste (mixture of low-level radioactive and hazardous wastes)
MWSF	Mixed Waste Storage Facility
MWTP	Mixed Waste Treatment Project
NDIR	Nondispersive Infrared
NESHAPS	National Emissions Standards for Hazardous Air Pollutants (CAA)
NOD	Notice Of Deficiency
NPDES	National Pollutant Discharge Effluent Standards (CWA)
NRC	Nuclear Regulatory Commission
NRHW	Non-Radioactive Hazardous Waste
ORIA	Office of Radiation and Indoor Air (EPA)
ORD	Office of Research and Development (EPA)
ORNL	Oak Ridge National Laboratory
ORP	Office of Radiation Protection
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste & Emergency Response (EPA)
OTA	Office of Technology Assessment
PCB	Polychlorinated Biphenyl
PIC	Products of Incomplete Combustion (RCRA/HSWA)
POHC	Principal Organic Hazardous Constituent (RCRA/HSWA)
PREPP	Process Experimental Pilot Plant (at INEL)
PTC	Permit To Construct
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
RMI	Reactive Metal Inc. (former Ohio site of DOE sub-contractor)
SCC	Secondary Combustion Chamber
SEG	Scientific Ecology Group

ACRONYMS (Continued)

SRS	Savannah River Site
SWDA	Solid Waste Disposal Act of 1965
TCC	Tertiary Combustion Chamber
TCLP	Toxicity Characteristic Leaching Procedure (40 CFR 261)
TFE	Tetrafluoroethylene (Teflon)
THC	Total Hydrocarbons
TRU	Transuranic
TSCA	Toxic Substances Control Act
UV	Ultra-violet
WAC	Waste Acceptance Criteria (DOE Order)
WERF	Waste Experimental Reduction Facility (at INEL)
WMIS	DOE Waste Management Information System
WROC	Waste Reduction Operation Complex
WWSB	WERF Waste Storage Building
Y-12	Area at DOE's Oak Ridge Plant

1. INTRODUCTION

In 1989, the U.S. Department of Energy (DOE) launched a major effort to bring its facilities into compliance with environmental regulations. The effort includes both remediation of existing contamination and the proper management of wastes from current operations. Both activities produce low-level radioactive and mixed wastes (LLR/MW) requiring treatment and disposal.

Incineration is an important component of DOE's strategy for managing LLR/MW from these facilities. The U.S. Environmental Protection Agency (EPA), Office of Radiation and Indoor Air (ORIA), in collaboration with DOE, Office of Environmental Restoration, has initiated a study of the incineration of LLR/MW. The overall goal of this joint study is to identify possible improvements in the process of incinerating LLR/MW.

This document, one in a series of reports addressing incineration of LLR/MW at DOE facilities, focuses primarily on technological and operational issues. Specifically, it presents the results of a survey of existing DOE radioactive and mixed waste incinerators and two commercial incinerators handling DOE wastes. The purpose of the survey was to collect data on current treatment systems, waste handling and acceptance criteria, and operational shortcomings and program issues relevant to the use of these incinerators for processing LLR/MW. The survey entailed a literature review, visits to selected locations, and telephone interviews with key personnel. A form was developed to provide a vehicle for obtaining and maintaining information developed in the course of the survey. The model form and individual facility surveys are included in Appendix A.

While this report focuses primarily on technological and operational issues, these issues must be considered in the context of current waste management programs and associated regulations. For this reason, Section 2 provides a summary of DOE's waste management programs and the associated regulatory environment. Section 2.1 gives an overview of waste management at DOE, including DOE's waste management strategy and the role of incineration in that strategy. Section 2.2 describes the regulations applicable to the management of LLR/MW. Section 3.0 describes LLR/MW incinerator operations; it provides a general description of typical operations at a LLR/MW incinerator, an overview of existing incineration systems, and descriptions of waste handling, waste acceptance criteria, and currently operating incinerators. Section 4.0 identifies and discusses current issues associated with the use of incineration in waste management.

2. BACKGROUND

To provide context for the technological and operational issues discussed in later sections, this section presents background information on DOE's waste management programs and the associated regulatory environment.

2.1 DOE WASTE MANAGEMENT

Proper management of DOE's LLR/MW is a very complex task. There is a large number of diverse sites that generate and handle DOE's wastes. Additionally, the wastes themselves are highly varied and subject to a broad array of regulatory requirements.

2.1.1 DOE Sites and Wastes

DOE is responsible for waste management and cleanup at over 100 contaminated facilities in 36 States and territories.[1] These facilities include national laboratories and nuclear weapons production and testing facilities. The extent of contamination at the facilities varies widely, from limited contamination in laboratories to contamination throughout large processing plants and surrounding lands. Several DOE facilities have literally hundreds of areas of contamination that are being investigated and cleaned up separately. For example, DOE's Hanford facility, which encompasses 570 square miles, is divided into about 1,100 individual waste sites containing radioactive and/or hazardous materials. These sites range in size from 1 square foot to 1,800 acres and have been grouped into 78 operable units based on their waste characteristics or other factors.

These sites may contain hazardous wastes, radioactive wastes, and/or mixed wastes. Hazardous waste is regulated under the Resource Conservation and Recovery Act (RCRA), as amended, and radioactive waste is regulated under the Atomic Energy Act (AEA), as amended.[2] Mixed wastes contain both hazardous components regulated under RCRA and radioactive components regulated under AEA.

Hazardous Waste

In developing RCRA, Congress established a two-pronged approach for determining whether a waste is hazardous and therefore subject to RCRA jurisdiction. Under Section 1004 of RCRA, Congress indicated that, before a material can be considered a hazardous waste, it must first meet the definition of a solid waste. In the RCRA regulations, EPA defines a solid waste as a material that is abandoned, recycled, or considered inherently waste-like (40 CFR 261.2). Incinerator ash or by-products that contain toxic constituents, for example, would qualify as a solid waste if they are destined for disposal or considered inherently waste-like (e.g., if they contain toxic constituents identified in §261.2(d)).

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[1] U.S. Department of Energy, Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994 - 1998, January, 1993, p. I-8.

[2] See Federal Facility Compliance Act (FFCA), Section 3021 (b).

Once a material is determined to be a solid waste, it may then be characterized as a hazardous waste. A solid waste is a RCRA hazardous waste if it meets at least one of two conditions: (1) the waste is specifically "listed" in 40 CFR Part 261, Subpart D, or (2) the waste exhibits one of the four characteristics identified in 40 CFR Part 261, Subpart C. These characteristics are toxicity, corrosivity, ignitability, and reactivity. Incinerator ash or by-product would qualify as a hazardous waste, for example, if it exhibited the characteristic of toxicity.[3]

Radioactive Waste

AEA has established authority over the following radioactive materials:

- **Source material**: defined as uranium, thorium, or any other material that is determined pursuant to provisions of AEA to be source material, as well as ores containing one or more of these materials in such concentrations as may be determined;

- **Special nuclear material**: defined as (1) plutonium, uranium enriched in the 233 isotope or in the 235 isotope, and any other material that is determined pursuant to AEA to be special nuclear material but which does not include source material; or (2) any material that is artificially enriched in any of the above, but which does not include source material; and

- **Byproduct Material**: defined as (1) any radioactive material (except special nuclear material) yielded in, or made radioactive by exposure to, the radiation incident to the process of producing or utilizing special nuclear material; and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.

There are also several subclasses of radioactive waste that contain AEA materials. These include:

- **High-level waste:** The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation;

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[3] 40 CFR 261.3(b) specifies that a solid waste that is mixed with a listed hazardous waste, or is mixed with any material and exhibits a characteristic, is a hazardous waste, except under certain conditions. 40 CFR 261.3(c) specifies that a solid waste derived from treatment, storage, or disposal of a hazardous waste is a hazardous waste, except where certain criteria are met. This is particularly relevant to incinerator ash. If the incinerator ash results from the incineration of a listed hazardous waste that is not excluded under §260.20 and 260.22, for example, the ash would be a RCRA hazardous waste. However, materials that are reclaimed from solid waste and used beneficially are not solid waste unless burned for energy recovery or used in a manner constituting disposal.

- **Transuranic (TRU) waste:** Waste that is contaminated with alpha-emitting transuranium nuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram of waste at the time of assay without regard to source or form; and

- **Low-level waste (LLW):** Radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or certain byproduct material.[4]

Mixed Waste

Mixed waste is radioactive waste also listed as hazardous or exhibiting a hazardous characteristic under the RCRA Subtitle C program. The radioactive component of mixed waste is source, special nuclear, or byproduct materials as defined by AEA, which are excluded from regulation under RCRA.

2.1.2 DOE's Waste Management Strategy

DOE is involved in a major effort to bring Department activities into compliance with applicable environmental requirements. The effort involves two major programs: Environmental Restoration (ER) and Waste Operations (WO).[5] Both ER and WO produce and manage LLR/MW. The ER program assesses and remediates facilities contaminated with radioactive, hazardous and mixed wastes generated by past DOE nuclear operations. Most remediation involves contaminated soil or groundwater, and may produce large volumes of contaminated media requiring treatment and disposal.

The goal of DOE's WO program is the safe management and disposal of wastes generated by current DOE operations. Another important objective of the WO program is waste minimization, or reductions in the volume and toxicity of DOE's hazardous, radioactive, mixed and other wastes.[6] Operations wastes are less likely than ER wastes to be in the form of contaminated media.

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[4] See DOE Order 5820.2A.

[5] See DOE's Five Year Plan, cited above, and U.S. Department of Energy, Environmental Restoration and Waste Management (EM) Program, June, 1991.

[6] Pollution prevention is the preferred approach in EPA's "waste management hierarchy," and is the focus of the Pollution Prevention Act of 1990. Recognizing the shift toward pollution prevention as a waste management strategy, DOE has issued several internal orders to promote waste reduction and pollution prevention. In 1990, DOE consolidated these orders in a "Waste Reduction Policy Statement", requiring all DOE program and Field Offices to "institute a waste reduction policy to reduce the total amount of waste that is generated and disposed of by DOE operating facilities through waste minimization (source reduction and recycling) and waste treatment." DOE sees this statement as the first step in the development of a comprehensive Department pollution prevention program. (U.S. Department of Energy, "Pollution Prevention and Waste Minimization", in Environmental Restoration and Waste Management: Information Sheets, November, 1991).

DOE estimates show very large quantities of mixed waste derived from ER and routine operations. At the end of 1991, DOE sites contained an estimated 13 million m^3 of soil and 440,000 m^3 of other solid wastes contaminated with LLR/MW and requiring remediation.[7] DOE's estimated annual generation rate of LLR/MW wastes was 66,047 m^3 in 1991, with a cumulative inventory through 1991 of 101,375 m^3.[8]

Because of the different materials involved, the appropriate treatment of ER and operations waste differs significantly. For instance, incineration may be used to destroy contaminants in soil from ER activities, but it will not significantly reduce the volume of the treated waste, since soil is inorganic and non-combustible. However, for wastes not contained in media, incineration may significantly reduce waste volume.[9]

At DOE, management of radioactive waste is controlled by DOE Order No. 5820.2A, which establishes policy guidelines and minimum requirements for management of DOE LLR/MW and contaminated facilities. Excerpts from this Order are included as Appendix B. Chapter III of that Order deals specifically with the management of LLW, and Section 3 of the Chapter identifies the basic requirements for LLW management, including waste acceptance criteria (WAC). These basic requirements are listed in Exhibit 2-1.

2.1.3 The Role of Incineration

Incineration as a waste management strategy serves several purposes. It destroys some hazardous materials by breaking them down into simpler chemical forms; it may eliminate liquids in the waste that would otherwise complicate waste management; it decreases waste volume; and it may generate usable energy.

Incineration is currently a critical component of DOE's strategy for managing LLR/MW. It is the primary treatment technology for both ER and operations wastes containing organic hazardous constituents. Given the quantities of DOE wastes described above, and assuming a large proportion contain organic constituents, DOE will have to incinerate large volumes of waste.

DOE's incinerators were originally constructed for research purposes, to test the design and use of incinerators for waste treatment. They were not intended to process large volumes of waste on an operational scale. The facilities have since been modified and retrofitted to meet DOE's increasing demand for incineration capacity. However, the

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[7] In-place volumes. Waste from remediation activity may be more or less depending on the remedy and technology selected.

[8] U.S. Department of Energy, Integrated Data Base for 1992: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, Characteristics, October, 1992.

[9] See Section 4.2 for a discussion of technologies for treatment of ER wastes.

Exhibit 2-1

DOE GUIDELINES FOR WASTE ACCEPTANCE CRITERIA (DOE Order 5820.2A - 9/26/88)

(1) Waste shipment from one field organization to another for treatment, storage or disposal shall be done in accordance with the requirements established by the operations office having responsibility for operations of the receiving facility.

(2) Waste acceptance criteria shall be established for each low-level waste treatment, storage, and disposal facility, and submitted to the cognizant field organization.

(3) Generators of waste shall implement a low-level waste certification program to provide assurance that the waste acceptance criteria for any low-level waste treatment, storage, or disposal facility used by the generator are met. Generators and facilities receiving the waste are jointly responsible for assuring compliance with waste acceptance criteria. Generators are financially responsible for actions required due to nonconformance.

(4) Generator low-level waste certification programs shall be subject to a periodic audit by operators of facilities to which the waste is sent by the generator.

(5) The waste acceptance criteria for storage, treatment, or disposal facilities shall address the following issues:

- (a) Allowable quantities/concentrations of specific radioisotopes to be handled, processed, stored or disposed of;
- (b) Criticality safety requirements (waste forms and geometries);
- (c) Restrictions regarding low-level waste classified for security reasons;
- (d) External radiation and internal heat generation;
- (e) Restrictions on the generation of harmful gases, vapors, or liquids in waste;
- (f) Chemical and structural stability of waste packages, radiation effects, microbial activity, chemical reactions, and moisture;
- (g) Restrictions for chelating and complexing agents having the potential for mobilizing radionuclides; and
- (h) Quantity of free liquids.

constraints of their original design still limit their efficiency for large-scale waste processing.

2.2 REGULATORY CONTEXT

Three separate sets of regulations apply to DOE's LLR/MW. The hazardous wastes are regulated under RCRA, the radioactive wastes are regulated under AEA, and the mixed wastes are controlled jointly under both RCRA and AEA.

2.2.1 Hazardous Waste

Under RCRA Subtitle C, EPA and authorized States regulate the treatment, storage and disposal of solid wastes that are hazardous. In establishing the definition of solid waste under RCRA, Congress exempted AEA source, special nuclear, and byproduct material (S. 1004). Because these materials are not solid waste, they cannot be RCRA hazardous waste. As a result, EPA and authorized States have the authority to regulate the hazardous component of a mixed waste, but cannot regulate the radioactive component. The RCRA regulations that are most relevant to DOE's incinerator operations are the requirements for permitting, technical and operational requirements for incinerators, and the Land Disposal Restrictions.

RCRA requires that hazardous waste treatment, storage and disposal facilities operate under permit. Owners or operators of facilities managing hazardous waste are required to obtain permits containing design and operating standards for their facilities. The permit application consists of two parts. Part A includes general information about the facility. Part B contains detailed technical information on how the applicant intends to operate the facility to comply with EPA's relevant standards. Facilities that existed when EPA's hazardous waste rules went into effect receive "interim status" when they submit Part A, and are subject to interim status standards until their permit is approved or denied. New facilities cannot receive interim status; they must be permitted before they can begin construction or operation.

In addition, RCRA contains specific technical and operational requirements for hazardous waste incinerators at permitted facilities. These requirements include restrictions on the composition of waste feeds, performance standards for efficiency in destroying hazardous constituents, and emissions standards for particulates and acid gases. A trial burn is usually conducted to demonstrate that the facility can meet performance and emissions standards. EPA's incinerator requirements currently do not restrict incineration or emissions of toxic metals.

In 1991 EPA began regulating boilers and industrial furnaces (BIFs) that burn hazardous waste as fuel. The requirements of the BIF rule supplement RCRA's general incinerator requirements, and <u>do</u> restrict the combustion and emissions of toxic metals, using health risk-based standards. The current regulatory approach is to limit the metals content in the waste feed, thus controlling the amount discharged through the stack (for a given metals removal efficiency). Depending on the specific risk-based scenario chosen, the allowable limits in the feed may be based upon measured metal emissions during a compliance test. Though the BIF requirements do not currently apply to incinerators, permit writers may apply them to incinerators on a case-by-case basis. In the future, EPA may consider revising RCRA incinerator regulations to address toxic metals at all facilities.

Congress amended RCRA in 1984 through the Hazardous and Solid Waste Amendments (HSWA). One of the most significant new requirements of HSWA is the restriction on hazardous waste land disposal, defined to include any permanent or temporary placement of waste on or in land. The Land Disposal Restrictions (LDRs) require treatment of wastes to minimize toxicity before land disposal is permitted. Treatment standards are based on the performance of the Best Demonstrated Available Technology (BDAT) for treating each hazardous waste. These restrictions on land disposal have increased the role of incineration in waste management, both as a treatment technology and a means of reducing the volume of waste requiring land disposal.

2.2.2 Radioactive Waste

Several agencies have radioactive waste management programs. These agencies include the U.S. Nuclear Regulatory Commission (NRC) and its Agreement States, EPA, DOE, the Department of Defense (DoD), and other Federal agencies.

NRC regulates commercial (private-sector) activities through licenses to receive, possess, use (including storing, sampling, testing, and treating) and dispose of materials and wastes containing source, special nuclear, and byproduct material. Twenty-nine States have entered into agreements with NRC (i.e., Agreement States), whereby the Commission has relinquished to the States its regulatory authority over source, byproduct, and small quantities of special nuclear material. DOE is exempt from NRC regulations except as specified in Section 202 of the Energy Reorganization Act of 1974 (i.e., DOE facilities that accept commercial high-level waste).

The AEA (42 U.S.C. 2011, et. seq.) provides broad authority to control the management, processing, and utilization of source, special nuclear, and byproduct material. Section 274(h) of the AEA established the Federal Radiation Council, consisting of the Atomic Energy Commission (AEC) and other agencies, to advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards. Reorganization Plan No. 3 of 1970 (Appendix I, 5 U.S.C.A.) transferred from the AEC to EPA the responsibility for establishing generally applicable standards for the protection of the environment from radioactive material. EPA's guidance and regulations under AEA apply to NRC and Agreement State licensees, as well as to DOE and other Federal agencies, although implementation and enforcement responsibilities are vested in other agencies, such as NRC and DOE. Of particular interest, EPA is in the process of developing regulations that govern radiation site cleanup and the management and recycle/reuse of radioactively contaminated materials. These regulations are likely to significantly affect the volumes of

LLR/MW generated during DOE site remediations and how those wastes can be managed.

DOE is primarily responsible for controlling the management and disposal of radioactive material at Government-owned and -operated facilities. DOE has instituted requirements for hazardous and radioactive waste management in a series of internal DOE orders. These orders, which commonly incorporate identical or slightly modified provisions that appear in NRC and EPA regulations, have the same effect for DOE facilities or "within DOE" as regulations.

DoD, through its Departments of Army, Navy, and Air Force, controls a large number of sites both in and outside the contiguous United States. Additional military sites are controlled by DOT through the U.S. Coast Guard. Most of DoD's radioactive waste management activities are regulated by NRC and/or EPA. DoD's Defense Environmental Restoration Program has been ongoing since 1983 to restore active sites and formerly utilized defense site. Additionally, DoD's Installation Restoration Program consists of over 17,500 potential hazardous waste sites located at 1,877 installations,[10] some of which are known to have radioactive contamination.

Other Federal agencies with programs applicable to radioactive waste include the Department of Transportation (DOT), the Federal Emergency Management Agency (FEMA), and the Department of the Interior (DOI). DOT has issued regulations that set forth packaging, labeling, recordkeeping, and reporting requirements for the transport of radioactive material (49 CFR Parts 171 through 179). FEMA and DOI may play a role in radioactive waste site cleanups in certain cases.

2.2.3 Mixed Waste

Mixed waste is regulated under both AEA and RCRA. Under AEA, DOE is primarily responsible for the federal government's generation and possession of nuclear material, while NRC is mainly responsible for the generation and possession of nuclear materials at commercial facilities.[11] In addition, EPA is authorized under Reorganization Plan No. 3 to develop standards under the AEA, which NRC and DOE implement by incorporating them into their regulations and orders. These EPA standards are intended to provide a safe level of protection from radiological hazards for human health and the environment. EPA also retains authority under RCRA over hazardous waste generation, treatment, storage, and disposal. Thus, a joint regulatory approach has arisen whereby EPA and either NRC or DOE are responsible for the radioactive (AEA)

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[10] Baca, T.E., "DoD Environmental Requirements and Priorities," Federal Facilities Environmental Journal, Autumn 1992.

[11] A few gray areas cloud this clear division. For example, NRC has authority over several small federal facilities, such as the National Institutes of Health and the Bureau of Standards. Also, while DOE is responsible for developing and operating the proposed high-level waste repository, NRC will have licensing authority for the facility.

component of mixed waste, and EPA is responsible for the hazardous (RCRA) component.[12]

The 1992 Federal Facilities Compliance Act (FFCA) revised the definition of mixed waste by amending Section 1004 of the Solid Waste Disposal Act (SWDA), adding the following new paragraph: "The term 'mixed waste' means waste that contains both hazardous waste and source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954...." In addition, recognizing the difficulties that DOE faced in coming into compliance with both RCRA and AEA regulations after 1984, the FFCA exempted DOE's mixed wastes from RCRA regulation for three years.

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[12] See EPA's Clarification of RCRA Applicability to Mixed Waste, July 3, 1986, and DOE's Clarification of the Definition of By-Product Material, May 1, 1987.

3. DESCRIPTION OF INCINERATOR OPERATIONS

This section starts with a general introduction to incinerator operations and the particular incinerators that DOE uses for LLR/MW treatment. It then presents and discusses the results of the survey of DOE and commercial incinerators, organized into different subject areas.

3.1 OVERVIEW OF EXISTING INCINERATION SYSTEMS

Section 3.1.1 describes the typical operations at a generic LLR/MW incinerator. The particular incinerators used by DOE are then introduced in Section 3.1.2, followed by the schematics of each incinerator presented in Section 3.1.3.

3.1.1 General Description of Incinerator Operations

Incineration involves the introduction of wastes into an incinerator in a bulk form (e.g., as boxes, bags, or drums), shredded, in a sludge form (e.g., slurry), or injected as liquid (EG&G 1988, ASME 1988). The feed rate is governed by the combustible nature of the material and introduction of an additional source of fuel. If in a liquid form, waste may be introduced as a mixture of fuel and waste. Processing rates generally range from 34 to 1,043 kg/h for currently operating or planned DOE incinerators (EPA 91c). The waste/fuel ratio is determined by the combustion properties of the waste and incinerator capacity. The considerations noted above apply generally to all waste forms (mixed and low-level wastes). As combustion occurs, oxygen is consumed and the combustion gases are entrained in a secondary combustion chamber. Proper combustion conditions are maintained by controlling the amount of air, waste feed rate, and temperature. Special attention is given to the residence time in order to ensure that complete oxidation occurs and that the hazardous components are destroyed.

Suspended particulates, fumes, and products of incomplete combustion, if any, are captured in exhaust scrubbers and filtration devices before the combustion gases are released out the stack. Off-gas treatment generally involves passing the hot flue gases into a series of components to remove suspended particulates, acid gases, and radionuclides. Such systems include scrubbers (e.g., venturi scrubbers), heat-exchangers, filters and separators, high efficiency particulate air (HEPA) filters, and adsorbers. Other forms of off-gas cooling include quenching by water injection and dilution by introducing air at ambient temperature. Particulate emissions, depending on particle sizes and exhaust velocity, are trapped in heat-exchangers, filters, or electrostatic separators. The chemical and radioactive constituents of the off-gas can vary significantly from those of the input waste. The combustion process does not destroy the radioactivity associated with the waste, only the chemical and physical forms of the radionuclides.

As the feed material is consumed, the ash is collected at the bottom of the combustion chamber or in ash bins. Some of the ash, however, is entrained with the off-gas and settles or collects in various parts of the off-gas treatment system. The deposition of ashes in various parts of the system is dependent upon waste feed, off-gas velocity, particle size and density, combustion process, residence time, and the efficiency of the treatment system components. Frequently, the bulk of the ash is retained at the point of combustion. Smaller amounts are collected in other sections of the incinerator system (e.g., post-combustion chamber, filter bags, and in precipitators). Minimal amounts are retained on HEPA filters, heat-exchangers cooling coils, and at other unspecified locations.

Usually ash handling is performed remotely, via a ram or conveyor, and the operator is separated from the ash by a physical barrier. Ash generally is removed through ash drop out ports or other engineered designs for ash removal. The handling of ash is also performed with proper ventilation to keep the ash from being dispersed in the immediate area. Sometimes, ashes are discharged into a glovebox and chute connected to a drum. Ashes may also be dumped directly into a treatment system for processing (e.g., via cement, or bitumen solidification). Incinerator ashes are analyzed to characterize radiological and chemical properties in order to verify compliance with waste acceptance and disposal criteria.

Incineration has been shown to yield varying volume reduction factors (VRF), commonly 4 to 40 for most types of compressible dry active waste (DAW) and combustible solids, and greater than 100 for liquids and most plastics. Incineration yields waste residues that are of much higher radionuclide concentrations than the original waste stream. Consequently, ash containers or bins may have higher external radiation exposure rates. When radiation exposure levels are expected to be high, system designs strive to minimize personnel interaction with equipment and ash bins. Shielding of ash collection bins and other ash handling equipment may also be needed.

Actual airborne radionuclide emissions are also known to vary for the reasons given above. In addition, many incinerators process wastes with radiological and physical properties that vary as a function of time. Accordingly, it is difficult to characterize emissions in generic terms. A general perspective on the type and extent of airborne emissions can, however, be obtained from operating facilities.[13] Unfortunately, little information exists that directly compares the radiological properties of the waste introduced in the incinerator with actual airborne emissions. Generally, data only summarize airborne emissions on a yearly basis, with no correlation with waste throughputs.

3.1.2 Identity and Status of LLR/MW Incinerators

This report focuses on the DOE and commercial incinerators listed in Exhibit 3-1. The report examines only those units intended primarily for the processing of LLR/MW, rather than for such activities as uranium recovery.

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[13] A survey of several U.S. and European facilities indicates that stack releases and off-site exposures are well within established limits (IAEA 1989). Typically, stack releases range from non-detectable levels to less than one percent of the limits.

Exhibit 3-1

U.S. Radioactive and Mixed Waste Incinerators

Unit	Location	Current Status	Comments
DOE INCINERATORS			
TSCA Incinerator	Oak Ridge Gaseous Diffusion Plant	In full-scale operation since 1991	EPA Region 4 responsible for compliance and enforcement.
WERF	Idaho National Engineering Laboratory	Facility closed since Feb. 1991. Planned restart in 1993.	Facility closed to update Operational Safety Requirements.
CAI	Los Alamos National Laboratory	On stand-by since 1987.	Facility closed to upgrade. Announced restart in 1993, likely restart in 1995.
Glass Melter	Mound Laboratory	On stand-by. Planned restart in 1993.	Awaiting RCRA Part B permit from Ohio EPA.
CIF	Savannah River Site	Under construction. Planned operation in January, 1996.	Startup deferred 2 to 3 years while RCRA Part B permit negotiated.
COMMERCIAL INCINERATORS			
SEG	Oak Ridge, TN	Full-scale operations began 4th quarter 1989	RCRA Part B permit pending.
DSSI	Kingston, TN	In full-scale operation	System modified to meet new BIF regulations.

The operating status of the incinerators listed in Exhibit 3-1 varies. Several DOE facilities that were active in the past have been shut down. Two facilities are on stand-by, awaiting RCRA permits. DOE has cancelled several planned incinerator construction projects for various reasons. In addition, DOE has one operating incinerator and sends wastes to two active commercial incinerators.

Since 1985, DOE has shut down three incinerators (the Beta/Gamma Incinerator at Savannah River, the fluid bed unit (FBU) at Rocky Flats, and the controlled air incinerator at Lawrence Livermore). Two other incinerators have been closed until technical, regulatory or administrative work can be completed: the controlled air incineration (CAI) system at Los Alamos, and the Waste Experimental Reduction Facility (WERF) at INEL.

At the Mound Laboratory in Miamisburg, Ohio, a small joule-glass melter (JGM) is currently awaiting a permit from the Ohio EPA. DOE is planning to use the JGM to treat site-generated wastes but not necessarily wastes from ER activities. Construction of the Consolidated Incineration Facility (CIF) at Savannah River, after it began in January, 1993, was deferred for several years while negotiating a RCRA Part B permit with regulatory authorities.

DOE decided not to build a new incinerator as part of the Decontamination and Waste Treatment Facility (DWTF) at Lawrence Livermore due, in part, to unfavorable public reaction. DOE also has canceled another unit in the final stages of construction, the Process Experimental Pilot Plant (PREPP) at Idaho National Engineering Laboratory (INEL). One project in the planning stage (the LLR/MW incinerator at Los Alamos) was canceled because alternative waste handling approaches were available.

DOE has an operating incinerator at one site. At the Oak Ridge Gaseous Diffusion Plant (K-25), DOE brought on line a large rotary kiln incinerator which is permitted to burn TSCA wastes in addition to LLW, mixed wastes, and hazardous waste. The unit is referred to as the TSCA incinerator.

Independent of DOE, two private sector plants have also recently come on line. One is the controlled-air incinerator operated by the Scientific Ecology Group (SEG -- a Westinghouse subsidiary) in Oak Ridge that is permitted to burn low-level waste. The other is the cogeneration boiler operated by Diversified Scientific Services Inc. (DSSI) in Kingston, Tennessee, that is permitted to burn mixed solvent-based wastes. SEG has announced tentative plans to build a second incinerator of essentially the same design as the existing unit.

In addition to those operating, on stand-by and under-construction incinerators noted in Exhibit 3-1, DOE expects to construct three additional incinerators. If all of these units come into operation as projected, DOE will have the following complement of government-owned incinerators in operation for processing low-level and mixed wastes by the turn of the century:

- Rotary Kiln - 2 units (TSCA, CIF);
- Controlled Air - 2 units (WERF, CAI);
- Glass Melter - 1 unit (Mound Laboratory); and
- System not yet determined - 3 units.

The SEG and DSSI commercial incinerators and perhaps other commercial incinerators also may be built in the near future. It is uncertain how many of these incinerators will be significantly involved in treating ER wastes.

3.1.3 Schematic Presentation of the Various Units

Exhibit 3-2 provides simplified block diagrams for eight of the incinerators discussed above. As shown, each of these incinerators has a unique air pollution control (APC) train. Of the systems with defined components, all except the TSCA rotary kiln use

HEPA filters. More detailed schematic diagrams for five of the systems are included in Appendix C.

Over the years, incinerator designs have evolved from relatively simple to very complex systems. It is also common practice for many incinerator designs to be essentially one of a kind. Accordingly, it is not possible to identify one design as a representative or typical system. The CAI system at Los Alamos, however, incorporates a broad range of features and can serve as an illustrative model for other incinerators.

The first part of the CAI system includes a waste inspection system. Wastes are initially characterized by a gamma spectroscopy system to evaluate their radiological characteristics. Next, the waste package or container is passed through an x-ray scanner for visual inspection of its contents. The next components include a waste inspection glove-box and feeder where the waste is prepared prior to being introduced into the incinerator. The incinerator itself is comprised of a primary and secondary combustion chamber. Connected to the bottom of the incinerator is a self-contained ash handling unit. Combustion gases are extracted from the top of the incinerator and channeled into the following major components: a quench column, a venturi scrubber, a packed column scrubber, an off-gas demister and super-heater, a set of HEPA filter and charcoal adsorber banks, a set of two exhaust fans, and an effluent stack. The exhaust stack is equipped with a continuous effluent sampling and monitoring system that measures gas emissions. These components are also serviced by other subsystems which include cooling, scrubber operation, and process instrumentation and control.

3.2 WASTE HANDLING

A variety of DOE waste streams are treated by incinerators both within the DOE complex and in the private sector. The following sections include brief summary descriptions of some of these units, including discussion of their waste handling and acceptance criteria. The descriptions are based on the information collected during the survey and incorporated in Appendix A.

Not all of these incinerators are equally suited to processing the waste forms expected from ER. An ad hoc working group within DOE has characterized the general applicability of various generic thermal treatment units to six general waste forms (DOE 92a). Exhibit 3-3 presents results that are relevant to incinerators, extracted from that study. In the context of the DOE study, "dry solids" consist of items such as grouts, bricks, soils, concrete, asphalt, salts and ashes. "Large heterogeneous" solids comprise items such as equipment, glove boxes, construction debris, wood, paper, plastics, rubber and synthetics. "Small heterogeneous" solids include such items as filters, ceramic materials, graphite, various combustibles and inorganic wastes. Organic and aqueous liquids generally connote relatively energetic and non-energetic pumpable liquids, respectively.

Exhibit 3-3 shows that only the rotary kiln is capable of handling the variety of materials expected from ER activities; the unit can accept a wide variety of waste forms. Other

Exhibit 3-2
Simplified Block Flow Diagram
Comparison of Operating and Stand-by, LLW and Mixed Waste Incinerator Flow Sheets in US

Facility	Primary Combustor	Secondary Combustor	Primary Gas Cooling	Air Pollution Control Trains Acid Gas Scrubbing and Particulate Removal							Exhaust	
TSCA	Rotary Kiln	SCC	Adiabatic Quench	Venturi Scrubber	Demister	Packed Bed Scrubber	Ionizing Wet Scrubber				ID Fan	Stack
HWMF	Fixed Hearth	SCC									ID Fan	Stack
SEG	Fixed Hearth	SCC, TCC	3-Pass Boiler	Bag House	HEPA Filter	Packed Bed Scrubber					ID Fan	Stack
DSSI	Boiler		Dry Scrubber	Bag House	HEPA Filter	Carbon Adsorber					ID Fan	Stack
WERF	Fixed Hearth	SCC	Heat Exchanger	Bag House	HEPA Filter						ID Fan	Stack
CAI	Fixed Hearth	SCC	Evaporative Quench	Venturi Scrubber	Packed Bed Scrubber	Demister	Flue Gas Re-heat	HEPA Filter	Carbon Adsorber	HEPA Filter	ID Fan	Stack
Glass Melter	Melter		Evaporative Quench	Venturi Scrubber	Cyclone Separator	Flue Gas Re-heat	HEPA Filter				ID Fan	Stack
CIF	Rotary Kiln	SCC	Evaporative Quench	Steam-Driven Jet Scrubber	Cyclone Separator	Demister	Flue Gas Re-heat	HEPA Filter			ID Fan	Stack

Exhibit 3-3

Waste Stream/Incinerator Compatibility Matrix

INCINERATOR	WASTE STREAMS					
	Aqueous Liquid	Organic Liquid	Wet Solids	Large Hetero. Solids	Small Hetero. Solids	Dry Solids
Controlled Air		X				X [c]
Fluidized Bed		X	X		X [c]	
Liquid Injection		X				
Rotary Kiln		X	X	X	X	X
Joule Melter		X	X			X

c - combustibles only
Source: "Minutes from TTWG Meeting III," R. Gillins, SAIC, January 3, 1992.

treatment techniques will probably be required to process certain problem ER wastes, particularly those generated in small volume. Furthermore, there are other types of incinerators that might be suitable for processing ER wastes, but which are not currently in the DOE planning base and are not included in the summary table. None of the incinerators listed are capable of processing aqueous feeds, because incineration is generally not the preferred treatment technology for aqueous wastes of low organic content. Some aqueous liquids, however, are processed as supplementary feeds, principally to control temperatures in rotary kilns and liquid injection incinerators.

3.3 WASTE ACCEPTANCE CRITERIA

Exhibit 3-4 summarizes available information on the types of feeds that are now or will be accepted at existing and planned LLR/MW incinerators. Information on all of the DOE incinerators comes in part from the Treatment, Storage and Disposal Capabilities Data Base maintained by the Hazardous Waste Remediation Action Program (HAZWRAP)

Exhibit 3-4

Acceptable Feeds for Radioactive and Mixed Waste Incinerators

Incinerator	Status	Acceptable Feeds									
		Solid LLW	Liquid LLW	Solid Mixed LLW	Liquid Mixed LLW	Solid TRU	Liquid TRU	Solid LLW-PCB	Liquid LLW-PCB	Solid Mixed LLW & PCB	Liquid Mixed LLW & PCB
K25-TSCA	Operating	X	X	X	X	--	--	X	X	X	X
SEG	Operating	X	X	--	--	--	--	--	--	--	--
DSSI	Operating	--	X	--	X	--	--	--	--	--	--
INEL-WERF	On stand-by	X	X	X	X	--	--	--	--	--	--
LANL-CAI	On stand-by	X	X	X	X	X			X		X
Mound-Glass Melter	On stand-by	X	X	X	X	--	--	--	--	--	--
SRS-CIF	Under Construction	X	X	X	X	--	--	--	--	--	--

X = Specifically Acceptable
-- = Specifically Unacceptable
Blank = Presumed Acceptable
? = Not currently defined

SOURCE: WMIS Data Base (Private Communication from L. Wachter, HAZWRAP Office, September 1991)

Exhibit 3-4 (Continued)

Acceptable Feeds for Radioactive and Mixed Waste Incinerators

Incinerator	Status	Acceptable Feeds								Comments
		Liquid PCB	RCRA Solid	RCRA Liquid	Solid TRU - Mixed	Liquid TRU - Mixed	Liquid TRU - PCB	Liquid TRU - Mixed & PCB	Accept Off-Site Waste	
K25-TSCA	Operating	X	X	X	--	--	--	--	Yes	No reactives or corrosives
SEG	Operating	--	--	--	--	--	--	--	Yes	Seeking RCRA permit
DSSI	Operating	--	--	X	--	--	--	--	Yes	No halogens or heavy metals
INEL-WERF	On stand-by	--	X	X	--	--	--	--	?	PCB's <50 ppm; ∝ <0.1 nCi/g
LANL-CAI	On stand-by	X	X	X		X	X	X	No	No Freon, no solid PCB waste
Mound-Glass Melter	On stand-by	--		X	--	--	--	--	No	No dioxins - applied for RCRA Permit
SRS-CIF	Under Construction	--	X	X	--	--	--	--	No	No PCBs, TRU or HLW

X = Specifically Acceptable
-- = Specifically Unacceptable
Blank = Presumed Acceptable
? = Not currently defined

SOURCE: WMIS Data Base (Private Communication from L. Wachter, HAZWRAP Office, September 1991)

Office managed by Martin Marietta Energy Systems, Inc. in Oak Ridge, Tennessee. This data base and the companion hazardous waste profiles data base are part of a larger data base called Waste Management Information System (WMIS), also managed by Martin Marietta. Data on the two commercial incinerators are based on company literature and staff interviews.

Acceptable feeds in Exhibit 3-4 are denoted with an X. These are feeds which have been specifically identified for the respective units. Feeds that are specifically denoted as unacceptable are designated with a dash. A number of feeds have not been specifically identified as acceptable, but resemble other acceptable feeds; for these, it is reasonable to presume acceptance. For example, if an incinerator is approved for mixed wastes, presumably it can also handle RCRA wastes.

Since wastes expected from future ER activities have not been adequately characterized, the current site- or unit-specific WACs are generally geared to wastes from current operations. The extent to which ER wastes will dictate future changes in a given WAC is not known. The following section describes WACs and waste handling criteria for various incinerators which currently process or plan to process DOE wastes.

3.4 CURRENTLY OPERATING OR "ON STAND-BY" INCINERATORS

The following information on specific facilities is excerpted from the survey forms presented in Appendix A.

3.4.1 TSCA Incinerator (A-4)

System Description and Status

The TSCA Incinerator located at the Oak Ridge Gaseous Diffusion Plant is a 6-ft diameter x 25-ft long rotary kiln unit rated at 10 million Btu/hr with a secondary combustion chamber rated at about 22 million Btu/hr; the total system maximum heat release rate is 28 million Btu/hr. The incinerator uses a wet off-gas treatment system comprised of a quench tower, venturi scrubber, demister, packed-bed scrubber, two-stage ionizing wet scrubber, ID fan, and a 100-ft stack. The system is permitted to handle both TSCA and RCRA wastes.

After initial startup problems involving ID fan failure, the system was restarted in early 1990. It began full-scale operations about a year later, in April 1991. The unit is currently operating mainly on liquid wastes, with 2.2 million pounds processed in FY-1991 and 2.8 million pounds in FY-1992.

The facility's maintenance procedures typically include two planned outages every year, one in the spring for a few weeks and a major one in the fall for 1 to 2.5 months, depending on maintenance requirements. Maintenance activities during these outages include fiberglass repair, replacement of pumps and deteriorating equipment, and any major upgrades. The facility also conducts routine maintenance activities (e.g., cleaning nozzles in off-gas treatment systems) as needed throughout the year (ROG 93).

Waste Handling and Acceptance Criteria

Given its inherent flexibility, the rotary kiln incinerator at the K-25 site in Oak Ridge can handle a variety of physical forms of waste including liquids (both organic and aqueous), solids, and sludges, both containerized and in bulk (TSCA 91). In addition, the unit has both RCRA and TSCA permits which enables the processing of hazardous wastes (or mixed wastes) and PCB-containing wastes. The unit can accept solids such as contaminated soils, absorbents, and biological materials; liquids such as waste oils, solvents, and water solutions; sludges; solids from wastewater treatment; and degreaser residues. Waste may contain PCBs, hazardous organics, and low-level enriched uranium.

Liquid wastes are stored in 5,000-gal receiving tanks and then pumped to 10,000-gal blending tanks for feeding to the incinerator burners or nozzles. Drums are deheaded and drained of free liquids and then shredded. Shredded waste is moved from the storage bin with an automated crane/grapple and delivered to the feed ram. Bulk solids can also be fed to the ram by belt conveyor. Sludge is pumped through a nozzle from drums. Organic and aqueous wastes are pumped to burners and nozzles in the combustion train.

Exhibit 3-5 summarizes the physical characteristics of the various waste streams. The TSCA incinerator accepts wastes from the following DOE locations: K-25, Y-12, ORNL, Paducah, Portsmouth, RMI, and Fernald.

Exhibit 3-5

Physical Characteristics of Waste Streams
for K-25 TSCA Incinerator

Characteristic	Liquid [a]	Solid	Sludge
Viscosity (cp at 100°F)	< 5,000	N/A	5,000 to 500,000
Solids (wt %)	< 10	> 50	10 to 50
Freezing Point (°F)	< 40	N/A	N/A
Boiling Point (°F)	> 100	N/A	N/A
Particle Size (in.)	N/A	< 1/16	> 1/16

[a] Aqueous solutions contain > 90% water by weight.

Although the TSCA incinerator is capable of handling a variety of waste types and forms, the near-term processing plan is to burn primarily liquid low-level mixed wastes, because of concern about the handling and ultimate disposition of incinerator residuals derived from off-site wastes. Under the operating strategy for the next few years, a significant quantity of liquids will be processed through 1994; between 1994 and 1996 both liquid and solid mixed wastes will be processed; and by the end of 1996, the inventory of mixed waste liquids will have been incinerated (IT 92).

Current restrictions on wastes are as follows:

- Wastes must be free of dioxin wastes as defined in 40 CFR 268.31 and listed as waste codes F020 through F023 and F026 through F028 in 40 CFR 261.
- Wastes must be free of cyanide wastes as defined in waste codes F007 through F011 listed in 40 CFR 261.
- Waste must be free of explosive material which detonates on heating or percussion, ignites spontaneously in dry or moist air, or meets the definition of reactive waste as defined in 40 CFR 261 or as designated by EPA hazardous waste code D003.
- Waste containing uranium with U-235 enrichment of less than 1% must not exceed 0.08 Curies per shipment (i.e. per truckload).
- Waste containing uranium with U-235 enrichment of more than 1% must have total uranium content of less than or equal to 5 ppm.
- In general, the waste form must be nonvolatile, such that it does not rapidly evaporate when the waste container is opened.
- If the boiling point of the waste is less than 100° F, acceptance will be based on a case-by-case evaluation.

For liquid organic wastes the corrosivity must be limited to less than 6.35 mm/yr, and for aqueous wastes the Ph must be greater than 6 for drummed liquids or between 8 and 10 for bulk liquids. Allowable metal contents are listed in Exhibit 3-6. Restrictions on chloride, sulfur and fluoride in liquids are as follows:

• Total Chloride:	< 89 wt %
• Total Sulfur:	< 6 wt % (drums)
	< 3 wt % (bulk)
• Total Fluoride:	< 85 wt % (drums)
	< 25 wt % (bulk)

Exhibit 3-6

Metals Contamination Limits
for TSCA Incinerator Wastes (ppm)

Metal	Liquid (Drums)	Liquid (Bulk)	Solids	Sludge
Aluminum	20,000	11,000	80,000	80,000
Beryllium	10	5	5	5
Cadmium	1,500	500	800	800
Chromium	6,000	3,300	6,000	6,000
Lead	2,500	2,000	1,000	1,000
Mercury	200	60	120	120
Zinc	65,000	65,000	65,000	65,000
Plutonium	0.004 [a]	0.004 [a]	0.004 [a]	0.004 [a]

[a] Or 246 pCi/g.

Solid materials in drums are required to be shreddable, which limits rebar, pipe and concrete pieces to less than 2 inches in diameter. Total chlorides, sulfur and fluorides are limited to 75, 3, and 21 wt %, respectively. Corrosivity limits for sludges are the same as for liquids. Total chlorides, sulfur and fluorides are limited to 75, 10, and 21 wt %, respectively.

Waste received for processing must be identified by radionuclide content. Prior to processing, TSCA incinerator staff analyzes the waste and determines whether or not, when treated along with other wastes, it will create a situation where the annual committed effective dose equivalent limits[14] will be exceeded. Required lower limits of detection for specific nuclides are listed in Exhibit 3-7.
Waste shipping containers must meet the following requirements:

- Maximum dose equivalent rate at contact - 50 mrem/hr;
- Maximum dose equivalent rate at 2 feet - 5 mrem/hr;

[14] 10 CFR 20.1003 defines "committed effective dose equivalent" as the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues (i.e., $\Sigma_{tissues/organs}$ (tissue/organ weighting factor x committed dose equivalent)). The "committed dose equivalent" is the dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Exhibit 3-7

Required Lower Limits of Detection (LLD) for Radionuclides in TSCA Incinerator Wastes

Radionuclide	Required LLD (Pci/g)	Radionuclide	Required LLD (pCi/g)
H-3	60	Pb-210	1
C-14	60	Th-228	1
P-32	5	Th-230	1
Co-57	0.1	Th-232	1
Co-60	0.5	Th-234	1
Kr-85	5	Pa-234m	1
Sr-90	5	U-alpha	1
Tc-99	20	Np-237	1
I-131[a]	0.7	Pu-238	1
Cs-137	1	Pu-239	1

[a] I-131 not required if waste has been stored more than six months.

- Transferrable beta/gamma surface contamination - 1000 dpm/100 cm^2; and
- Transferrable alpha surface contamination - 200 dpm/100 cm^2.

3.4.2 Scientific Ecology Group (SEG) Incinerator (A-8)

System Description and Status

The SEG incinerator is commercially owned and operated by the Scientific Ecology Group (a Westinghouse subsidiary) in Oak Ridge, Tennessee. The system is a fixed-hearth, controlled-air unit of Scandinavian design rated at 11 million Btu/hr. The primary unit is coupled with secondary and tertiary combustion chambers, though the tertiary chamber is seldom used. The off-gas treatment system consists of a fire-tube boiler, baghouse, bank of HEPA filters, quench chamber, packed-bed scrubber, ID fan, and an exhaust stack. Reheated air is added to the stack for plume suppression.

Primary feed to the system is low-level waste (dry active waste, or DAW), but liquid waste can be fed into a burner in the secondary combustion chamber. SEG also has at the site a liquid injection incinerator which typically handles low-level radioactive waste oils.

The unit began operation in late 1989 and in 1990 processed 2.6 million pounds of DAW and about 25,000 gallons of oil. In 1992 6.7 million pounds of DAW were burned. All oil has been burned in the liquid injection incinerator since 1991. SEG is planning to obtain a RCRA permit to process mixed wastes. They have incinerated wastes both from DOE sources and from the private sector and are considering adding a second solid waste incinerator.

Waste Handling and Acceptance Criteria

Most of the waste SEG handles is generated by nuclear power plants; less than five percent is from DOE. LLW received at SEG includes paper, cloth, wood, rubber with some metal particles, glass and plastics. Typical heat content is 6,500 to 13,000 Btu per pound. All solid waste is hand-sorted into wheeled containers holding about 50 ft^3 (about 300 lbs). Twenty-two wheeled containers are loaded into a feeding magazine and then automatically fed into the incinerator. The wheeled containers ride up a vertically inclined trolley to a waste charging chute. The upper chute door opens, waste is dumped into the chamber (air lock), and the upper door closes. When incinerator feed is required, the lower door opens and the waste falls into the furnace.

The SEG controlled-air incinerator is designed to handle DAW with no more than 5% PVC. All dry wastes are hand sorted to remove metals, selected plastics and other undesirable feeds. Animal carcasses, with their high tritium and C-14 contents, are not acceptable feeds (SEG). As an adjunct to the hand sorting program for removal of acid gas-forming materials, SEG has worked with more than thirty suppliers to the nuclear industry to ensure that their products are acceptable for incineration at SEG. These vendors supply "Certified Incinerable" items to their customers.

Specific radionuclide limits for acceptance of DAW are presented in Exhibit 3-8. In addition, waste containers received at the SEG facility must have contact radiation levels of less than 200 mR/hr and removable external contamination levels of less than 2,200 dpm/100 cm^2 for beta/gamma emitters and less than 220 dpm/100 cm^2 for alpha emitters.

Other excluded materials are gases, chelating agents, hazardous chemicals, pyrophorics and explosives. Solid wastes must not contain significant quantities of free-standing liquids. Residuals from any waste accepted by SEG must also be acceptable at the destination burial ground.

Waste acceptance criteria for contaminated oils are presented in Exhibit 3-9. It should be noted that the total halogens level can be as high as 4,000 ppm if the generator can demonstrate that the oil contains less than 100 ppm of any individual halogenated solvent listed as an F001 or F002 waste and can certify that there has been no additional mixing of hazardous constituents with the oil.

Exhibit 3-8

SEG General Waste Acceptance Criteria [a]

Material	Criterion (radionuclide content per package)
Mixed Fission and Activation Products (Z < 84)	< 25 mCi/cf
Ra-226	< 0.1 Mci/cf and < 10 Nci/g
Th-232	< 5 Mci/cf
U-238 as metal or oxide	< 15 Mci/cf
U-233, U-235	< 0.1 gm/cf
Plutonium	< 10 Nci/g
Transuranics	< 10 Nci/g

[a] Additional incinerator-related limits may be imposed for H-3, C-14, Tc-99 and I-129.

3.4.3 Diversified Scientific Services, Inc. (DSSI) Cogeneration Boiler (A-3)

System Description and Status

Diversified Scientific Services, Inc. (DSSI), a private, commercial concern, operates a cogeneration boiler rated at 16.5 million Btu/hr (but limited by state air permit to 14.5 million Btu/hr) in Kingston, Tennessee. The unit is currently in full-scale operation. The boiler's operation generates sufficient power to drive a 150-kw electrical generator, and the excess is sold to the local electric utility. Off-gas treatment involves a semi-dry scrubber system consisting of a spray dryer, baghouse, HEPA filter, carbon bed adsorber, ID fan, and an exhaust stack.

Construction of the facility was initiated in mid-1989, and the off-gas treatment system was modified to conform to the new BIF regulations (56 CFR 7134) at the end of 1991. The major fuel supply to the boiler is radioactively contaminated spent solvents such as scintillation fluids. DSSI has handled wastes from DOE sites and from commercial sources, and at the time of the survey was bidding on additional DOE wastes.

Exhibit 3-9

SEG Waste Acceptance Limits for Contaminated Oil

Toxicity Characteristic

Heavy Metals (40 CFR 261.24)

Arsenic	<5.00 mg/l
Barium	<100.00 mg/l
Cadmium	<1.00 mg/l
Chromium	<5.00 mg/l
Lead	<5.00 mg/l
Mercury	<0.2 mg/l
Selenium	<1.00 mg/l
Silver	<5.00 mg/l

Organics

Organic compounds listed in 40 CFR 261.24 must be certified absent by generator or oil must be tested to meet the Toxicity Characteristic Leaching Procedure (TCLP).

Total Halogens	1000 ppm (max.)
PCB's	2.00 ppm
Flashpoint	140° F(min.)
Viscosity	<3000 ssu
Solids Content	<10 vol %

Radiological Analysis (Averaged over truckload lot)

All nuclides<1E-4 microcuries/ml
Uranium <1E-5 microcuries/ml
No other alpha emitters greater that 10% of total

Maximum Individual Isotope Activities

H-3X
C-14
Tc-9
I-129

Waste Handling and Acceptance Criteria

DSSI's industrial boiler for electrical cogeneration is designed to handle mixed low-level solvent wastes without halogens or heavy metals. Vials or containers of glass and plastic are crushed and the solvents separated and transferred to one of seven 250-gal holding tanks for testing. If the material meets the WAC, it is transferred to one of three 10,000-gal carbon steel storage tanks for feed to boiler.

From a RCRA perspective, DSSI can handle waste solvents including EPA designations D001 and F001-F005 plus numerous D, U, and P listed materials. A listing of these acceptable solvents is included as Appendix D. Solvents containing halogens or heavy metals are unacceptable as fuels. From an Atomic Energy Act perspective, DSSI can handle about 2,000 isotopes typical of those found in medical, institutional and nuclear power plant wastes. Wastes containing some source and special nuclear materials from DOE and Department of Defense (DOD) facilities are also acceptable. Waste can be received in containers varying from 5 to 85 gallons or in bulk from tanker trucks (DSSI). The radioactive materials license issued by the state of Tennessee specifies that the physical and/or chemical form of the wastes is "any as associated with liquid scintillation type fluids, solutes, solvents, and associated materials." Licensed isotopes are listed in Exhibit 3-10, as are the total quantities which can be held on the property at any one time. The annual quantity of radioactive material which can be burned is limited to 22.5 Curies of H-3 and C-14 combined and 1.5 Curies of all other approved isotopes combined. In addition, the limiting concentrations for combustion are 0.05 microcuries per gram of H-3 and C-14, combined, and 0.002 microcuries per gram of all other authorized isotopes, combined.

3.4.4 Waste Experimental Reduction Facility (WERF) Incinerator (A-5)

System Description and Status

The Waste Experimental Reduction Facility (WERF) Incinerator at INEL is a dual-chambered controlled-air combustion system rated at 5 million Btu/hr. Solid and liquid wastes are charged to the primary combustion chamber. The incinerator off-gas treatment system consists of a shell-and-tube heat exchanger, baghouse, bank of HEPA filters, ID fan, and a 49-ft stack. Acid gas removal facilities are not included, thus limiting the throughput of halogen wastes.

The system began processing LLW in September 1984 and was shut down in February 1991 to update Operational Safety Requirements. Restart is planned in 1993. The system completed a RCRA trial burn of liquid wastes in 1988 and has an Interim Status RCRA Permit.

Exhibit 3-10

Allowable Quantities of Radioisotopes at DSSI

Item	Isotope	Allowable Quantity
1	H-3, C-14, S-35, Cl-36, Ca-45, Fe-55, Fe-59, Cs-137, Co-60, Co-58, Co-57, Gd-153, Zn-65, P-32, P-33, Na-22, Rb-86, Hg-203, In-111, Ga-67, Mn-54, Sc-46, Se-75, Cd-109, Ni-63, Cu-64, Sn-113, Sn-119m, I-125, I-131, Bi-207, Ce-141, Au-195	Total of Item 1 combined: 10 Ci
2	Cr-51, Cs-134, Tc-99, Ge-68	Each isotope: 2 Ci
3	Ra	10 milliCi
4	Uranium (not U-233 or U-235), plus thorium	Total of Item 4 combined: 200 kg
5	U-235	175 g [a]
6	U-233	100 g [a]
7	Plutonium	100 g [a]
8	Any radioisotope with atomic numbers 1 through 83 except as included in items 1, 2, and 3 above.	Total of Item 8 combined: 1 Ci

[a] The sum of the actual quantities of Items 5, 6, and 7 when each is divided by this quantity shall not exceed unity.

Waste Handling and Acceptance Criteria

Combustible solids in cardboard boxes are placed on a roller conveyor, weighed and then moved through air lock to an elevator and into a waste-loading chute. Liquid waste in drums is pumped to a burner.

LLW feed for the WERF incinerator is packaged in 2′ x 2′ x 2′ plastic-lined, corrugated cardboard boxes. Other package requirements are presented in Exhibit 3-11 (INEL 87). Containers with free liquids are prohibited in the boxes. In addition, the mercury content of the feed material must be held to levels at which emissions do not exceed 0.05 mg/m^3 (HAZWRAP).

The WERF Air Quality Permit to Construct issued by the state of Idaho, Division of Environmental Quality, in October 1987 limits waste feeds to those included in the DOE permit application (Richards). Permitted feeds are listed in Exhibit 3-12.

WERF is currently developing mixed waste acceptance criteria in anticipation of system restart. Draft waste acceptance criteria for mixed wastes are included in Appendix E

Exhibit 3-11

Package Specifications for WERF Low-Level Waste Feed

Characteristics	Corrugated Cardboard Boxes
Gross weight limit	60 lb/box
Dimension limit	2 ft by 2 ft by 2 ft (swelling due to excessive loading is not permitted)
Radiation limit[a]	Individual boxes shall not exceed 20 mR/h at contact. The shipping container shall not exceed 200 mR/h at contact.
Contamination limit	External box surfaces shall be less than 200 dpm/100 cm^2 beta-gamma and 20 dpm/100 cm^2 alpha removable.
TRU content	Less than 10^{-1} nCi/g
Fissile material limit	Trace quantities only (less than 250 dpm/100 cm^2 alpha)
Box liner[b]	Yellow polyethylene (4 mil minimum)
Box condition	The filled boxes are to be free of rips and punctures. The box condition shall provide for the integrity of the contents during normal handling and shall not have been wetted or excessively weathered.
Closure	After removal of the box from the collection receptacle, twist the liner into a neck and fold it over onto itself and tape it to provide a seal. Close both sets of lid flaps and fully tape the exposed seam and edges. Use 2-in. cloth type tuck tape or carton closure tape that does not contain PVC or other halogens.
Markings	Attach required radiological labels and include the following additional information: Source facility and building or location.
Acceptable materials	Wood, paper, cloth, towels, polyethylene bags, sheeting and empty polyethylene sample bottles with lids removed.
Prohibited materials[c]	Items containing polyvinylchlorides (PVCs), glass, fiber glass, respirators, aerosol cans, steel-toed boots and shoes and other metallic wastes. (Buttons, snaps, zippers, small nails, staples and other similar items are acceptable.) NOTE: Herculite and Tygon contain PVCs.

Exhibit 3-11 (continued)

Characteristics	Corrugated Cardboard Boxes
Bulk wood waste	The WERF can accept bulk wood waste materials such as shoring, temporary containments and scaffolding to be sized at WERF and packaged in boxes for burning. This type of material is to be shipped in WERF bins or D&D bins and is not to be mixed with metallic waste. Nonstandard wood waste may also be eligible in accordance with Section 8.3.
Mixed hazardous flammable liquid	See Note d.

a. Radiation limits are currently being evaluated and may be increased. These changes will be published as a DRR or revision in the event that they should occur.

b. Box liners are not required for waste generators that collect the waste in 4 mil (minimum) bags. The bags can be necked and tape sealed and be put directly in the boxes so long as the exterior of the bag is free from contamination.

c. Complete segregation of this waste classification is required. Any chemicals or metals that can be recombined with other elements as a result of the combustion process and that can result in chemical or corrosive attack of the incinerator and off-gas components must be eliminated from the waste stream.

d. The WERF can accept flammable liquids for incineration that are contaminated with radioisotopes up to 3.4×10^{-5} Ci/l. Other hazardous materials in flammable liquids are acceptable as long as the degree of difficulty in destruction is not greater than that for organic chlorine. The heat of combustion of the hazardous constituent must be greater than 0.24 Kcal/g (432 BTU/lb). The fluid mixture must have minimum heat of combustion of 10,000 BTU/lb. The hazardous liquid materials that are within the above concentrations may also be included in boxed waste as long as they are totally absorbed in an eligible absorbent material with 100% excess absorbent. The total absorbed quantity cannot exceed 1 L/box.

Exhibit 3-12

WERF Incinerator Feeds
Specified in Air Quality Permit to Construct

Degreasing Solvent (Stoddard Solvent)
Degreasing Sludge (Trichloroethane)
Thinners, Strippers and Paint Solids (Mineral Spirits, Toluene, Xylene, Acetone)
De-inking Solvent Sludge (Tetrachloroethylene, Naphtha)
Miscellaneous Ignitables
Mixed Organic Waste
Lab Wastes (Carbon Tetrachloride)
Mixed Formaldehyde and Mercuric Nitrate*
Formaldehyde from Analysis
Solvent Cleaning (Trichloroethylene)
Degreasing of Reactor Components (Acetone)
Paint Stripping (Methylene Chloride)
Combustible Wastes (Paper, Bottle Samples, Gloves)
Silver-Zeolite
Scintillation Fluid (xylene, toluene)
Degreasing Solvent (Freon 112)
Freon Decontamination Still Bottoms and Filters
Silver Nitrate and Potassium Chromate Solutions
Miscellaneous Lab Wastes
Laboratory Radiological Leach Solution (Hexone, CCl_4)

[a] One-time Waste

(INEL 91). Tritium and carbon-14 specifications in this table are derived from Operational Safety Requirements, which set annual feed limits of 1000 Ci for H-3 and 315 Ci for C-14, and assume 100% on-stream at a feed rate of 400 lbs/hr. Fissile material at the WERF site is limited to 15 grams at any one time. Tri-chlorofluoromethane is specifically excluded from waste feeds.

Waste acceptance criteria for WERF are undergoing a comprehensive review as part of the program to prepare the incinerator for restart. It is likely that the WAC information in Exhibits 3-11, 3-12, and Appendix E will change significantly (Reidesel).

3.4.5 Controlled Air Incinerator (CAI) (A-2)

System Description and Status

The CAI at Los Alamos National Laboratory (LANL) is a dual-chambered unit rated at 1.5 million Btu/hr. The off-gas treatment system includes an adiabatic saturation quench, high-energy venturi scrubber, packed-bed absorber/demister, off-gas reheater, primary bank of HEPA filters, carbon bed adsorber, secondary HEPA filter, parallel ID fans, and stack. The primary HEPA filter bank contains four modules, two of which are operational while two are standby. Each module contains a prefilter, a primary HEPA filter, and a secondary HEPA filter in series.

The CAI began operation in 1979, was granted a TSCA permit in 1984, completed a RCRA trial burn in 1986 and has been shut down since 1987 for a complete facility upgrade. Operation is expected to resume in 1995. This is the only unit in the DOE complex capable of incinerating TRU wastes.

Waste Handling and Acceptance Criteria

The CAI can handle a broad range of liquid and low-density solid feeds including LLW, TRU, mixed waste, and waste containing PCBs. Solid wastes are packed in 1′ x 1′ x 2′ cardboard boxes. An x-ray unit is used for inspection of boxes of solid wastes for free liquids or non-combustibles prior to feeding. Waste boxes are placed in a glove box, moved onto the side-ram elevator platform, and raised into position in front of the main feeder ram. Boxes are fed one at a time at a predetermined rate into the incinerator. Liquids can also be injected through a burner or nozzle into the incinerator when solids are not being fed.

The typical solid waste feed is 35% cellulose, 12% PVC, 23% polyethylene and 30% polyisoprene with a heat content of 6,900 Btu/lb. The heating value of any listed hazardous wastes in the feed stock must be at least 0.24 kcal/g (432 Btu/lb) if the concentration of the listed waste exceeds 0.01%. When the heating value is too low, liquid feeds can be blended with diesel oil to meet this specification. Quantities of trichloromonofluoromethane (Freon 11), tribromomethane, and dichlorodifluoromethane (Freon 12) in the waste feed are limited to 0.01%. The physical forms of permitted wastes include gases, liquids, solids and sludges.

Each batch of waste scheduled for incineration must be physically surveyed to determine its radionuclide content; process knowledge is not acceptable. Liquid wastes must be analyzed to determine metals content, and the metals content must be sufficiently low that the emissions screening limits specified in EPA "Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerators," Vol. IV, March 1989 are not exceeded. The emission levels assume a facility in complex terrain with adjustment for effective stack height. Process knowledge can be applied to no more than 80% of such wastes.

The chlorine content of the wastes, plus that in any fuel which is simultaneously burned, is limited to 99.4 pounds per hour. In addition, the feed rates for liquid and solid hazardous wastes are limited to ensure that the maximum thermal input does not exceed 1.5 million Btu/hr.

Allowable EPA waste codes include D001 (ignitables), D012 (Endrin), D016 (2,4-D), F001-F005 (spent solvents), F027 (chlorophenols), F028 (soil treatment residues), and a large number of listed U and P wastes. Because of its size and design, this unit will not play a major role in processing ER wastes.

3.4.6 Mound Glass Melter (A-6)

System Description and Status

Mound Laboratory operates a joule-heated glass melter. The melt chamber is 7′ x 4′ x 3.5′ high and uses soda-lime-silica cullet as feed. The off-gas treatment system includes a quench chamber, high-efficiency venturi scrubber, cyclone demister, a multistage bank of HEPA filters, ID fans, and stack.

The unit was placed in operation at the beginning of 1982. In the past, it has been used for limited processing of low-level wastes. Application has been made to the state of Ohio for a RCRA permit, and full permitted operation is expected in 1993.

Waste Handling and Acceptance Criteria

Waste is fed into the furnace through a port in the melt-chamber ceiling. Scintillation vials are crushed and fed into the furnace via two glove boxes. One glove box has a water-cooled screw feeder and the other has a vibrating screw feeder (for IX resins). Liquid wastes are injected directly into the furnace.

At this time, formal WAC for the glass melter at the Mound Plant have not been developed. Current plans for the unit call for the processing of limited quantities of mixed waste and hazardous waste which have been or will be generated on site. This includes vials of scintillation fluids in inventory, combustible solids, some oils, and some spent solvents. Limited future generation is expected, and the available backlog should be destroyed in about six years together with annually generated wastes (HAZWRAP). There are no plans to burn imported low-level wastes in the glass melter although this is deemed feasible and is so indicated in the WMIS data base. This unit will probably not be used significantly for treatment of ER wastes.

3.4.7 <u>Consolidated Incineration Facility</u> (A-7)

System Description and Status

The unit planned for the Savannah River Site (SRS) is a 8 ft diameter x 25 ft long rotary kiln incinerator rated at 18 million Btu/hr. The off-gas treatment system for the Consolidated Incineration Facility (CIF) includes a spray adiabatic saturation quench chamber, steam-driven free jet scrubber, cyclone separator, mist eliminator, reheater, HEPA filter bank, ID fans, and stack.

Construction of the CIF has been deferred for several years due, in part, to the time required to negotiate a RCRA Part B permit with regulatory authorities. The permit was granted in September 1992, and SRS estimates that 39 months will be required for construction, pre-operational check out, completion of the trial burn, and other startup activities. This would put the start of normal operations at the beginning of 1996.

Waste Handling and Acceptance Criteria

The CIF unit will be fed low-level, mixed and hazardous wastes including solids, sludges, organic liquids, and aqueous liquids. Solid wastes include filtered solids from paint thinners, sludges and other chlorinated and non-chlorinated organics. Major solids will be rags, plastic and cloth work suits, shoe covers, PVC sheeting, mops, and floor cleaning equipment. Other solids include solvents, pesticides, and herbicides on absorbent material and limited amounts of contaminated soils. Liquid wastes include solvents, machine cutting and extrusion press oils, paints and thinners, motor and compressor lubricating oils, lab wastes, pesticides, herbicides, and organic process waste streams. Solid wastes will be transported to the CIF in closed incinerable containers which are placed on a conveyor, checked for radiation rate, weighed, x-rayed for foreign objects, and assayed for radioisotope content.

Aqueous waste (mainly sump waste) will be stored in a 6,500-gallon tank. Radioactive benzene will be received by pipeline from storage tanks at the Defense Waste Processing Facility (DWPF). Two 4,300-gallon agitated, insulated, and temperature-controlled tanks for hazardous waste blending and feeding will also be provided.

Because the rotary kiln incinerator at SRS will probably not be operational until early 1996, detailed waste acceptance criteria have not yet been developed. However, a general outline of acceptable wastes is available. The CIF will accept only wastes generated at SRS. This will include low-level, mixed, and hazardous wastes in the form of solids, sludges, organic liquids, and aqueous liquids. A major feed will be contaminated benzene from the DWPF. Although the kiln is capable of accepting soils, operators do not plan to process significant quantities of such materials for two reasons:

- The backhoe device which removes wet ash from the ash pit has a limited capacity (250 lbs/hr), based on ash density from burning paper and plastics; and

- There is concern about slagging fostered by soil constituents.

Waste acceptance criteria will be based on operating the CIF as a Low-hazard Nuclear Facility. This decision, in turn, establishes allowable limits on the radiological and hazardous chemical inventories at the facility (SRS 91). In the event of a serious accident involving release of waste inventory, personnel exposure would be within acceptable limits. During operation a computational approach is used to set the acceptable quantities of individual radioisotopes and chemicals which can be present at the CIF at any one time. Separate inventories are established for the tank farm and for the incinerator system.

For the tank farm, an accident resulting in release of the waste inventory must not expose an individual 100 meters away to a 50-year committed dose of more than four rem. ICRP-30 guidelines are used in this analysis. The analysis assumes a source reduction factor of unity for tritium and 0.01 for all other radionuclides during a two-hour duration release. Exhibit 3-13 lists the acceptable radionuclides and the respective dose conversions adjusted by the appropriate source reduction factor. The corresponding site boundary exposure from this postulated release would be 0.007 rem.

Exhibit 3-13

Sample Fissile Material Calculation - CIF

Nuclide	Segment Inventory (Ci)	Specific Activity (Ci/g)	Mass Amount (g)	Conversion Factor (Ref. 10)	Equivalent U-235 Mass (g)
	(A)	(B)	(C=A/B)	(D)	(E=CxD)
U-233	0	9.5E-03	0	1.20E+00	0
U-235	3.66E-05	2.1E-06	1.74E+01	1.00E+00	1.74E+01
Pu-239	3.22E-02	6.2E-02	5.19E-01	1.60E+00	8.31E-01
Pu-241	0	1.1E+02	0	2.40E+00	0
Total (Must be < 600 grams)					1.82E+01

Chemical hazards from a tank farm accident are treated in a similar manner. The exposure criterion is that the maximally exposed individual at 100 meters will be subjected to an airborne concentration of no more than 50% of the Immediately Dangerous to Life and Health (IDLH) value or 50% of the Emergency Response Planning Guideline-2 value. The analysis assumes a source reduction factor of unity for gases and volatile liquids and 0.01 for nonvolatile liquids, precipitated solids, and dissolved solids during a 30-minute release. Details are included in Appendix F.

Inventories in the incinerator building are set in a similar manner and consider dry boxed waste, dry ash in the incinerator unit, and wet ash. These three sources are summed to determine if the exposure to an individual at 100 meters exceeds 4 rem for the suite of radionuclides or 50% of the IDLH value. Radionuclide source reduction factors, assuming a fire in the CIF building, are as follows:

- 1.0 for tritium;
- 0.01 for all nuclides in boxed waste and fly ash and Ru-106 in wet ash; and
- 1E-4 for all other nuclides in wet ash.

Inventory limits on fissile materials will be set based upon criticality considerations. The principal fissile element expected in the CIF wastes is U-235, but trace amounts of U-233, Pu-239 and Pu-241 may also be present. As illustrated in Exhibit 3-13, limits on each isotope are set such that the equivalent U-235 mass in either the tank farm or the incinerator building does not exceed 600 grams.

3.5 WASTE AND RESIDUAL MANAGEMENT

An important consideration when reviewing the waste acceptance criteria discussed above is whether or not the various facilities can, within the terms of their permits, accept off-site waste. Of those DOE incinerators with clearly defined plans, only the TSCA incinerator at K-25 accepts wastes from other locations[15] (Portsmouth, Paducah, Fernald, Reactive Metals Inc. (RMI), ORNL, and Y-12). Even though the TSCA incinerator can handle off-site wastes, open issues remain with the state of Tennessee and other agencies about the disposition of residuals derived from wastes imported from out-of-state. Consequently, the near-term emphasis is on incinerating liquid wastes which produce very little ash.

A recent paper presented by Ross et al. (MWTP 92a) categorized wastes that would be processed under the proposed Mixed Waste Treatment Project (MWTP). This study demonstrated that about 98% of the mixed waste volume is generated at 12 DOE sites (Fernald, K-25, ORNL, Paducah, Portsmouth, Y-12, Savannah River, Hanford, Rocky Flats, Los Alamos, Lawrence Livermore, and INEL). As noted above, the first six sites on this list are permitted to process their wastes at the TSCA incinerator, assuming that certain ash management issues are resolved. Incinerators exist at INEL and Los Alamos,

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[15] It is not clear at this time whether WERF will accept off-site waste feeds. Limited off-site shipments have been handled in the past (Reidesel).

and construction has begun on the CIF at Savannah River. If the planned FBU at Rocky Flats is not constructed, this would leave only RFP, Hanford and LLNL without mixed waste incineration capability among the 12 major sites.

The remaining 2% of the mixed waste volume is distributed among 21 other DOE sites. Unless DOE's policy is to process waste on-site at every mixed waste location, it could consider shipping the small quantities of waste from these minor generators to other facilities. DOE could also consider shipping wastes from the three major generators that are without incineration capacity (i.e RFP, Hanford, and LLNL) to off-site facilities, assuming capacity is available. If this were done, about 815 m^3 of inventoried combustible wastes plus 153 m^3 of annually generated combustible waste would probably require off-site processing. This approach would require broadening the WAC and the underlying permits at the selected off-site treatment locations and dictate further consideration of packaging, labeling and transportation criteria.

The two commercial facilities handle wastes from a variety of sources and have, on a limited basis, processed DOE wastes. An issue that the commercial facilities must address when handling DOE wastes is how to comply with DOE Order No. 5820.2A, "Radioactive Waste Management." The DOE policy outlined in this Order specifies that LLR/MW shall, if practical, be disposed of at the generator's site, or if on-site disposal is not available, at another DOE site. Ensuring that all hazardous and radioactive constituents contained in residuals are returned to the generator is not a trivial matter. It will entail campaigning of specific waste shipments for isolation of resulting residuals. This campaigning may diminish or preclude the benefits from mixing compatible wastes for processing reasons, including throughput, use of auxiliary fuel, control of effluent concentration, etc.

As plans now stand three facilities would be capable of processing TRU wastes: the existing CAI at Los Alamos, the proposed FBU at Rocky Flats, and the proposed IWPF incinerator at INEL. PCB treatment capability would exist at the TSCA incinerator at K-25, the CAI, and the proposed FBU.

Wastes from ER activities are expected to contain large amounts of soil, rubble and debris. As noted previously, of those incinerators currently in the DOE operational, stand-by and planning base, the rotary kiln is best suited to treat these types of materials. The CIF rotary kiln, however, does not plan to process significant quantities of soils, and the TSCA kiln requires some modifications to its solids handling system to effectively process significant quantities of such materials (IT 92). Thus, additional thermal treatment capacity, particularly rotary kiln capacity, may be needed to accommodate these materials.

A variety of "problem" wastes exist within the DOE Complex. In some cases pretreatment of these waste will be required to meet incinerator WACs. For example, certain PCB-contaminated wastes from the Y-12 Plant contain quantities of mercury and uranium in excess of levels acceptable at the TSCA incinerator (i.e. >5 ppm U and >200 ppm Hg). If these wastes were to be incinerated for PCB destruction, treatment to first remove the metals contamination would be necessary. Alternative waste management strategies may need to be developed for such wastes.

4. SUMMARY AND DISCUSSION OF ISSUES

Though incineration has become a major waste management technology, its use is controversial, particularly for hazardous, radioactive and mixed wastes. Incineration does not destroy all the toxic constituents of the wastes burned. Heavy metals and radionuclides, for instance, are not destroyed. Instead, they either remain in the residual ash or volatilize and become entrained in the off-gases. The entrained contaminants are then either removed by pollution control equipment or captured in the residual ash. The incineration process also may create new products of combustion, which may be toxic. The possibility of hazardous and radioactive emissions from routine operations or from accidents, and the difficulties in disposing of ash containing concentrated contaminants, have generated public opposition to incineration as a waste management technology.

Some existing incinerators have successfully addressed the above concerns and have reduced the potential for environmental risks to acceptable levels. However, if incineration is to become a practical technology for treating LLR/MW and other wastes, changes need to occur. Regulators and operators need to assure the operational safety of incinerators, to address legitimate concerns about the risks they pose to human health and the environment. Further, the public needs to understand and accept the technology and the remaining risks. This chapter presents specific operational and technical issues identified through the survey described in the report, and discusses possible improvements that can help achieve the goals just described.

4.1 OPERATIONAL ISSUES

Major operational issues according to the survey results include permitting process complexities, the cost-effectiveness of DOE versus commercial incinerators, and inaccuracies reported in waste manifests. A lack of consensus on risk assessment methods and difficulties in communicating risks to the public pose additional challenges that must be faced if incineration is to become an accepted treatment technology for LLR/MW.

4.1.1 Permitting Process Complexities

The permitting process is one major constraint on incinerator operations. Most facilities surveyed, whether in the public or the private sector, expressed concern about the complex process required to obtain a permit for construction and operation of a LLR/MW incinerator. For Federal agencies, the process is further complicated by coordination requirements within the department and among facilities, and the time involved in securing Congressional funding. For DOE in particular, an additional constraint is that the modifications and retrofitting which DOE facilities have undergone make permitting more difficult than it is for new facilities constructed specifically to process large volumes of waste. Finally, at the permitting agencies, frequent staff turn over and the dynamic nature of relevant regulations add to the difficulty of the process. It appears that more coordinated effort among Federal agencies is needed to effectively address complexities of the permitting process. One approach for this coordination would be the establishment of a national, interagency team (including DOE, EPA, and other Federal agencies), to address incinerator permitting issues specific to LLR/MW.

4.1.2 Cost-Effectiveness of Public vs. Private Incinerators

The incinerator operating procedures of the private sector and DOE differ greatly. DOE's existing incinerators are relatively small, able to process small quantities of wastes from particular sites rather than provide a large incineration capacity for the entire Department. The cost per unit of waste processed by these small incinerators is relatively high — they must be permitted individually, they have required expensive modifications and retrofittings to meet DOE's growing demand for incineration capacity, and they cannot operate with the same efficiency of larger-scale systems. The private sector, on the other hand, has been able to move forward more quickly with fairly large-scale incinerators. As a result, the cost per unit of waste processed is often lower at commercial than at DOE facilities.

To alleviate this cost disparity, greater use of private-sector LLR/MW incinerators could be considered for more cost-effective waste handling, especially for smaller DOE and other Federal facilities. Such an approach would require DOE to revise its current requirement that LLR/MW and its residuals be disposed at the generator's site or another DOE site (See Section 3.5). Alternatively, DOE could consider constructing fewer incinerators of larger scale. Further study is needed to analyze these choices. For example, the permitting and operating cost savings that may be realized from a few large incinerators would need to be weighed against potentially greater transportation costs and risks.

4.1.3 Waste Manifesting Practices

Several of the survey sites reported that waste generators tend to overstate the levels of radioactivity in their waste. For instance, generators may report the highest obtained reading rather than an average when surveying a waste container. If waste manifesting practices consistently overstate radioactivity levels, then the estimates and public perceptions of radiation risks from LLR/MW incineration may be needlessly inflated. However, given the uncertainty of radiation measurements and risk assessment methods, conservative assumptions may be appropriate to avoid understating risk. DOE and EPA should assess waste manifesting practices to ensure consistency and the appropriate degree of conservatism.

4.1.4 Risk Assessment and Communication

Risk assessment is an essential step in determining the potential hazards of incinerator emissions to human health and the environment. The appropriate risk assessment methodology to use is a major issue, both within and outside the government. EPA alone has prepared numerous publications on various aspects of the process (see references EPA 86a through EPA 91b in the reference list). The variety of methodologies can lead to discrepancies in risk assessment results. To address these discrepancies, DOE could monitor attempts by outside groups to reach a consensus on the appropriate risk assessment methodologies. Consideration also could be given to the formation of a special task force, including top EPA and DOE risk assessors and members of the scientific community, to reach consensus on major issues regarding risk assessment methods.

Another issue related to risk assessment is the best way to communicate risk estimates to the public. The mention of "radiation exposure" normally evokes concern and sometimes fear in the public, regardless of the magnitude of the risks involved. Moreover, people are especially concerned about risks that they cannot control (i.e., involuntary risks), such as the risks associated with environmental releases from LLR/MW processing. While risk assessments may establish a scientifically credible basis for risk estimates, they are difficult for the lay public to understand and appreciate. In addition, the public often distrusts or rejects risk assessments as being highly uncertain and speculative, or simply an attempt to technically justify a preordained decision. Dealing with public perception requires development of the necessary program and tools for effectively communicating risk to affected members of the public. This includes preparing materials and holding public meetings to present information simply and in a way that will reach target audiences.

4.2 TECHNICAL ISSUES

The survey results indicate that the primary technical issues associated with LLR/MW incineration relate to emissions controls and mechanisms to detect and respond to accidents. In particular, the survey identified the following specific technical issues:

- HEPA filters;
- Emissions monitoring and process measurement;
- Management of residuals; and
- Systematic measurement of metals and radionuclide partitioning.

4.2.1 High-Efficiency Particulate Air Filters

Most of the currently operating, on stand-by and planned incinerators described in this report use High Efficiency Particulate Air (HEPA) filters to remove particulate matter from off-gas. The HEPA filter medium is paper-based. Discussions with managers of currently operating and recently operated systems including WERF, DSSI, and SEG indicate that properly designed, maintained, and operated HEPA filter systems show no operational problems. However, in spite of these satisfactory operational reports, some concern may remain about using a combustible filter medium downstream of a combustion system. In particular, the public may perceive it as being be undependable and needlessly risky.

To allay these concerns, there has been considerable research and development over the last several years to develop a non-combustible, sintered-metal filter equivalent in performance to a conventional HEPA filter. For example, LLNL has initiated testing of a sintered-metal HEPA filter on a uranium grit blasting system. LLNL also compared the current filter structure to the particle size distribution found in incinerator off-gas, and concluded that the particulates would become deeply imbedded in the filter medium, making it impractical to clean (BER 92). Additional development work is needed to improve the structure of the sintered-metal filter to the point where such filters can be field tested in an incinerator system. Continued development, testing, and demonstration of sintered-metal filters also needs to be monitored.

4.2.2 Emissions Monitoring and Process Measurement

Monitoring incinerator operations is critical to ensure that routine emissions comply with permissible (regulated) levels. A monitoring system that includes a detection system also provides an early warning of abnormal conditions (such as accidents), which may allow operators to prevent excessive emissions. Incinerator off-gas characteristics can be determined in two ways:

- Certain parameters are monitored continuously (continuous emissions monitoring, or CEM)[16] and, through an appropriate control system, corrective actions such as waste feed cut-off are automatically implemented if a parameter departs from its prescribed limits. Physical parameters such as temperature, flow rate, and opacity are often monitored in this way. Chemical parameters that are frequently monitored continuously (and periodically sampled) include oxygen, carbon monoxide, hydrocarbons, acid gases, and NO_x.

- Components of the off-gas such as particulates, heavy metals, and radionuclides (which may also include heavy metals) can be sampled by an isokinetic sampling system mounted in the exhaust stream and analyzed periodically. Such a sampling and analysis program is conducted at intervals prescribed by the regulatory agencies. Because this information is not available in real time, it cannot be used to respond to system upsets.

Traditionally, many scientists and regulators have considered CEM the best and most desirable form of monitoring to ensure compliance with emissions limits. Under RCRA regulations, CEM is required for several parameters at hazardous waste incinerators (40 CFR Part 264, Subpart O). Similarly, under the BIF requirements (which technically do not apply to incinerators, but may be used for incinerators by permit writers) also require continuous monitoring of CO and a number of other parameters.

Continuous monitoring of CO emitted from LLR/MW incinerators is required to ensure that the combustion efficiency remains high. After years of combustion research, EPA has concluded that CO emissions are a conservative indicator of combustion conditions,

[16] Depending on the parameter being analyzed, CEM systems consist of a pollutant concentration monitor and sometimes an emissions flow monitor, combined with an automated data acquisition and handling system for continuously measuring and recording emission parameters.

and that low CO emissions (less than 100 ppm on a rolling hourly average, corrected to 7% O_2 on a dry volume basis) indicates high organic destruction and removal efficiency (DRE) and low emissions of products of incomplete combustion (PICs). The converse, however, is not always true; CO emissions greater than 100 ppm do not necessarily indicate low DRE and high PIC emissions. EPA has thus implemented a two-tiered approach for control of PIC emissions, requiring continuous hydrocarbon (HC) monitoring as an additional condition to determine PIC emissions when the CO exceeds 100 ppm.

Although CO is a very conservative indicator of the effectiveness of the incineration process, it may also be desirable to measure individual organic species in the off-gas directly. Researchers at Argonne National Laboratory are studying the use of fourier transform infrared spectroscopy (FTIR) to continuously monitor incinerator off-gas for organic species (IC 89D, IC 91). Recent work, which was reported at the 1992 Incineration Conference, has demonstrated that the process also works well on chlorinated hydrocarbons. DOE planned to fund a test on an operating incinerator in 1992 (DEM 92).

Sandia Livermore National Laboratory recently began a program to study the feasibility and detection limits for a continuous metal emission monitoring system based upon laser spark emission spectroscopy (BRG 92). Initial work will involve metals in aerosols and will seek to demonstrate the sensitivity of the method.

The need exists to develop, test, and standardize monitoring methods for radionuclide emissions. Incineration systems should incorporate monitoring devices both at the point of emission from the stack and at earlier stages of the incineration process. This will allow early warning of filter breakthrough before the final filtering stage or stack release, and allow shutdown before operations cause undue risk.

Further research and development is needed for both CEM and periodic sampling of LLR/MW incinerator emissions. EPA and DOE should continue to monitor FTIR development, testing, and demonstration for continuous emissions monitoring of speciated organics, as well as the development of laser spark emission spectroscopy for continuous emissions monitoring of metals.

At the same time, an automated and/or more frequent periodic sampling and analysis program is a necessary complement to CEM. At present, filter sampling and counting methods allow detection of radionuclides at levels 4 to 6 orders of magnitude below that of CEMs and should continue to be used for more accurate measurement of actual releases and assessment of risks from incineration.

4.2.3 Residuals Management

A key, but often under-emphasized, element in the safe and effective use of incineration as a waste treatment process is management of the process residuals. Incinerator ash is usually the most prominent of the residuals. The main component of incinerator ash is bottom ash discharged from the primary and secondary combustion chambers. Lesser quantities of fly ash are collected from heat exchangers, baghouses, and other devices. Other wastes that must be considered include scrubber dry solids or blowdown liquids and sludges, and spent HEPA filters.

Ash is not a hazardous waste if the waste treated in the incinerator was considered hazardous solely because it exhibited a characteristic, and that characteristic was destroyed during incineration. However, if the incinerator is treating a mixed waste where the hazardous component is a listed waste, then under the RCRA "derived-from rule," the ash is also a listed waste unless it is subsequently delisted.[17]

In addition, the concentration of metals and radionuclides in the ash will be higher than in the waste feed because of the substantial volume reduction inherent in the incineration process. Thus, it is possible that when treating a waste that is not a hazardous waste, the concentrating effects of the incineration process may result in ash that is a hazardous waste. In either case, incinerator residues often will require additional treatment to remove or limit the mobility of metals. Post-incineration treatment may include stabilization, solidification, vitrification, extraction, or another treatment process that allows the residue in final form to comply with LDRs and be placed in a secure landfill for final disposal. Coordination and collaboration among appropriate entities (EPA, DOE, NRC, etc.) is needed to develop specific guidelines and procedures for identifying appropriate regulatory requirements for the management of incinerator residuals, as well as acceptable methods for treating and disposing of the residuals.

4.2.4 Systematic Measurement of Metals and Radionuclide Partitioning

The recognition that emissions of metals and radionuclides from incinerator stacks can represent a significant health and environmental risk has led to a considerable amount of research to better characterize the way they partition between the various incinerator effluents (off-gas, bottom ash, fly ash, scrubber blowdown, etc.). Attempts to obtain a metals mass balance throughout the incinerator/APC train[18] have so far proven difficult (WAT 91). Further research and development activities are needed to improve the analysis of metals and radionuclides mass balance, possibly using non-radioactive isotopes as surrogates for radioactive constituents. Consideration could be given to sampling before and after each piece of equipment in the incineration/APC train to determine the partitioning of metals and radionuclides into different residual effluents. Also, the effectiveness of HEPA filters in reducing metal and radionuclide emissions from incinerators could be measured.

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[17] In Shell Oil v. EPA, No. 80-1532 (D.C. Cir. Dec. 6, 1991) the mixture and derived-from rules were vacated and remanded to EPA for failure to provide adequate notice and opportunity for comment before their 1980 promulgation. In response to the remand, EPA published an interim final rule in March 1992, which reinstated these rules until April 28, 1993. EPA is considering a number of alternative rulemaking options on hazardous waste identification that may affect waste mixtures and residues.

[18] That is, to trace all the metals and radionuclides in an incinerator's inputs and determine their distribution in its outputs.

4.3 CONCLUSION

Incineration is a critical component of DOE's LLR/MW management strategy. Though the technology has been refined and its use has increased over the past decade, additional work is required to ensure that it is a practical and accepted technology. Resolution of remaining operational and technical issues presented in this report is a critical component of this effort. These issues are intended to facilitate discussion and can serve as a starting point.

APPENDIX A
Incinerator Survey Forms

APPENDIX A-1
INCINERATOR SURVEY FORM

RADIOACTIVE AND MIXED WASTES

1. KEY CONTACTS (name, address, position, telephone)

2. SYSTEM DESCRIPTION

   A. Waste Handling (including segregation, weighing, assay, feed types, etc.)
   B. Incinerator (type, capacity, operating parameters)
   C. Off-Gas Treatment
   D. Off-Gas Monitoring
   E. Ash Handling and Disposal
   F. Ash Monitoring
   G. Liquid Effluent Handling
   H. Liquid Effluent Monitoring
   I. Safety Systems and Redundancies
   J. Planned Modifications (nature, reason for, schedule, cost)
   K. Permit Types and Requirements

3. OPERATING HISTORY

   A. Preliminary Planning (basis for system and component selection, alternate approaches considered)
   B. General Chronology (startup, trial burn, steady state, etc.)
   C. Description of Upsets, Accidents and Corrective Actions
   D. On-Stream Analysis - (actual versus nameplate capacity, on-stream time-historical and expected in future.)
   E. Radionuclide Mass Balance
   F. Staffing
   G. Operating Cycle
   H. Waste Disposal Issues (HEPA filters, scrubber liquor, etc.)

4. OPERATING AND MONITORING PRACTICES (Current and Planned Changes)

   A. Waste Classification and Handling Procedures
   B. Ash and Liquid Effluent Management
   C. Stack Monitoring
   D. Response to System Upsets (inc. management responsibilities, notifications, evacuation plans etc.)
   E. Operator Training
   F. Incinerator and APC System Operation
   G. Maintenance Procedures (inc. special problems, high maintenance items)

H. Contingency Plans
I. Operating and Maintenance Costs
J. Environmental Monitoring

5. WASTE FEEDS

A. Description - (type [LLW, Mixed, TRU], physical form, chemical character, nature and quantity of radionuclides)
B. Source - (location, waste producing process)
C. Quantity - (in inventory, currently produced, expected future production)
D. Waste Acceptance Criteria - (current, planned changes, reasons for change, impact on feeds)

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures
B. Laboratory Analysis - (instrumentation used, limits of detection and sensitivity, QA/QC procedures, analytical interferences effecting radionuclide mass balances)
C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach
B. Adverse Public Reactions (including state and local government involvement)
C. Risk Assessments
D. Regulatory and Permitting Requirements

APPENDIX A-2
INCINERATOR SURVEY FORM

CAI - LANL

1. KEY CONTACTS

Los Alamos National Laboratory
Los Alamos, NM, 87545

Stan Zygmunt (505) 667-7391

2. SYSTEM DESCRIPTION

A. Waste Handling
American Science and Engineering 90 kv x-ray unit for inspection of boxes of solid wastes for free liquids or non-combustibles. Jomar Systems multiple energy gamma assay system for TRU isotopic species and concentrations. Waste boxes placed in glove box and moved onto side ram elevator platform and raised into position in front of main feeder ram. Feed one box at a time at predetermined frequency into incinerator.

B. Incinerator
Dual chamber CAI (modified Environmental Control Products model ECP 500-T), designed by Joy Energy Systems for solid and liquid waste feed. Incinerator is rated at 1.5 million Btu/hr for either solids or liquids (which are not fed simultaneously). Primary chamber operates at 1400 - 2000^{o} F while secondary chamber operates at 2000 - 2200^{o} F. No waste feed into secondary chamber. For fast shutdown 100 lb/hr of steam is available for snuffing primary chamber.

C. Off-Gas Treatment
Components include water spray quench column to cool gases from 2000 - 2200^{o} F to about 160^{o} F, high energy venturi scrubber, counter-current packed column absorber/demister, offgas superheater, primary HEPA filters (99.97% removal at 0.3 microns), carbon bed absorber for residual organics, secondary HEPA filters, parallel ID fans, and vent stack. Primary HEPA filter bank contains four modules, two of which operate in parallel and two are serve as backup. Each module contains a prefilter, a primary HEPA filter and a secondary HEPA filter in series.

D. Off-Gas Monitoring
Offgas sampled for CO, CO_2 and water at station upstream of ID fans. Continuous stack monitoring system involving pseudo-isokinetic sampling

head and filter analyzed weekly for radionuclides. Note that this stack also is the exhaust for room ventilation air which accounts for about 10,000 acfm as compared to the incinerator which contributes about 1200 acfm.

E. Ash Handling and Disposal
Ash from primary combustion chamber falls into an air-cooled hopper and then through two knife gate valve module into 55 gal drums. After assay, ash is solidified in drum cementation process with the details yet to be determined.

F. Ash Monitoring
Ash assayed for radionuclides and analyzed chemically. Segmented gamma scanning used to measure TRU content of ash.

G. Liquid Effluent Handling
Scrub solution from quench, venturi, and packed column units is collected in sump tank, passed through a hydrocyclone for particulate removal, cooled in a heat exchanger and recirculated to the process. Blowdown is filtered through polypropylene filter bags and discharged into an on-site liquid waste treatment plant.

H. Liquid Effluent Monitoring
Blowdown sampled prior to discharge to on-site waste treatment plant.

I. Safety Systems and Redundancies
Automatic shutoff of waste feed if process upset or failure occurs. Feed cannot be restarted until proper operation is restored. System has uninterruptable power supply with diesel generator, and pressurized water tanks to backup municipal water supply. Redundant pumps are provided for scrub solution circulation. HEPA filter redundancy described in 2C above. Building HEPA system provides additional backup. Pressure drop across HEPA filters is continuously monitored and tied to high pressure alarm which indicates need to switch from one bank to the other. Low pressure drop indicates breach of HEPA and need to switch to building HEPA system.

J. Planned Modifications

K. Permit Types and Requirements
TSCA, NESHAPS (laboratory-wide), RCRA (State of NM).

3. OPERATING HISTORY

A. Preliminary Planning

B. General Chronology
Cold testing and modification from 1976 - 1980.
Operation begun in 1979.
TSCA permit granted in 1984.
RCRA trial burn in 1986.
Facility in standby mode for upgrade since 1987.
RCRA permit from state of New Mexico Health and Environment issued November 8, 1989

C. Description of Upsets and Accidents and Corrective Actions
Superheater moved further upstream from HEPA filter bank to minimize filter blockage by liquid droplets. This provides about 1 sec of residence time in duct for droplet evaporation prior to HEPA bank. Severe chloride corrosion found in impellers and housings of original ID fans. Fans have been replaced with new units containing galvanized internals and incinerator shutdown procedures have been modified to eliminate post-run condensation in blowers.

D. On-Stream Analysis

E. Radionuclide Mass Balance

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures
Solid wastes packed in 1x1x2 ft cardboard boxes and shipped in DOT approved metal containers holding 32 boxes. Containers opened and checked for surface alpha. No solid waste sorting operation; waste packages not accepted for incineration returned to generating group. Pu in CAI process administratively controlled to 400 g (400 g X 0.0714 Ci/g = 28.56 Ci of alpha activity). Combustible mixed waste liquid inventory limited to 4230 gal.

B. Ash and Liquid Effluent Management
Ash handling system can accommodate large clinkers and non-combustibles up to about 12" dia. Ash from burning listed wastes must be cemented before disposal. Scrub solution is routinely monitored by specific gravity for build up of salts and when level reaches 1.03 blowdown is initiated. Scrubber solution continuously monitored for Ph and recycle water flow rate. Liquid effluents and filters must be disposed of as hazardous wastes.

C. Stack Monitoring
Continuous monitoring and/or recording devices observed hourly during waste feed operations and observations recorded. Parameters include CO, total hydrocarbons and radioactivity. The CO limit is 100 ppmv with an allowable 5 minute excursion to 500 ppmv. THC limit is 20 ppm for one hour rolling average with allowable excursion to 100 ppm for one minute max. and single reading of 500 ppm. Radioactivity may not exceed background by more than 10 % with allowable excursion to 50% above background for no more than one minute.

D. Response to System Upsets
Three shutdown modes (controlled, fast and scram) are provided with automatic and/or manual initiation. Loss of primary water supply initiates controlled shutdown of incinerator.

E. Operator Training

F. Incinerator and APC System Operation
Approximately 70 process parameters monitored on real time basis including waste feed rate, primary combustion chamber temperature, secondary combustion chamber temperature, SCC oxygen content, and combustion air flow.

G. Maintenance Procedures
Carbon absorber materials must be replaced every 2000 hours per RCRA permit. Automatic cutoff system must be tested every 2000 operating hours.

H. Contingency Plans

I. Operating and Maintenance Costs

J. Environmental Monitoring
LANL maintains 25 air monitoring stations in vicinity of lab as well as stations for ground water, surface water and soils monitoring. Incinerator building monitored and sampled for airborne releases of alpha radioactivity using continuous air monitors and fixed head sampling devices.

5. WASTE FEEDS

A. Description
Primarily solid TRU waste (i.e. >100 Nci/g - mostly Pu-239 contamination) such as rags, rubber gloves, booties, cheese cloth, etc.; some solid and liquid LLW and Mixed Wastes containing TRU isotopes; RCRA/TSCA

wastes. Typical solid waste is 35% cellulose, 12% PVC, 23% PE and 30% polyisoprene with a heat content of 6900 Btu/lb. RCRA permit states that gases, solids, liquids and semi-solid sludges may be incinerated. Chlorine content of waste plus fuel for each batch must not exceed 99.4 lbs/hr.

B. Source
LANL only per RCRA permit.

C. Quantity
See Tables 1-7 and 1-8 Radiation and Mixed Waste Incineration Report Volume 1. (Ref. 3)

D. Waste Acceptance Criteria
Maximum concentration of radioactivity in waste feed matrix limited to 15000 nCi/g.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures
Monitor for Pu-239 - alpha and mixed fission products - beta (weekly or monthly). Pu-239 concentrations are generally less that the lower limit of detection, and, when detected, almost always run at less than 10% of the MPC (in the period 1980-1990 one measurement was noted as high as 25.5% of MPC). This includes other sources than just the incinerator. Total Pu release from 1979 through 1989 YTD was 0.4746 uCi. Similarly the total release of mixed fission products from 1981 to 1989 YTD was 8.846 uCi. (See Table TA-50-37 attached.) Annual emissions of Pu and mixed fission products were 2 to 5 orders of magnitude below Radiation Concentration Guide limits in every year. See Tables 1-15, 1-16, 1-17 and 1-18 Radiation and Mixed Waste Incineration Report, Volume 1 for more details.

B. Laboratory Analysis

C. Prospects for Real Time Radioactive Emissions Monitoring
Looking into purchase of Berthold LB-150-D Alpha/Beta particulate monitor (or a continuous alpha monitor) as on-line check for HEPA filter integrity.

7. OTHER ISSUES

A. Public Outreach
Community meetings on incineration held in Los Alamos, Taos, and Santa Fe.

B. Adverse Public Reactions
Citizens group protested lack of regulations by state of NM for incineration of radioactive wastes and the fact that environmental impact statement on incineration not prepared. Complained that Dallas Region of EPA is responsible for ongoing inspection and Dallas is too far away.

C. Risk Assessments
Assessment of Radiation Doses and Resulting health Risks from the Controlled-Air Incinerator, Thomas Buhl - LANL, July 1989.

D. Regulatory and Permitting Requirements

8. REFERENCES

Hazardous Waste Incineration at Los Alamos National Laboratory, LALP-89-30, July, 1989.

Letter From Charles V. Warner - Waste Management Group LANL to Richard Mayer U. S. EPA Dallas TX dated August 23, 1989 with attachments.

Radiation and Mixed Waste Incineration Background Information Document Volume 1: Technology, EPA 520/1-91-010-1, May 1991.

Hazardous Waste Facility Permit issued by State of New Mexico Health and Environment Department, Environmental Improvement Division dated November 8, 1989. Permit NM 0890010515-1.

APPENDIX A-3
INCINERATOR SURVEY FORM

DSSI COGENERATION MIXED WASTE FUELED BOILER

1. KEY CONTACTS

Diversified Scientific Services, Inc.
P.O. Box 863
Kingston, Tennessee 37763
(615) 376-0084

James T. McVey, Executive Vice-President
Larry L. Hembree, Customer Service Representative
Joe Crider - Plant Manager

2. SYSTEM DESCRIPTION

A. Waste Handling
Feed is solvent waste containing low-level radioactivity. Wastes include D001, F001-005 plus numerous D, U, and P listed materials. Solvents may not contain halogens or heavy metals. Vials or containers of glass and plastic are crushed and the solvents separated and transferred to one of seven 250 gal. holding tanks for testing. If materials meets WAC, it is transferred to one of three 10,000 gal. carbon steel storage tanks for feed to boiler. The crushed container material is washed with solvent and after radiation survey is sent to an outside recycle facility.

B. Incinerator
York-Shipley mixed waste fueled boiler (three-pass) using natural gas as auxiliary fuel. Boiler drives Seeco electrical generator. Boiler rated at 16.5 million Btu/hr max. Minimum boiler operating temperature is 1800^{o} F with 1 second combustion chamber dwell time. Boiler limited to 14.5 million Btu/hr by state air permit.

C. Off-Gas Treatment
APC system consists of semi-dry scrubber (quench tower, packed column scrubber, and baghouse), prefilter (95 % eff.), HEPA filter (99.97 % eff.) and carbon adsorber. Particulate emissions limited to 3.09 lbs/hr and stack opacity may not exceed 20%. Gas exhausted through stack which is 30 feet high, 3.25 ft in dia, with a volume of 33,000 cfm, an exhaust temperature of 99^{o} F and a velocity of 70 ft/sec. Building is 20 ft high at center and 16 ft high at eaves.

D. Off-Gas Monitoring
Stack is continuously monitored for alpha, beta, and gamma radiation, tritium, carbon-14, particulates, uncombusted organic vapors and CO. All of these monitors will alarm at levels below licensed allowable limits and shut feed down when upper set point is reached.

E. Ash Handling and Disposal
Ash will be solidified (at DSSI or Chem Waste Management) to meet TCLP and sent to Envirocare in Utah for burial.

F. Ash Monitoring
TCLP testing.

G. Liquid Effluent Handling
Dry scrubber.

H. Liquid Effluent Monitoring

I. Safety Systems and Redundancies

J. Planned Modifications
Have just completed addition of scrubber and baghouse.

K. Permit Types and Requirements
Radioactive Materials License - Tennessee Department of Conservation, Division of Radiological Health.
APC Permit - Tennessee Department of Health and Environment, Tennessee APC Board.
Treatment, Storage and Disposal (Type-B) Permit - Tennessee Department of Health and Environment, Division of Solid Waste.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs) Permit - U.S. EPA.
Electrical Cogeneration Permit - Federal Energy Regulatory Commission.

3. OPERATING HISTORY

A. Preliminary Planning

B. General Chronology
Permitting activities initiated in July 1987. Construction initiated about July 1989.

C. Description of Upsets, Accidents and Corrective Actions

D. On-Stream Analysis
Design feed rate - 2 gpm.
Annual capacity - about 1.1 million gallons at 100% on-stream.
Processed about 4800 gal. through end of 1991.

E. Radionuclide Mass Balance

F. Staffing

G. Operating Cycle
Plan to run to run 24 hrs/day, 5 days per week now and 7 days per week later.

H. Waste Disposal Issues

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures

B. Ash and Liquid Effluent Management

C. Stack Monitoring
CO, radionuclides, particulates and uncombusted organic vapors. Current specifications include 6.96 lbs/hr particulates, 5 lbs/hr Hcl, 0.029 lbs/hr Cl_2 and 0.0124 lbs/hr HF.

D. Response to System Upsets

E. Operator Training

F. Incinerator and APC System Operation
Sensors monitor fuel feed rate, boiler temperature, steam production, etc. Blowdown boiler daily collecting 200 gal. of water which is processed through IX bed and returned as makeup.

G. Maintenance Procedures

H. Contingency Plans

I. Operating and Maintenance Costs

J. Environmental Monitoring

5. WASTE FEEDS

A. Description
Waste solvents with low-level radioactivity. Feed limited to 0.05 Uci/g of H-3 and C-14 or 0.002 Uci/g of all other licensed isotopes.

B. Source
Have handled some hexone-water mixtures from Hanford with tritium and trace alpha. Bidding on other DOE wastes.

C. Quantity

D. Waste Acceptance Criteria
Solvents containing halogens or heavy metals are not acceptable. Typically handle D001, F001 to F005 fluids plus several listed D, U and P wastes.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures

B. Laboratory Analysis
Have gamma spectrometer and GC. Will add GC-MS soon.

C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach
Approximately 50 sessions were conducted with local regulatory officials, fire departments, neighbors, elected representatives (federal, state and local), near-by communities, radio, television, and newspaper reporters, chambers of commerce, professionals, interest groups and civic organizations. Notice of public gatherings with community residents was published in local newspapers and announced by distributed invitations to provide a question and answer forum. Public hearings were held per applicable regulations.

B. Adverse Public Reactions
Not a significant problem.

C. Risk Assessments
Risk assessment done using AIRDOSE and assuming worst case isotopic release of 2.7 times allowable annual limit and 33% of all food consumed being home produced resulted in total body dose of 13.2 mrem/yr. If 100%

of all food consumed was home grown, the annual total body dose was 27.9 mrem.

D. Regulatory and Permitting Requirements

APPENDIX A-4
INCINERATOR SURVEY FORM

K-1435 TSCA - ORGDP

1. KEY CONTACTS

Oak Ridge K-25 Site
Martin Marietta Energy Systems Inc.
Oak Ridge, Tennessee 37831

Tom Rogers, Div. Mgr. - (615) 574-9009
Dr.W.D. Bostick - (615) 574-6827, mass balance work
Brenda Snyder - (615) 576-4976, WAC

2. SYSTEM DESCRIPTION

A. Waste Handling
Liquid wastes stored in 5000 gal receiving tanks then mixed in 10000 gal blending tanks. Drum deheading, emptying and draining facilities, as well as solid waste shredding provided. Shredded waste is taken from bin with grapple and delivered to feed ram while other bulk material is fed to ram by belt conveyor.

B. Incinerator
Rotary kiln (6 ft ID x 25 ft long) with ram feeder for solids operating at 1500 to 1800^{o} F followed by secondary combustion chamber operating at 1800 to 2200^{o} F. Solids retention time is 23 to 90 minutes. SCC gas residence time is 4 sec. Incinerator and off-gas treatment systems were designed and constructed by International Waste Energy Systems. The kiln has a maximum heat release rate of 10 million Btu/hr while the SCC is rated at about 22 million Btu/hr. The total system maximum heat rate is 28 million Btu/hr.

C. Off-Gas Treatment
Water quench tower cools gases from 2200^{o} F to 188^{o} F, venturi scrubber removes particles greater than 1 micron and some HCl, demister removes water droplets, packed bed scrubber removes additional soluble and reactive gases, two-stage, horizontal crossflow wet ionizing scrubber removes particles under 1 micron before exhausting through 100 ft stack. No HEPA filters in system. No redundant ID fan. All ducting in APC system is FRP.

D. Off-Gas Monitoring
Stack is monitored for U, Tc, I, gross alpha, beta and gamma.
Specifications include 99.5% HCl removal, combined acid gas removal of 99.2%, particulates less than 0.06 gr/dscf.

E. Ash Handling and Disposal
Solids leaving kiln fall into a water-filled sump from which they are removed by drag link conveyor to collection hopper and transferred into 55 gal. drums.

F. Ash Monitoring
Solids from E above assayed and stored for future disposal.

G. Liquid Effluent Handling
Blowdown liquid is sent to 30,000 gal. purge tanks and then to a treatment facility for neutralization and solids removal. Carbon columns are available to remove organics as required.

H. Liquid Effluent Monitoring
Analyzed for organics to see if carbon treatment is required.

I. Safety Systems and Redundancies

J. Planned Modifications

K. Permit Types and Requirements
NESHAPs - Monitor stack for U, Tc, I, and gross alpha, beta and gamma.
RCRA - for hazardous wastes. TSCA - for PCBs. State of Tenn. for air.
NPDES - for water.

3. OPERATING HISTORY

A. Preliminary Planning
See Report No. X-OE-141 for details.

B. General Chronology
Public hearings for EIS held in 1981.
EIS issued in June, 1982.
Construction started in early 1984. System cost $26 million.
Startup - June, 1987.
TSCA permit received in March, 1989
RCRA trial burn completed in June, 1989.
ID fan failure in June, 1989.
Fan replaced and system restarted on March 23, 1990.
Full-scale operation since April, 1991.

C. Description of Upsets and Accidents and Corrective Actions
Operations suspended in June 1989 due to failure of induced draft fan. New fan procured under improved QA plan.

D. On-Stream Analysis
Feed rate for liquid wastes is 500-900 lb/hr; for solid wastes is 700 lb/hr; and for sludges is 450 lb/hr. Maximum combined feed rate for all products is 2618 lbs/hr. State air permit limits annual incineration rates to 2562 tons for solids and 6954 tons for liquids. In FY-1991 processed 2.18 million lbs of waste mostly liquids. In FY-1992 plan to process 2.5 million lbs of liquids and ca. 100,000 lbs of solids for test purposes.

E. Radionuclide Mass Balance
In 1988 fed 9.5E-5 Ci of Tc-99 in liquid wastes and measured 1.6E-3 Ci out the stack. Have developed some data on U in feed and U in stack.

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures
RCRA and TSCA wastes stored in separate areas.

B. Ash and Liquid Effluent Management
Ash generation is about 10 ft^3/hr during operation, ash which is a mixed waste contains about 20% moisture and has a density of about 67 lbs/ft^3. Ash is, for the interim, stored in 4x4x6 ft lined boxes which are traceable to specific burn campaigns. In FY-91 generated 26 drums of ash mostly from some soils testing.

C. Stack Monitoring

D. Response to System Upsets

E. Operator Training

F. Incinerator and APC System Operation
Incinerator is required by permit to have Destruction Removal Efficiency (DRE) of 99.993% for non-PCBs and combustion efficiency of at least 99.95%.

G. Maintenance Procedures

H. Contingency Plans

I. Operating and Maintenance Costs

J. Environmental Monitoring
Five long-standing air monitoring stations in place at ORGDP and additional stations to be added to support incinerator.

5. WASTE FEEDS

A. Description
Handles solids such as contaminated soils, absorbents, and biological materials; liquids such as waste oils, solvents and water solutions; as well as sludges including paint sludges, oil and grease sludges, solids from waste water treatment and degreaser residues. Waste may contain PCBs, hazardous organics and low enriched uranium.

Major radionuclides expected in feeds include H-3 - 1.58 Ci/yr; C-14 - 0.18 Ci/yr; P-32 - 0.20 Ci/yr; S-35 - 0.076 Ci/yr; Cr-51 - 0.011 Ci/yr; Tc=99 - 14.6 Ci/yr; I-125 - 0.29 Ci/yr; I-131 - 0.051 Ci/yr; and U - 0.42 Ci/yr.

Feeds for 1988 and 1989 included 20490 gal and 19233 gal liquids and 160 ft^3 and 133 ft^3 solids, respectively.

B. Source
Diffusion plants at Oak Ridge, Paducah and Portsmouth. The Y-12 Plant and ORNL in Oak Ridge. The Feed Materials Production Center at Fernald, OH and the RMI Extrusion Plant at Ashtabula, OH. As of 1Q 1992 had processed no wastes from ORNL or RMI.

C. Quantity
Annual generation rates estimated to be 15.2 million lbs/yr solids/sludges and 220,000 gal/yr of liquids. Current inventory includes 3.2 million lbs of liquids and 18.8 million lbs of solids.

D. Waste Acceptance Criteria
All wastes from processes involving radionuclides must be analyzed for those nuclides. See Report K/HS-252/r2 for details.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures
Continuously perform isokinetic sampling of stack for U, Tc, I-125, I-131, gross alpha, gross beta, and gross gamma for NESHAPS requirement using filter, condenser and impingers. Samples assayed weekly. Other test results include DRE for POHCs >99.99% avg. (7 tests); particulates 0.034 gr/sdcf avg. and 0.003 to 0.077 gr/sdcf range (24 tests); HCl removal 99.92% avg. and 99.66 to 99.99% range (25 tests); combustion efficiency >99.99% avg. (3 tests); CO in stack gas <10 ppm avg. and 1-16 ppm range (24 tests).

B. Laboratory Analysis
QA/QC procedures described in document K/PS-1032.

C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach
Public hearings relative to EIS held in Oak Ridge, Kentucky and Ohio in 1981. Additional public meetings held in Oak Ridge in 1987 and 1988 and in Kingston, TN in 1988.

B. Adverse Public Reactions
Not a major issue.

C. Risk Assessments

D. Regulatory and Permitting Requirements

8. REFERENCES

National Emission Standard for Hazardous Air Pollutants Compliance Verification Plan for the K-1435 Toxic Substances Control Act Incinerator, K/HS-109, M.L. Ambrose, July 28, 1986.

Analysis of the Environmental Significance Resulting From Changes in the K-25 Toxic Substance Control Act Incinerator Design and Waste Streams Since the Issuance of the Final Environmental Impact Statement, K/HS-109 Attachment 3, R.E. Saylor et. al., August 16, 1985.

Waste Acceptance Plan and Analytical Protocol for the K-1435 Toxic Substance Control Act Incinerator, Project No. 409371.25, IT Corp., October 1, 1986.

Untitled, K/SS-455, Undated Draft.

Letter from W.D. Adams, ORO to S.P. Cowan, Office of Waste Operations Dated October 5,1990.

Startup and Trial-Burn Tests of the Oak Ridge TSCA/RCRA incinerator, Reter J. Kroll and Tom O. Rogers, Presented at 1989 Incineration Conference, Knoxville, Tenn.

APPENDIX A-5
INCINERATOR SURVEY FORM

WERF-INEL

1. KEY CONTACTS

D.D. Cochran, Shift Supervisor
EG&G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415
(208) 526-8008

2. SYSTEM DESCRIPTION

A. Waste Handling
Combustible solids in PE-lined cardboard boxes on roller conveyor automatically-scanned by X-ray for non-combustibles and beta/gamma monitor for radioactivity, weighed and passed through air lock to an elevator and into a waste-loading chute. Solid wastes fed continuously for 4 hours. Can vary from 100% wood to 100% plastic. Rely on waste segregation to remove acid-forming materials (no wet scrubber). No chemical assay for low-level waste feed. Liquid waste in drums is sampled, connected to liquid waste supply line and pumped to vortex burner.

B. Incinerator
Dual-chambered CA combustion unit (Model 1000TL) manufactured by Environmental Control Products (now Ecolaire) in Charlotte NC. Incinerator operates in sub-stoichiometric mode during solid waste feed then shifts to excess air mode by providing underfire air to burn fixed carbon. With liquid wastes always runs with excess air. System rated at 5 million BTU/hr.

C. Off-Gas Treatment
Dry system with shell and tube heat exchanger (flue gas inside tubes), bag house filter, HEPA filters (stainless steel frame and glass media), parallel ID fans and 49 ft stack (North stack). Separate South stack handles cooling air from HX and other building exhausts.

D. Off-Gas Monitoring
Annubar for stack gas volumetric flow, non-dispersive IR analyzer for continuous CO and HCl, O_2 monitor in SCC, CAM in stack.

E. Ash Handling and Disposal
Bottom ash passes into cooling hopper, then into a shredder to break up clinkers, and then through a gate valve into a drum. Flyash can be pneumatically-conveyed to a separate drumming station or handled manually. All ash is solidified in cement.

F. Ash Monitoring
Total C content runs less than 0.5%. Raw ash randomly sampled for gross radioactivity. Stabilized ash tested by TCLP.

G. Liquid Effluent Handling
Dry system.

H. Liquid Effluent Monitoring
Not required.

I. Safety Systems and Redundancies
Spark arrestor upstream of baghouse. Automatic solid and liquid waste feed cutoffs. UV detector for propane pilot on auxiliary fuel system. Primary and secondary combustion chamber temperature controllers interlocked with burners, waste feeders and steam quench.

J. Planned Modifications
Considering installation of larger capacity burners for faster startup and better burnout of carbon. Have installed packed column scrubber for acid gas removal but have not piped it into incinerator system. Installing distributive control system for better data keeping and reduced possibility of operator error.

K. Permit Types and Requirements
Currently operating under RCRA Interim Status permit after trial burn with liquid waste system in 1988. INEL will submit facility-wide RCRA part B at end of 1992. Permit to Construct (PTC) from state of Idaho specifies materials which can be incinerated.

3. OPERATING HISTORY

A. Preliminary Planning
Originally designed for solid waste only.

B. General Chronology
Began processing radwastes in September 1984; limited operation through October, 1985; then began accepting from all INEL waste generators.

Through May 1988 had operated about 4500 hours and burned 4250 m^3 of waste. Shut down February 1991 to update Operational Safety Requirements. Restart was scheduled for October 1991 but has now been delayed at least 15 months.

C. Description of Upsets and Accidents and Corrective Actions
Ash removal system clogged with clinkers requiring replacement of system. Sporadic wet, sticky flyash requires reduction of off-gas cooling thereby raising baghouse from 149-177^o C to 204-215^o C for 30-60 minutes. Bridging across flyash hopper outlet requires immediate transfer after pulse cleaning or air jet breakup. Slag buildup on lower chamber floor must be routinely chipped out or ash ram will jam. Some refractory wear noted around lower door to loading chute requires routine repair. Heat exchanger tubes not properly cleaned during early operations. Now reamed out after each 28 day burn cycle.

D. On-Stream Analysis
Nameplate capacity is 400 lb/hr (180 kg/hr). However, PTC limits average feed rate to 200 lbs/hr. On-stream time in 1986 was 15% and in 1987 was 23%. During the time actually on-stream the average feed rate in 1986 was 76 kg/hr and in 1987 was 56 kg/hr.

E. Radionuclide Mass Balance
Total radioactive releases were 0.27 uCi in 1986, 1.8 uCi in 1987, 2.6 uCi in 1988 and 1.3 uCi in 1989. Waste feeds were 1620, 1475, 1996 and 1621 m^3/yr 1986-1989 respectively.

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures
All mixed waste is processed via Mixed Waste Storage Facility or WERF Waste Storage Building. Boxes of waste feed checked by X-rays for booties, tygon tubing, masks, etc. (Cl issue) and rejected if acid gas formers are excessive. Mixed wastes must be chemically assayed and, consequently, boxes are opened, sampled, visually inspected and repackaged.

B. Ash and Liquid Effluent Management
Fly ash and bottom ash stabilized with Portland cement using differing ash/cement ratios. Fly ash handling system not currently approved for use by DOE-HQ.

C. Stack Monitoring
During normal conditions NO_2, CO and HCl emissions run at 5-30 ppm each, SO_2 is 15-25 ppm and HC is 5-20 ppm. Particulates are 0.0018 gr/dscf.

D. Response to System Upsets

E. Operator Training
Safety training of operators is monthly. Operators also receive 40 hours OSHA training, 24 hours of OSHA hazardous facility training, rad worker training and respirator training.

F. Incinerator and APC System Operation
Currently installing computerized control system; until new system is installed data are recorded manually by operators. Permit prohibits burning liquid and solid wastes simultaneously.

G. Maintenance Procedures
Preventive maintenance provided for all instrumentation and equipment which could cause unsafe condition.

H. Contingency Plans
Have spill contingency plan (SWIM) in case of waste feed spills.

I. Operating and Maintenance Costs
Crew consists of supervisor, console operator, field operator and health physicist each shift.

J. Environmental Monitoring

5. WASTE FEEDS

A. Description
WERF originally handled solid LLW only; working on RCRA permit to handle liquid mixed and LLW; eventually will handle solid mixed and LLW. Solid wastes supplied in 2x2x2 ft or 20" boxes weighing less than 60 lbs.

B. Source
Currently handling only wastes produced at INEL. Have handled two shipments from LLNL in past.

C. Quantity
About 40,000 ft^3 of combustibles currently at WERF (8/91).

D. Waste Acceptance Criteria
Chlorinated constituents must be held at low levels to insure that HCl emissions remain below 4 lb/hr.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures
Total radioactive releases in 1987 were 2 microcuries. Measure HCl, CO, O_2, volumetric flow, temperature, and gross radioactivity.

B. Laboratory Analysis
For CO use NDIR, for O_2 use ZrO probe made by Westinghouse-Hagan.

C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach
Considering preparation of some descriptive material on facility.

B. Adverse Public Reactions
Has not been an issue at WERF.

C. Risk Assessments

D. Regulatory and Permitting Requirements

8. REFERENCES

Performance History of the WERF Incinerator, J.D. Dalton, H.A. Bohrer and G.R. Smolik, International Conference on Incineration of Hazardous, Radioactive and Mixed Wastes, May 3-6, 1988, San Francisco, CA.

Information transmitted to L. Coe, S. Cohen and Assoc. from EPA Regional Office, Seattle, WA on March 7, 1989.

Status Report on the INEL RCRA Permit for Incineration of Hazardous Waste; Conference on Incineration of Low-Level and Mixed Wastes, J.N. McFee, J.D. Dalton, and H.A. Bohrer, April 1987, St Charles, IL.

Letter from J.E. Solecki, IOO to E. Jordan, EM-321 dated October 5, 1990.

Private Communication - A. Wollerman and D.D. Cochran, EG&G, August 15, 1991.

APPENDIX A-6
INCINERATOR SURVEY FORM

MOUND GLASS MELTER

1. KEY CONTACTS

Larry Klinger (513) 865-3078
Monsanto Research Corporation - Mound
P.O. Box 32
Miamisburg, Ohio 45342

2. SYSTEM DESCRIPTION

A. Waste Handling
Waste fed into furnace through port in ceiling. Scintillation vials crushed in vial eater and fed into furnace via two glove boxes. One glove box has water-cooled screw feeder and the other has vibrating screw feeder (for IX resins). Liquid wastes injected directly.

B. Incinerator
Penberthy Electromelt, Inc. Pyroconverter (joule-heated glass melter) with operating temperature range of 730 to 1350^{0} C. Propane burner (400,000 BYU/hr) used for startup and melting of glass pool. Melt chamber is 7 x 4 x 3.5 ft high. Uses soda-lime-silica cullet as feed.

C. Off-Gas Treatment
Wet off-gas scrubber consisting of spray tank, and high efficiency venturi scrubber followed by cyclone demister and several stages of HEPA filtration (99.97% efficient for 0.3 micron particles).

D. Off-Gas Monitoring

E. Ash Handling and Disposal
Waste glass containing ash poured into molds for cooling at end of each run. Approximate volume reduction ratio is 15 to 1.

F. Ash Monitoring

G. Liquid Effluent Handling
Sludge from scrubber reprocessed through glass melter (ca. 1 kg per 240 kg of wastes). Liquid effluents mixed with cement for disposal (ca. 1 L per 1.7 kg of wastes).

H. Liquid Effluent Monitoring

I. Safety Systems and Redundancies

J. Planned Modifications

K. Permit Types and Requirements
Have applied to Ohio EPA for RCRA Part B permit.
Will require NESHAPs permit.

3. OPERATING HISTORY

A. Preliminary Planning

B. General Chronology
Initial work begun in 1981.
Furnace put in operation in January 1982.
Did "simulated" RCRA trial burn in December 1984.

C. Description of Upsets, Accidents and Corrective Actions
Drain failure occurred three times (through ca. 1986). Had two electrode failures in same period. Have some concern about radioactive contamination in refractory.

D. On-Stream Analysis
After startup, furnace was at idle temperature of 1000^{o} C or operating temperature of 1300 to 1370^{o} C for four years except for 24 week shutdown to prepare for some radwaste experiments and 4 weeks for furnace repair. Operating feed rate is 23 kg/hr and annual treatment capacity is 181.6 m^3. Plan to operate 7 hours per day, five days per week, and 38 weeks per year (23x7x5x38 = 30,590 kg/yr).

E. Radionuclide Mass Balance

F. Staffing

G. Operating Cycle
See D above.

H. Waste Disposal Issues

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures
Scintillation vials crushed in commercial vial eater.

B. Ash and Liquid Effluent Management

C. Stack Monitoring
Demonstrated 99.5% HCl removal in scrubber. In 54 DRE measurements found only one that was less than 99.99%, problem was xylene (PIC from kerosene burning when kerosene was 90% of total feed). In repeat run got 99.999% DRE for xylene.

D. Response to System Upsets

E. Operator Training

F. Incinerator and APC System Operation

G. Maintenance Procedures

H. Contingency Plans

I. Operating and Maintenance Costs
For low-level waste (IX resins) Mound cost is $0.11 per kg.

J. Environmental Monitoring

5. WASTE FEEDS

A. Description
Have done experimental work on DAW, wet IX resins (with 55% bound water), cartridge filters and filter sludge (ca. 80% water).

B. Source
Plan to handle only on-site wastes. Materials include scintillation cocktails, combustibles, fuel-cycle wastes, non-combustibles, plastics, rubber, and sludges.

C. Quantity
As of mid-1991 had inventory of 43,000 kg of mixed waste and expect to generate 2.313 kg per yr of additional mixed waste and 39,322 kg per yr of non-radioactive solvent waste. Backlog along with current generation will be worked off in six years.

D. Waste Acceptance Criteria
Mound waste only. Can handle liquid and solid low-level and mixed waste. Solid feed must be significantly reduced in size.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures

B. Laboratory Analysis

C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach

B. Adverse Public Reactions

C. Risk Assessments

D. Regulatory and Permitting Requirements

8. REFERENCES

Private Communication from Lise J. Wachter - HAZWRAP dated September 11, 1991.

"Glass Furnace Project Final Report - An Evaluation of Operating Experience for Low-level Nuclear Waste Processing," MLM-3229, Larry M. Klinger and Katherine M. Armstrong, Monsanto Research Corporation-Mound, February 28, 1985.

"Application of a Glass Furnace System to Low-Level Radioactive and Mixed Waste Disposal," Larry M. Klinger and Katherine M. Armstrong, Monsanto Research Corporation-Mound, 1986.

APPENDIX A-7
INCINERATOR SURVEY FORM

CONSOLIDATED INCINERATION FACILITY

1. KEY CONTACTS

Westinghouse Savannah River Company
P.O. Box 616
Aiken, SC 29802

William J. Maloney, Process Engineer, Environmental Protection Section, (803) 725-1086 (RCRA Permit);
William D. Thompson, (803) 557-2225, Senior Engineer, Solid Waste Facility Projects;
Deborah Salem, (803) 557-2222, Engineer, Solid Waste Facility Projects;
Heather Burns, (803) 557-2225.

2. SYSTEM DESCRIPTION

A. Waste Handling
Aqueous waste (mainly sump waste) stored in 6500 gallon tank. Radioactive benzene received by pipeline from storage tanks at DWPF. Two 4300 gallon agitated, insulated and temperature controlled tanks for hazardous waste blending also provided. Tank farm includes 12,000 gallon fuel oil storage tank; all tanks in separate bermed storage area. Conveyor with weighing, radio-assaying and x-ray stations provided for solid waste containers (each 21 inches square) in incinerator building.

B. Incinerator
Rotary kiln rated at 18 million BTU/hr with separate nozzles for organic waste, auxiliary fuel oil and aqueous waste. Normal operating temperature is 1800^o F. Kiln is 8 ft ID x 25 ft long. Solids fed through air lock ram feeder. Kiln seals shrouded to capture any gas leakage. Minimum solids residence is 45 to 90 minutes. Secondary combustion chamber (6 ft ID x 33 ft long) will use waste benzene as primary heat source with separate fuel oil backup. Minimum SCC residence is 2 seconds and normal exit temperature is 2012^o F. Kiln capacity is 12 tons per day of solid and liquid waste. System designed by Chas. T. Main. Gas flow is 27,500 acfm at 1800^o F.

C. Off-Gas Treatment
Spray quench chamber for first stage particulate removal and acid-gas scrubbing followed by steam-driven free jet scrubber, cyclone separator and mist eliminator. Gas is reheated above dew point (ca. 300^o F), passed through HEPA filters to ID fans and up the stack.

D. Off-Gas Monitoring

Stack continuously monitored for CO and O_2. Radioactivity monitoring will include tritium, gross alpha, gross beta/gamma and gamma scan of collected particulates.

E. Ash Handling and Disposal

Ash discharged into water-filled trough. Cooled wet ash removed from trough with 250 lb/hr backhoe type device, filled in drums to preset weight, and conveyed to solidification system where ash is mixed with cement and water. Drums placed in permitted storage area before final on-site disposition in planned mixed waste disposal facility.

F. Ash Monitoring

Solidified ash in drums will be checked for surface contamination and given TCLP on random basis.

G. Liquid Effluent Handling

Scrubber blowdown allowed to build to 10% suspended solids and then sent to one of two 6000 gallon hold tanks. Later will be transported to planned hazardous waste treatment and disposal facility for dewatering and stabilization with concrete. If waste water is clean, it will be directed to NPDES outfall.

H. Liquid Effluent Monitoring

I. Safety Systems and Redundancies

J. Planned Modifications

K. Permit Types and Requirements

RCRA Part B - South Carolina DHEC
APC - South Carolina DHEC
Domestic Water Distribution - South Carolina DHEC
Sanitary Waste Water Collection - South Carolina DHEC
NPDES Modification - South Carolina DHEC
NESHAPs - EPA

3. OPERATING HISTORY

A. Preliminary Planning

B. General Chronology

"Basic Data Report for Current Appraisal of Cost (Rev 1)" issued September 1986

"Conceptual Design Report" issued October 1987

Original DOE schedule (Ref 1):

- 2/88 Title II design start
- 6/88 RCRA Part B and NESHAPs applications submitted
- 2/90 Construction start
- 11/91 Project turnover from construction
- 2/92 Trial burn
- 5/92 Routine operation

Revised schedule (early 1991):

- Revised scope of work issued in December 1989
- Title II design completed in May 1990
- Construction start in fall 1991
- Component testing in September 1992
- Trial burn in July 1993

Current schedule (2/92):

- Draft RCRA permit issued for comments in spring 1992
- RCRA permit issued and construction begins in summer 1992
- Normal operations begin 39 months after RCRA permit issued

C. Description of Upsets, Accidents and Corrective Actions

D. On-Stream Analysis

Plan to process 560,000 ft^3/yr of solid waste and 35,700 ft^3/yr of liquid waste and produce 35,700 ft^3/yr of cement stabilized ash and blowdown foe overall VR ratio of 22 to 1. Design basis is to process (on the average) 720 lbs/hr of boxed waste plus 187 lbs/hr (23 gph) of liquid waste (including 30 lbs/hr of no. 2 fuel oil) in primary combustion chamber and 139 lbs/hr (19 gph) of benzene and 130 lbs/hr of no. 2 fuel oil in the SCC. This equates to 5.3 million pounds annually based on the operating schedule noted in G below. More recently, the processing rate has been quoted as approximately 4 million pounds per year. (Ref 3).

E. Radionuclide Mass Balance

See Table 2 from reference 2 attached for total mass balance.

F. Staffing

Total staff will be 45 to 50 including four shift crews of five operators and a foreman. Balance are technical, administrative and maintenance people.

G. Operating Cycle
Planned 3 shifts (four crews) per day, 7 days per week and thirty operating weeks per year. Other documentation suggests a 56.3% weighted availability for solid and liquid wastes or 4930 hours per year.

H. Waste Disposal Issues
Blowdown from quench recirculation passed through cross flow filter to concentrate suspended solids to 10 wt% and then is pumped to one of two 6000 gallon FRP hold tanks. Blowdown waste transferred by tank truck to on-site cement stabilization facility and then to on-site disposal facility.

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures
Solid wastes transported to CIF in closed incinerable containers which are placed on conveyor, checked for radiation rate, weighed, x-rayed for foreign objects and assayed for radioisotope content. Containers are not opened.

B. Ash and Liquid Effluent Management

C. Stack Monitoring

D. Response to System Upsets

E. Operator Training

F. Incinerator and APC System Operation

G. Maintenance Procedures

H. Contingency Plans

I. Operating and Maintenance Costs
Capital cost was estimated in ca. 1987 to be $30 million with annual operating costs of $6.4 million (Ref 2). Current capital cost estimate for CIF including ashcrete facility is $90 million.

J. Environmental Monitoring

5. WASTE FEEDS

A. Description
Low-level, mixed and hazardous wastes including solids, sludges organic and aqueous liquids. Solid wastes include filtered solids from paint thinners, sludges and other chlorinated and non-chlorinated organics. Other solids include solvents, pesticides and herbicides on absorbent material and contaminated soils. Major solids will be rags, plastic and cloth work suits, shoe covers, PVC sheeting, mops and floor cleaning equipment. Liquid wastes include solvents, machine cutting and extrusion press oils, paints and thinners, motor and compressor lubricating oils, lab wastes, pesticides, herbicides and organic process waste streams. Radioactivity is mainly beta-gamma (fission products) with one stream containing trace amounts of uranium.

B. Source
All wastes generated on site. Benzene comes from Defense Waste Processing Facility.

C. Quantity
See attached table.

D. Waste Acceptance Criteria
No dioxins or PCBs. Only SRS wastes. Limited metals except benzene wastes which may contain up to 110 ppm Hg. No current plans to process any soils. Ash backhoe limits rate of future soil processing.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures

B. Laboratory Analysis

C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach
Have prepared video and literature in anticipation of public comment period on EA and draft RCRA permit. Have met with Aiken city council and participated in other public fora.

B. Adverse Public Reactions
Limited. Being watched by Greenpeace and Energy Research Foundation who have apparently supplied input questions to South Carolina DHEC for NOD's.

C. Risk Assessments

D. Regulatory and Permitting Requirements

8. REFERENCES

"Consolidated Incineration Facility - Program Information Report to the South Carolina Department of Health and Environmental Control," U.S. DOE - Savannah River Plant, April 1988.

"The Savannah River Plant Consolidated Incineration Facility," Daniel A. Weber, E.I. du Pont de Nemours and Co., Inc., ca. 1987.

"Startup, Operations and Maintenance Control for a Rotary Kiln Incinerator," William D. Thompson, Proceedings of 1991 Incineration Conference, p. 687, May 1991.

"CIF Basic Project Data," OPS-WMP-4740, Project S-2787, Rev. 3, September 18, 1990.

Planned Waste Feeds for CIF

	Projected Inventory (as of 1/1/93)	Projected Annual Generation	Waste Type
SOLIDS (ft^3)			
High Btu, drummed	440	440	NRHW
Chlorinated, drummed	380	380	NRHW
Beta/Gamma, boxed	200,000	560,000	10% Mixed, 90% LLW
LIQUIDS (gal)			
High Btu, drummed	22,000	22,000	NRHW
Chlorinated, drummed	500	500	NRHW
Aqueous, drummed	2,000	2,000	NRHW
Purex Solvent	36,000	8,000	LLW
Tritiated Oil	15,000	7,000	Mixed
DWPF Organic	0	50,000	Mixed
Naval Fuel Organic	31,000	0	Mixed
Fuel Oil Flush	20,000	9,000	Mixed
Aqueous Flush	7,000	1,000	Mixed

NRHW = Non-Radioactive Hazardous Waste

APPENDIX A-8
INCINERATOR SURVEY FORM

SEG INCINERATOR

1. KEY CONTACTS

Scientific Ecology Group, Inc.
P.O. Box 2530
1560 Bear Creek Road
Oak Ridge, Tennessee 37831
(615) 481-0222

H.W. Arrowsmith - President
Pete Keegan - Vice President, Sales and Marketing
Dewey E. Large - Senior Consultant
Walt Hipsher - Vice President, Regulatory Services and Transportation

2. SYSTEM DESCRIPTION

A. Waste Handling

All waste hand-sorted on manual lazy-susan sorting table at SEG prior to incineration to minimize halogens and heavy metals. PVC materials reduced to less than 5%. Sorted wastes packaged in wheeled containers holding about 50 ft^3 (ca. 300 lbs). Twenty-two wheeled containers are loaded into feeding magazine and automatically loaded into incinerator. Wheeled containers ride up vertical inclined trolley to waste charging sluice. Upper sluice door opens, waste is dumped into chamber and upper door closes. When feed is required lower door opens and waste falls into furnace.

B. Incinerator

Capacity is 800-1600 lb/hr for DAW and can simultaneously burn 30 gallons per hour of radioactive, non-hazardous waste oil in a liquid waste injection system. Incinerator is fixed hearth unit, Envikraft EK 980 NC, designed and built by Faurholdt Engineering and supplied by Studsvik Nuclear. Incinerator is rated at 11 million Btu/hr. Primary unit operates in pyrolysis mode at 1290 to 1650^{o} F, feeding secondary combustion chamber which has 2 burners and operates at 1830 to 2200^{o} F with 3-second residence time. Liquid wastes are fed into SCC burners. Auxiliary fuel is propane but will probably shift to natural gas. Unit also has tertiary combustion chamber operating at 900 to 1000^{o} F but burner there is seldom used. Also have separate liquid injection incinerator in same building used mainly to burn radioactive oil.

C. Off-Gas Treatment

Incinerator effluent (ca. 5000 scfm) enters 3-pass vertical carbon steel boiler and is quenched to about 360 to 430° F, then into 4-chamber baghouse with TFE-coated bags and next into a bank of parallel of HEPA filters. Essentially non-radioactive gas is quenched to about 200° F, run through a packed tower scrubber with caustic for acid gas removal, then through ID fan and into stack. Heated building air is added downstream of the ID fan to reduce water vapor plume. Gas exits at about 350° F. When burning radioactive oil, off-gas need only pass through HEPA filter bank.

D. Off-Gas Monitoring

Isokinetic nozzle in stack.

E. Ash Handling and Disposal

In addition to bottom ash, fly ash is collected from boiler and bag house. Ash transporter in furnace moves hearth ash to ash sluice system where upper gate opens allowing ash to fall into air-cooled chamber. When ash has cooled sufficiently lower gate opens and ash falls into tote bin attached to system through flexible air tight seal. Ash supercompacted in containers, stacked in overpacks, sealed, inspected for defects, surveyed, checked for contamination and labeled for shipment.

F. Ash Monitoring

See E above.

G. Liquid Effluent Handling

Blowdown from packed tower scrubber goes to liquid evaporator where excess water is removed.

H. Liquid Effluent Monitoring

I. Safety Systems and Redundancies

On-site 120 kw diesel generator for emergency electrical power. Parallel HEPA filters (with ability to switch from primary to secondary unit). Malfunction in waste feed charging system shuts feed down. Sluice doors interlocked to prevent upper and lower being open simultaneously. Auxiliary propane burner comes on if temperature in primary chamber falls below 1290° F. Pressure relief door on SCC. Cooling air provided to baghouse and/or HEPA filters if temperature rises above 440° F. Combustion air fans, cooling air fans, induced draft fans, pressure indicators, level indicators and flue gas quality monitors all duplicated and automatically switched over by logic control system. Water tank for emergency water supply to spray cool incinerator.

J. Planned Modifications

K. Permit Types and Requirements
NESHAPs - EPA Region IV
Radioactive Materials License - Tennessee Division of Radiological Health
Air Permit - Tennessee Division of APC

3. OPERATING HISTORY

A. Preliminary Planning
Proven design with extensive operational experience at Studsvik.

B. General Chronology
General SEG licensing activities initiated in 1985.
EPA granted permission to construct and operate incinerator under NESHAPs on November 23,1988.
Project funded by Westinghouse in January 1989.
Incinerator operation begun 4th Q 1989.

C. Description of Upsets, Accidents and Corrective Actions

D. On-Stream Analysis
Capacity is about 6 million lbs/yr of DAW depending on heat content of waste. Burned 2.6 million lbs of DAW in 1990 and 25,000 gal of oil in liquid injection incinerator. In 1991 burned 5.3 million lbs DAW. Plan for 1992 is 6 million lbs DAW.

E. Radionuclide Mass Balance
Information reported quarterly to EPA. Some info in NESHAPs permit application. Major mass balance problems because generators always overstate activity levels.

F. Staffing
Normal crew in incinerator building includes control room operator, field operator, two operators for liquid injection incinerator,and health physicist. Shift foreman serves entire plant.

G. Operating Cycle

H. Waste Disposal Issues
HEPA filters compacted and sent to burial site.

4. OPERATING AND MONITORING PRACTICES

A. Waste Classification and Handling Procedures
All DAW manually sorted.

B. Ash and Liquid Effluent Management
All effluents except stack off-gas collected on property. Some fly ash has leachable quantities of Pb and Cd and therefore all fly ash is be solidified with epoxy in B-25 containers for ultimate land disposal. Some hearth ash is class B waste and must be stabilized per 10 CFR 61. Prior to off-site shipment ash containers quantitatively analyzed for gamma-emitters. Blowdown from spray scrubber sump is sent to thin film evaporator. Clean water is recycled to system and wet salts are collected in plastic lined containers for transport to burial site.

C. Stack Monitoring
Filters recovered from oil-burning off-gas sampler analyzed to determine release rates for uranium, Tc-99, gross alpha and gross beta and gamma. Filters from isokinetic sampler in incinerator stack analyzed (weekly) for uranium, Tc-99, I-125, I-129, I-131, C-14, H-3, gross alpha, gross beta, and gamma scan of particulates. Scrubber removes 90% of HCl and 60-70% of SO_2.

D. Response to System Upsets

E. Operator Training
Initial operators trained in Sweden on Studsvik incinerator. All operators now trained on site with in-house program similar to INPO including oral boards.

F. Incinerator and APC System Operation
SCC monitored for temperature, pressure, O_2 and CO_2. Stack monitored for opacity. Primary chamber monitored for temperature and pressure. Bag house and HEPA filters monitored for temperature.

G. Maintenance Procedures

H. Contingency Plans

I. Operating and Maintenance Costs

J. Environmental Monitoring

5. WASTE FEEDS

A. Description
Low-level radioactive wastes including paper, cloth, wood, and rubber with some metal particles, glass and plastics. Typical heat content is 6500 to 13000 BTU per pound.

B. Source
Nuclear power plants and some DOE locations. In 1991 91% from nuclear utilities, 7% from brokers and 2% from DOE.

C. Quantity

D. Waste Acceptance Criteria
Unacceptable items include explosives, pyrophorics, shock sensitive or highly reactive materials, TSCA and RCRA wastes. Other prohibited materials include hospital waste and waste containing high concentrations of H-3 and C-14. Oils must contain less than 1E-4 uCi/ml radionuclides and less than 1E-5 uCi/ml uranium averaged over truckload lot. Have handled some DOE materials.

6. STACK MONITORING DETAILS

A. Current Stack Sampling Procedures

B. Laboratory Analysis

C. Prospects for Real Time Radioactive Emissions Monitoring

7. OTHER ISSUES

A. Public Outreach
Have promised city of Oak Ridge that nothing will be done at SEG site without permission from city.

B. Adverse Public Reactions
Has not been a major problem.

C. Risk Assessments
Conventional AIRDOS, plus two accident scenarios - failure of heat removal system and pressure excursion in incinerator. Based on burning 10 million pounds of waste annually, whole body dose at property line calculated to be 2.3 mrem and 0.3 mrem for nearest potential resident.

Release fractions were 0.01% for all nuclides except C-14 and H-3 which were 100%.

D. Regulatory and Permitting Requirements

Plan to seek RCRA permit.

APPENDIX B
Excerpts from DOE Order 5820.2A

U.S. Department of Energy
Washington, D.C.

ORDER

DOE 5820.2A

9-26-88

SUBJECT: RADIOACTIVE WASTE MANAGEMENT

1. PURPOSE. To establish policies, guidelines, and minimum requirements by which the Department of Energy (DOE) manages its radioactive and mixed waste and contaminated facilities.

2. CANCELLATION. DOE 5820.2, RADIOACTIVE WASTE MANAGEMENT OF 2-6-84.

3. SCOPE. The provisions of this Order apply to all DOE elements and, as required by law and/or contract and as implemented by the appropriate contracting officer, all DOE contractors and subcontractors performing work that involves management of waste containing radioactivity and/or radioactively contaminated facilities for DOE under the Atomic Energy Act of 1954, as amended (Public Law 83-703).

4. EXCLUSION. This Order does not apply to the management by the Department of commercially generated spent nuclear fuel or high-level radioactive waste, nor to the geologic disposal of high-level waste produced by the Department's activities and operations. Such materials are managed by the Office of Civilian Radioactive Waste Management under the requirements of the Nuclear Waste Policy Act of 1982, as amended (Public Law 97-425).

5. POLICY. Radioactive and mixed wastes shall be managed in a manner that assures protection of the health and safety of the public, DOE, and contractor employees, and the environment. The generation, treatment, storage, transportation, and/or disposal of radioactive wastes, and the other pollutants or hazardous substances they contain, shall be accomplished in a manner that minimizes the generation of such wastes across program office functions and complies with all applicable Federal, State, and local environmental, safety, and health laws and regulations and DOE requirements.

6. REFERENCES. (See Attachment 1.)

7. DEFINITIONS. (See Attachment 2.)

8. RESPONSIBILITIES.

   a. Assistant Secretary for Defense Programs (DP-1) has authority for establishing policy for the management of DOE waste and assuring that DOE waste generated by operations and activities under DP-1 cognizance, or any other waste within the purview of DP-1, is managed according to the requirements of this Order. DP-1 also has general responsibility for assuring that

DISTRIBUTION:

All Departmental Elements

INITIATED BY:

Office of Defense Waste and Transportation Management

DP-1 programmatic decisions include waste management considerations when appropriate. Specific responsibilities include:

(1) Assuring the safe storage and disposal of all DOE waste other than that managed by NE-1 and RW-1;

(2) Implementing new and alternative technologies and processes to improve management of DP waste;

(3) Developing and operating the Waste Isolation Pilot Plant, a facility near Carlsbad, New Mexico, for conducting research and development to demonstrate the safe disposal of radioactive waste from defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission;

(4) Conducting research and development for DOE waste transportation systems and providing for safe, efficient, and economic transport of materials, pursuant to DOE 1540.1;

(5) Managing DP contaminated facilities, including those that are surplus to program needs;

(6) Assuring that the environmental, safety, health, transportation, quality assurance, unusual occurrence, construction project management, real estate management, and facility design requirements set forth in DOE Orders are implemented for DP-1 waste management programs; and

(7) Supporting the information needs of the Integrated Data Base program on defense program activities and jointly managing and funding the program in cooperation with NE-1 and RW-1 (see Attachment 1, page 3, paragraph 23).

b. Director of Defense Waste and Transportation Management (DP-12) is charged with carrying out DP-1 waste management responsibilities for oversight of the waste management complex, for interpreting waste management policy, and for implementing the requirements of this Order for waste management facilities and operations funded by DP-12. Specific responsibilities include:

(1) Management of storage, treatment, and disposal operations for defense waste;

(2) Managing defense contaminated facilities that are excess to programmatic needs;

(3) Reviewing and approving new or alternative waste management practices;

(4) Conducting research and development for DOE waste transportation systems and providing for safe, efficient, and economic transport of materials, pursuant to DOE 1540.1;

(5) Conducting independent health, safety, and quality assurance audits of field waste management organizations, in cooperation with EH-1, to assess compliance with the requirements of this Order;

(6) Issuing, in consultation with EH-1, approval of exemptions from the requirements of this Order (paragraph 9) that are proposed by other Headquarters or field organizations;

(7) Issuing in consultation with EH-1 and Headquarters program organizations updated waste management guidance; and

(8) Approving documents, reports, and plans, as required by this Order, for DP programs and activities.

c. Director of Civilian Radioactive Waste Management (RW-1) is responsible for selected research and development, siting, construction, operation, and management activities assigned to the Secretary of Energy by the Nuclear Waste Policy Act of 1982 (Public Law 97-425) for the interim storage and disposal of high-level waste and spent nuclear fuel. Specific responsibilities include the following:

(1) The long-term care, in cooperation with NE-1, of closed commercial low-level waste sites transferred to DOE;

(2) Lead responsibility, in cooperation with NE-1 and DP-1, for the Integrated Data Base program (see Attachment 1, page 3, paragraph 23);

(3) Assurance that the requirements of DOE Orders are met for all waste management activities under RW-1 purview; and

(4) Independent health, safety, and quality assurance audits of field waste management organizations in cooperation with EH-1, to assess compliance with the requirements of this Order.

d. Assistant Secretary for Nuclear Energy (NE-1) is responsible for assuring that waste generated by operations funded by NE-1 is managed according to the requirements of this Order and that NE-1 program decisions include waste management considerations, as appropriate. Specific responsibilities include:

(1) Managing DOE wastes from NE-1 operations and activities, including the breeder reactor, space nuclear, naval reactor, and remedial action programs, as well as the Three Mile Island and West Valley projects;

(2) Managing waste generated by DOE enrichment operations and disposed at sites located at the Oak Ridge, Portsmouth, and Paducah gaseous diffusion plants;

(3) Managing any greater than Class C low-level waste, as defined in Section 3(b)(1)(D) of Public Law 99-240, which may be accepted by the Department for disposal in cooperation with DP-1;

(4) Developing and implementing alternative technologies and processes to support storage and disposal of waste or spent fuel generated by NE-1 operations;

(5) Managing NE-1 contaminated facilities, including those that are surplus to program needs, and waste storage/disposal sites;

(6) Developing and implementing commercial applications for waste byproducts;

(7) Assuring that environmental, safety, health, transportation, quality assurance, unusual occurrence, construction project management, real estate management, and facility design requirements set forth in DOE Orders, are implemented for NE-1 waste management programs;

(8) Conducting independent health, safety, and quality assurance audits of field waste management operations in cooperation with EH-1 to assess compliance with the requirements of this Order; and

(9) Supporting the information needs of the Integrated Data Base program on civilian nuclear program activities in cooperation with DP-1 and RW-1 (see Attachment 1, page 3, paragraph 23).

e. Assistant Secretary for Environment, Safety and Health (EH-1) is responsible for providing an independent overview of DOE radioactive waste management and decommissioning programs to determine compliance with DOE environment, safety, and health requirements and applicable Environmental Protection Agency (EPA) and state regulations. Specific responsibilities include:

(1) Advising the Secretary of the status of Departmental compliance with the requirements of this Order and applicable provisions of DOE 5480.1B, and EH Orders.

(2) Conducting independent appraisals and audits of DOE waste management and decommissioning programs consistent with the requirements of DOE 5482.1B.

(3) Reviewing site Waste Management Plans and Decommissioning Project Plans with regard to compliance with DOE environment, safety, and health requirements.

f. Director, Naval Nuclear Propulsion Program: Executive Order 12344, statutorily prescribed by PL 98-525 (42 USC 7158 note), establishes the responsibilities and authority of the Director, Naval Nuclear Propulsion Program (who is also the Deputy Assistant Secretary for Naval Reactors within the Department) over all facilities and activities which comprise the Program, a joint Navy-DOE organization. The policy principle promoted by these executive and legislative actions is cited in the Executive Order as "...preserving the basic structure, policies and practices developed for this Program in the past...". Accordingly, The Naval Propulsion Program is exempt from the provisions of this Order. The Director shall maintain an environmental protection program to assure compliance with applicable environmental statutes and regulations. The Director and EH-1 shall exchange information and cooperate as appropriate to facilitate exercise of their respective responsibility.

g. Directors of other Headquarters Program Organizations are responsible for implementing the requirements of this Order for all DOE waste generated by their programs until it is transferred to a DOE or licensed storage/disposal site. For all contaminated facilities under their jurisdiction, they are responsible for assuring that their programmatic decisions include waste management considerations, as appropriate, and for implementing the requirements of other applicable DOE Orders for their waste management programs.

h. Office of General Counsel (GC-1) provides legal advice to program organizations regarding DOE waste management and decommissioning activities involving DOE-owned and privately owned sites; renders legal opinion on DOE authority to undertake remedial action and other waste management activities; and renders legal opinions on, and concurs in, program actions to comply with the National Environmental Policy Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act, the Superfund Amendments and Reauthorization Act, and other legal authorities in conjunction with proposed waste management and decommissioning activities.

i. Assistant Secretary, Management and Administration (MA-1) is responsible for providing contractual and business advice to program organizations regarding DOE waste management activities, including use of DOE management and operating contractors in such activities.

j. Heads of Field Organizations are responsible for all activities that affect the treatment, storage, or disposal of waste in facilities under their jurisdiction regardless of where the waste is generated. Heads of field organizations with treatment, storage or disposal facilities responsibility have the authority for establishing waste management requirements at that facility (e.g., setting waste acceptance criteria, waste certification, verification of contents of waste shipped or to be shipped, concurring in waste reduction plans). In addition, they are responsible for assuring that the day-to-day waste management and surplus facility operations at their sites are conducted in compliance with the requirements of this Order and comply with all applicable Federal, State, and local statutes. Specific responsibilities include the following:

(1) Preparing annual updates of the Waste Management Plans for all operations under their purview according to the format in the Waste Management Plan Outline, Chapter VI. These Plans shall be submitted in December of each year and be distributed to DP-12, EH-1, and other appropriate Headquarters organizations for review and comment.

(2) Preparing supplements to this Order that identify specific detailed requirements for waste management practices and procedures conducted at their sites.

(3) Overseeing fiscal responsibility for transporting waste and establishing of fees to recover the incremental costs for storage and disposal of DOE waste at their sites.

(4) Establishing waste acceptance criteria and reviewing waste minimization plans of other field organization's facilities that generate radioactive, hazardous, or mixed waste that will be treated, stored or disposed of at facilities under their purview.

(5) Auditing any waste generating organization that ships waste to their sites for treatment, storage, or disposal to assure compliance with established waste acceptance criteria.

(6) Maintaining environmental, safety, and health programs for all DOE waste management operations under their purview.

(7) Managing contaminated facilities under their purview according to the requirements of this Order and guidance provided by Headquarters program offices, providing program secretarial officers with the necessary characterizational and engineering data for contaminated facilities, and developing site-specific priorities, schedules, and costs for remedial actions.

(8) Assuring that the requirements of the Order, applicable to contractors and subcontractors whose contracts fall within the scope of the Order, are properly reflected in the contract document.

(9) Defining and assuring that required quality assurance activities are established and implemented for all waste management activities under their purview, pursuant to the requirements of DOE 5700.6B and reporting unusual occurrences pursuant to the requirements of DOE 5000.3.

(10) Providing information, as requested, to the Integrated Data Base Program, Oak Ridge National Laboratory, for all types of waste under

their purview, including: high-level waste; transuranic waste; low-level waste; naturally occurring and accelerator produced radioactive material; mixed waste; and wastes from decommissioning activities (see Attachment 1, page 3, paragraph 23).

k. Manager of Albuquerque Operations Office is responsible, in addition to the responsibilities identified in paragraph 8j, for use of certified packaging, standard containers, transportation, waste acceptance criteria, and all other aspects related to transuranic waste emplacement at the Waste Isolation Pilot Plant. Within the Albuquerque Operations Office, a standing committee, the Waste Isolation Pilot Plant-Waste Acceptance Criteria Certification Committee, is responsible for review, audit, and approval of generator transuranic waste certification programs and activities. The Manager of the Albuquerque Operations Office, as Head of the Waste Isolation Pilot Plant project office, also has responsibility for the design, construction, technology development, and operational activities leading to permanent isolation of transuranic waste from the biosphere.

9. EXEMPTIONS. Exemptions from the requirements of this Order may be granted only with the approval of DP-12 in consultation with EH-1. New or alternate waste management practices that are based on appropriate documented safety, health protection, and economic analyses may be proposed by field organizations and adopted with the approval of DP-12 and EH-1.

10. IMPLEMENTING PROCEDURES AND REQUIREMENTS. Within 6 months of the date of issuance of this Order, Heads of Field Elements shall prepare and submit to appropriate Headquarters program organizations an implementation plan describing schedules, costs, and quality assurance activities for compliance with the requirements of this Order with copies to EH-1 for review and comment. Specific guidance for the plan will be issued by DP-12 under separate cover. Thereafter, the status of compliance with the requirements of this Order shall be reported to the appropriate Headquarters program organization in the annual update of the Waste Management Plans.

11. CLEARANCE UNDER THE PAPERWORK REDUCTION ACT OF 1980. This directive has been determined to contain information collections under the provisions of 5 CFR 1320, "Controlling Paperwork Burdens on the Public." The Office of Management and Budget (OMB) has issued a clearance to the Department (OMB No. 1910-0900) for these information collections.

BY ORDER OF THE SECRETARY OF ENERGY:

LAWRENCE F. DAVENPORT
Assistant Secretary
Management and Administration

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CHAPTER III

MANAGEMENT OF LOW-LEVEL WASTE

1. PURPOSE. To establish policies, requirements and guidelines, for managing the Department's solid low-level waste.

2. POLICY.

   a. DOE-low-level waste operations shall be managed to protect the health and safety of the public, preserve the environment of the waste management facilities, and ensure that no legacy requiring remedial action remains after operations have been terminated.

   b. DOE-low-level waste shall be managed on a systematic basis using the most appropriate combination of waste generation reduction, segregation, treatment, and disposal practices so that the radioactive components are contained and the overall system cost effectiveness is maximized.

   c. DOE-low-level waste shall be disposed of on the site at which it is generated, if practical, or if on-site disposal capability is not available, at another DOE disposal facility.

   d. DOE-low-level waste that contains non-radioactive hazardous waste components (mixed waste) shall conform to the requirements of this order, applicable EH Orders, and shall also be regulated by the appropriate regional authorities under the Resource Conservation and Recovery Act.

3. REQUIREMENTS.

   a. Performance Objectives. DOE-low-level waste that has not been disposed of prior to issuance of this Order shall be managed on the schedule developed in the Implementation Plan (See page 7, paragraph 10) to accomplish the following:

      (1) Protect public health and safety in accordance with standards specified in applicable EH Orders and other DOE Orders.

      (2) Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, ground water, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

(3) Assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure.

(4) Protect ground water resources, consistent with Federal, State and local requirements.

b. Performance Assessment.

(1) Field organizations with disposal sites shall prepare and maintain a site specific radiological performance assessment for the disposal of waste for the purpose of demonstrating compliance with the performance objectives stated in paragraph 3a.

(2) Each field organization shall, for each DOE reservation within its cognizance, prepare and maintain an overall waste management systems performance assessment supporting the combination of waste management practices used in generation reduction, segregation, treatment, packaging, storage, and disposal. Background and guidance on waste management systems performance assessment is provided in Attachment 1, page 3, paragraph 21.

(3) Where practical, monitoring measurements to evaluate actual and prospective performance should be made at locations as required, within and outside each facility and disposal site. Monitoring should also be used to validate or modify the models used in performance assessments.

c. Waste Generation.

(1) Technical and administrative controls shall be directed to reducing the gross volume of waste generated and/or the amount of radioactivity requiring disposal. Waste reduction efforts shall include consideration of process modification, process optimization, materials substitution and decontamination.

(2) Waste Generation Reduction. All DOE-low-level waste generators shall establish auditable programs (goals, incentives, procedures, and reports) to assure that the amount of low-level waste generated and/or shipped for disposal is minimized.

(3) Waste Segregation. Each DOE-low-level waste generator shall separate uncontaminated waste from low-level waste to facilitate cost effective treatment and disposal.

(4) Waste Minimization. Each DOE-low-level waste generator preparing a design for a new process or process change shall incorporate principles into the design that will minimize the generation of low-level waste.

d. Waste Characterization.

(1) Low-level waste shall be characterized with sufficient accuracy to permit proper segregation, treatment, storage, and disposal. This characterization shall ensure that, upon generation and after processing, the actual physical and chemical characteristics and major radionuclide content are recorded and known during all stages of the waste management process.

(2) Waste characterization data shall be recorded on a waste manifest, as required by paragraph 3m, and shall include:

(a) The physical and chemical characteristics of the waste.

(b) Volume of the waste (total of waste and any solidification or absorbent media).

(c) Weight of the waste (total of waste and any solidification or absorbent media).

(d) Major radionuclides and their concentrations.

(e) Packaging date, package weight, and external volume.

(3) The concentration of a radionuclide may be determined by direct methods or by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements.

e. Waste Acceptance Criteria.

(1) Waste shipped from one field organization to another for treatment, storage or disposal shall be done in accordance with the requirements established by the operations office having responsibility for operations of the receiving facility.

(2) Waste acceptance criteria shall be established for each low-level waste treatment, storage, and disposal facility, and submitted to the cognizant field organization.

(3) Generators of waste shall implement a low-level waste certification program to provide assurance that the waste acceptance criteria for

any low-level waste treatment, storage, or disposal facility used by the generator are met. Generators and facilities receiving the waste are jointly responsible for assuring compliance with waste acceptance criteria. Generators are financially responsible for actions required due to nonconformance.

(4) Generator low-level waste certification programs shall be subject to a periodic audit by operators of facilities to which the waste is sent by the generator.

(5) The waste acceptance criteria for storage, treatment, or disposal facilities shall address the following issues:

(a) Allowable quantities/concentrations of specific radioisotopes to be handled, processed, stored or disposed of;

(b) Criticality safety requirements (waste forms and geometries);

(c) Restrictions regarding low-level waste classified for security reasons;

(d) External radiation and internal heat generation;

(e) Restrictions on the generation of harmful gases, vapors, or liquids in waste;

(f) Chemical and structural stability of waste packages, radiation effects, microbial activity, chemical reactions, and moisture;

(g) Restrictions for chelating and complexing agents having the potential for mobilizing radionuclides; and

(h) Quantity of free liquids.

f. Waste Treatment.

(1) Waste shall be treated by appropriate methods so that the disposal site can meet the performance objectives stated in paragraph 3a.

(2) Waste treatment techniques such as incineration, shredding, and compaction to reduce volume and provide more stable waste forms shall be implemented as necessary to meet performance requirements. Use of waste treatment techniques to increase the life of the disposal facility and improve long-term facility performance, by improved site stability and reduction of infiltrating water, is required to the extent it is cost effective.

(3) The development of large scale waste treatment facilities shall be supported by appropriate the National Environmental Policy Act documentation in addition to the following:

(a) A document shall be prepared that analyzes waste streams needing treatment, treatment options considered and a rationale for selection of proposed treatment processes;

(b) A construction design report including projected waste throughputs and treatment methods, construction and operating cost estimates; and

(c) A Safety Analysis Report.

(4) Operation of waste treatment facilities shall be supported by adequate documentation including the following:

(a) Operation and maintenance procedures;

(b) Personnel training and qualification procedures;

(c) Monitoring and emergency response plans; and

(d) Records shall be maintained for each package of low-level waste that enters and leaves the treatment facility.

g. Shipment.

(1) The volume of waste and number of shipments of low-level waste shall be minimized and the shipments will be conducted based on plans developed by field organizations. Off site shipment of low-level waste shall be in compliance with DOE 1540.1.

(2) Generators shall provide an annual forecast in the third quarter of the fiscal year to the field organizations managing the off-site disposal facility to which the waste is to be shipped.

(3) Generators must receive advance approval from the receiving facility and shall certify prior to shipment that waste meets the receiving facility waste acceptance criteria. The certification program shall be auditable and able to withstand independent review.

(4) Each package of waste must comply with the labeling requirements of DOE 1540.1.

h. Long-Term Storage.

(1) Low-level waste shall be stored by appropriate methods, to achieve the performance objectives stated in paragraph 3a.

(2) Records shall be maintained for all low-level waste that enters and leaves the storage facility, (see paragraph 3m).

(3) The development and operation of a waste storage facility shall be supported by the following documentation (two or more of these may be combined for convenience):

(a) An analysis which identifies the need for the storage facility;

(b) A Construction Design Report, including projected waste planned for storage; construction and operating cost estimates;

(c) A Safety Analysis Report and appropriate National Environmental Policy Act documentation; and

(d) Operational procedures and plans.

(4) Storage of waste to allow for nuclides to decay or storage of wastes until they can be disposed of by approved methods are acceptable.

i. Disposal.

(1) Low-level waste shall be disposed of by methods appropriate to achieve the performance objectives stated in paragraph 3a, consistent with the disposal site radiological performance assessment in paragraph 3b.

(2) Engineered modifications (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, radium) for each disposal site shall be developed through the performance assessment model (see paragraph 3b(1)). In the course of this process, site specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.

(3) An Oversight and Peer Review Panel of DOE, contractor, and other specialists in performance assessments will be selected by DP-12, with participation by EH-1 and operations office representatives. Through consultation and review, this panel shall ensure consistency and technical quality around the DOE complex in the development and application of performance assessment models that include site specific geohydrology and waste composition.

(4) Disposition of waste designated as greater-than-class C, as defined in 10 CFR 61.55, must be handled as special cases. Disposal systems for such waste must be justified by a specific performance assessment through the National Environmental Policy Act process and with the concurrence of DP-12 for all DP-1 disposal facilities and of NE-20 for those disposal facilities under the cognizance of NE-1.

(5) The following are additional disposal requirements intended either to improve stability of the disposal site or to facilitate handling and provide protection of the health and safety of personnel at the disposal site:

(a) Waste must not be packaged for disposal in cardboard or fiberboard boxes, unless such boxes meet DOT requirements and contain stabilized waste with a minimum of void space. For all types of containers, void spaces within the waste and between the waste and its packaging shall be reduced as much as practical.

(b) Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as is reasonably achievable, but, in no case, shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container, or 0.5 percent of the volume of the waste processed to a stable form.

(c) Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(d) Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged as identified in paragraph 3i(5)(e).

(e) Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C.

(f) Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.

(6) Waste containing amounts of radionuclides below regulatory concern, as defined by Federal regulations, may be disposed without regard to radioactivity content.

(7) Disposal Site Selection.

(a) Disposal site selection criteria (based on planned waste confinement technology) shall be developed for establishing new low-level waste disposal sites.

(b) Disposal site selection shall be based on an evaluation of the prospective site in conjunction with planned waste confinement technology, and in accordance with the the National Environmental Policy Act process.

(c) The disposal site shall have hydrogeologic characteristics which, in conjunction with the planned waste confinement technology, will protect the groundwater resource.

(d) The potential for natural hazards such as floods, erosion, tornadoes, earthquakes, and volcanoes shall be considered in site selection.

(e) Site selection criteria shall address the impact on current and projected populations, land use resource development plans and nearby public facilities, accessibility to transportation routes and utilities, and the location of waste generation.

(8) Disposal Facility and Disposal Site Design.

(a) Design criteria shall be established prior to selection of new disposal facilities, new disposal sites, or both. These design criteria shall be based on analyses of physiographic, environmental, and hydrogeological data to assure that the policy and requirements of this Order can be met. The criteria shall be also based on assessments of projected waste volumes, waste characteristics, and facility and disposal site performance.

(b) Disposal units shall be designed consistent with disposal site hydrology, geology, and waste characteristics and in accordance with the National Environmental Policy Act process.

(9) Disposal Facility Operations.

(a) Field organizations shall develop and implement operating procedures for low-level waste disposal facilities that protect the environment, health and safety of the public, and facility personnel; ensure the security of the facility; minimize the need for long-term control; and meet the requirements of the closure/post-closure plan.

(b) Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.

(c) Operating procedures shall include training for disposal facility operating personnel, emergency response plans, and a system of reporting unusual occurrences according to DOE 5000.3.

(d) Waste placement into disposal units should minimize voids between containers.

(e) Operations are to be conducted so that active waste disposal operations will not have an adverse effect on filled disposal units.

j. Disposal Site Closure/Post Closure.

(1) Field organizations shall develop site-specific comprehensive closure plans for new and existing operating low level waste disposal sites. The plan shall address closure of disposal sites within a 5-year period after each is filled and shall conform to the requirements of the National Environmental Policy Act process. Performance objectives for existing disposal sites shall be developed on a case-by-case basis as part of the National Environmental Policy Act process.

(2) During closure and post closure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines.

(3) Corrective measures shall be applied to new disposal sites or individual disposal units if conditions occur or are forecasted that could jeopardize attainment of the performance objectives of this Order.

(4) Inactive disposal facilities, disposal sites, and disposal units shall be managed in conformance with the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act, and the Superfund Amendments and Reauthorization Act, or, if mixed waste is involved, may be included in permit applications for operation of contiguous disposal facilities.

(5) Closure plans for new and existing operating low-level waste disposal facilities shall be reviewed and approved by the appropriate field organization.

(6) Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.

k. Environmental Monitoring.

(1) Each operational or non-operational low-level waste treatment, storage, and disposal facility shall be monitored by an environmental monitoring program that conforms with DOE 5484.1 and, at a minimum, meet the requirements of paragraph 3K(2) through 3K(4).

(2) The environmental monitoring program shall be designed to measure: (a) operational effluent releases; (b) migration of radionuclides; (c) disposal unit subsidence; and (d) changes in disposal facility and disposal site parameters which may affect long-term site performance.

(3) Based on the characteristics of the facility being monitored, the environmental monitoring program may include, but not necessarily be limited to, monitoring surface soil, air, surface water, and, in the subsurface, soil and water, both in the saturated and the unsaturated zones.

(4) The monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives. The monitoring program shall be able to ascertain whether or not effluents from each treatment, storage, or disposal facility or disposal site meet the requirements of applicable EH Orders.

l. Quality Assurance. Consistent with DOE 5700.6B, the low-level waste operational and disposal practices shall be conducted in accordance with applicable requirements of American National Standards Institute/American Society of Mechanical Engineers Nuclear Quality Assurance-1 (See Attachment 1, page 5, paragraph 48) and other appropriate national consensus standards.

m. Records and Reports.

(1) Each field organization shall develop and maintain a record keeping system that records the following: a historical record of waste generated, treated, stored, shipped, disposed of, or both, at the facilities under its cognizance. The data maintained shall include all data necessary to show that the waste was properly classified, treated, stored, shipped, and/or disposed of. The data maintained in the system shall be based on the data recorded on waste manifests.

(2) Waste Manifest. Records shall be kept and accompany each waste package from generator through final disposal. The manifest shall contain data necessary to document the proper classification, and assist in determining proper treatment, storage, and disposal of the waste. Waste manifests will be kept as permanent records. At a minimum, the following data will be included:

(a) Waste physical and chemical characteristics,

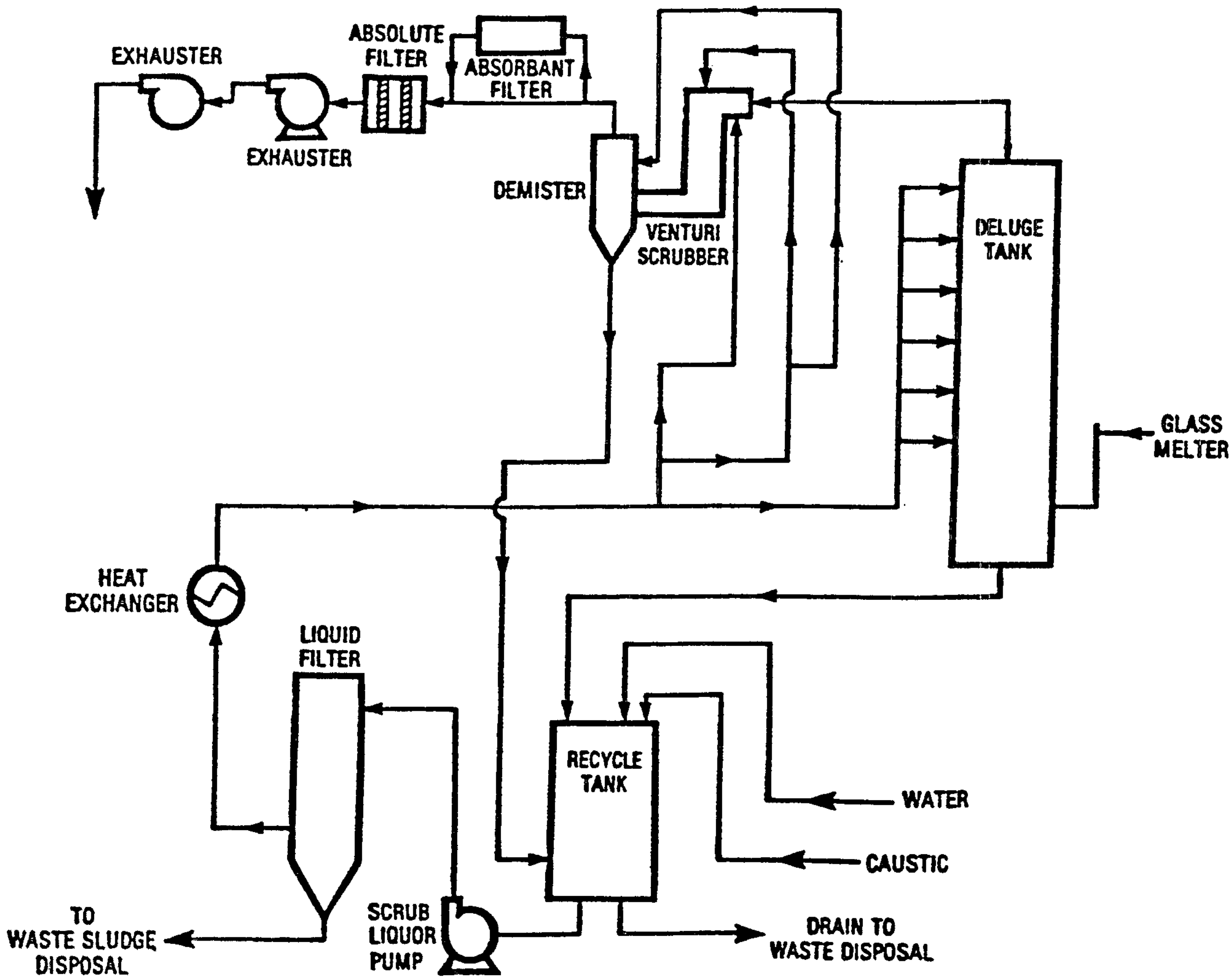
(b) Quantity of each major radionuclide present,

(c) Weight of the waste (total of waste and any solidification or absorbent media),

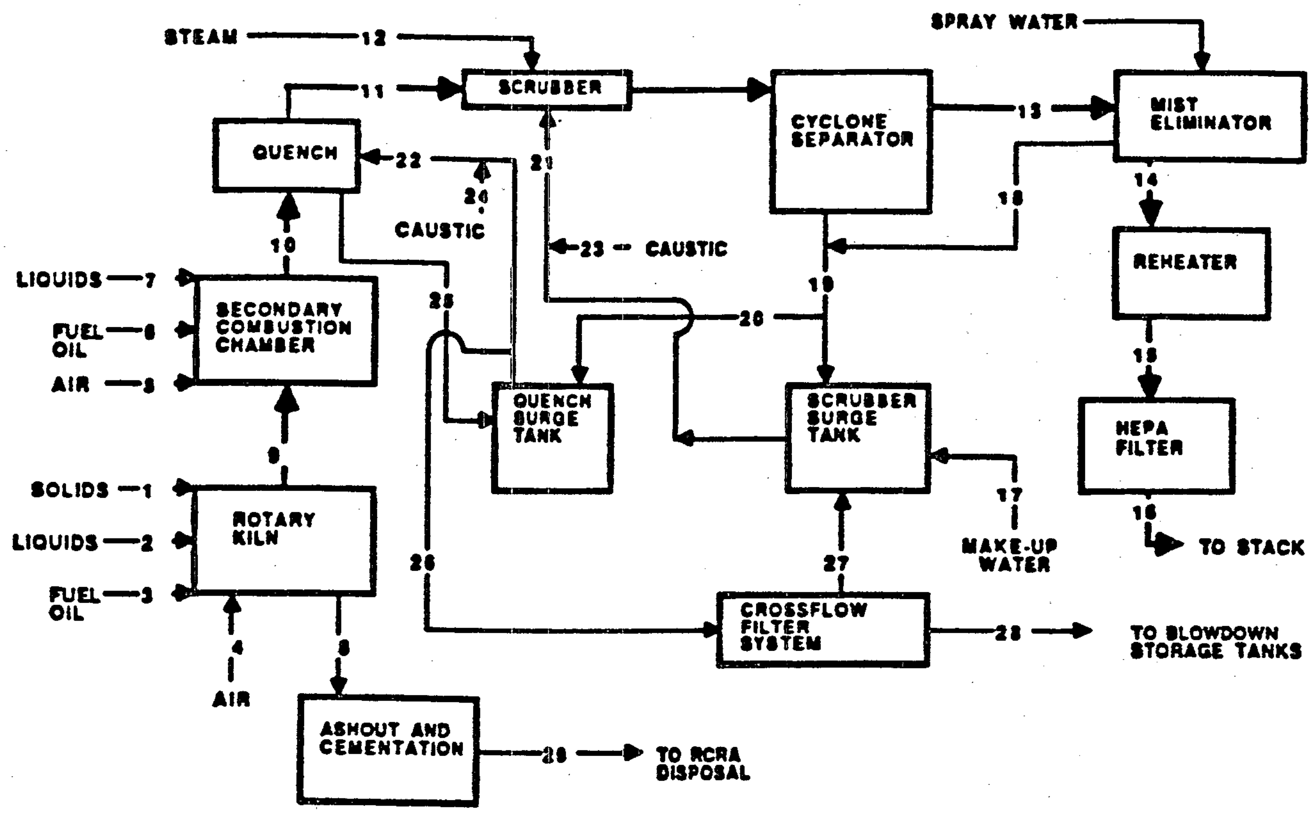
(d) Volume of the waste (total of waste and any solidification or absorbent media), and

(e) Other data necessary to demonstrate compliance with waste acceptance criteria.

APPENDIX C
Schematics and Flow Diagrams of Selected Incinerator Systems

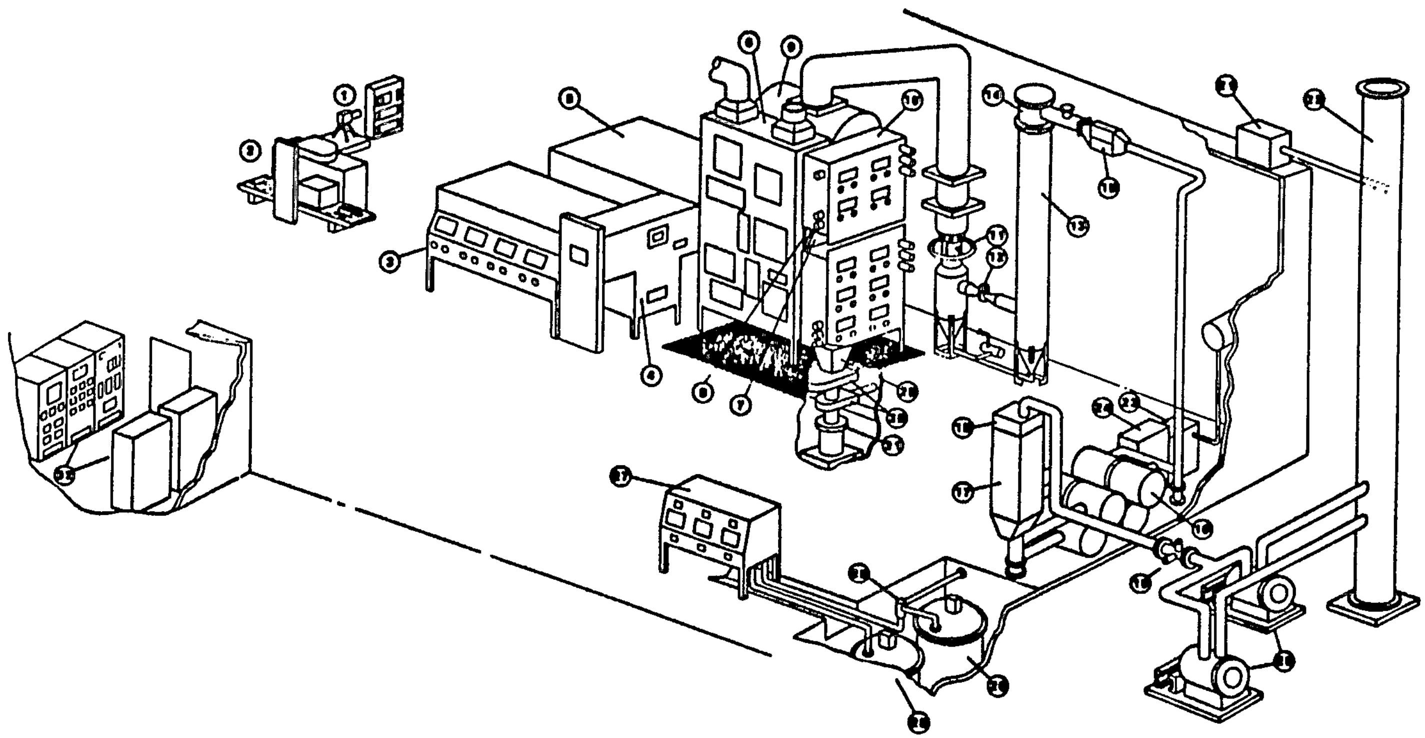


Appendix C-1
Glass Melter - Mound Laboratory



CIF PROCESS FLOWSHEET

Appendix C-2
Consolidated Incineration Facility - Savannah River Site

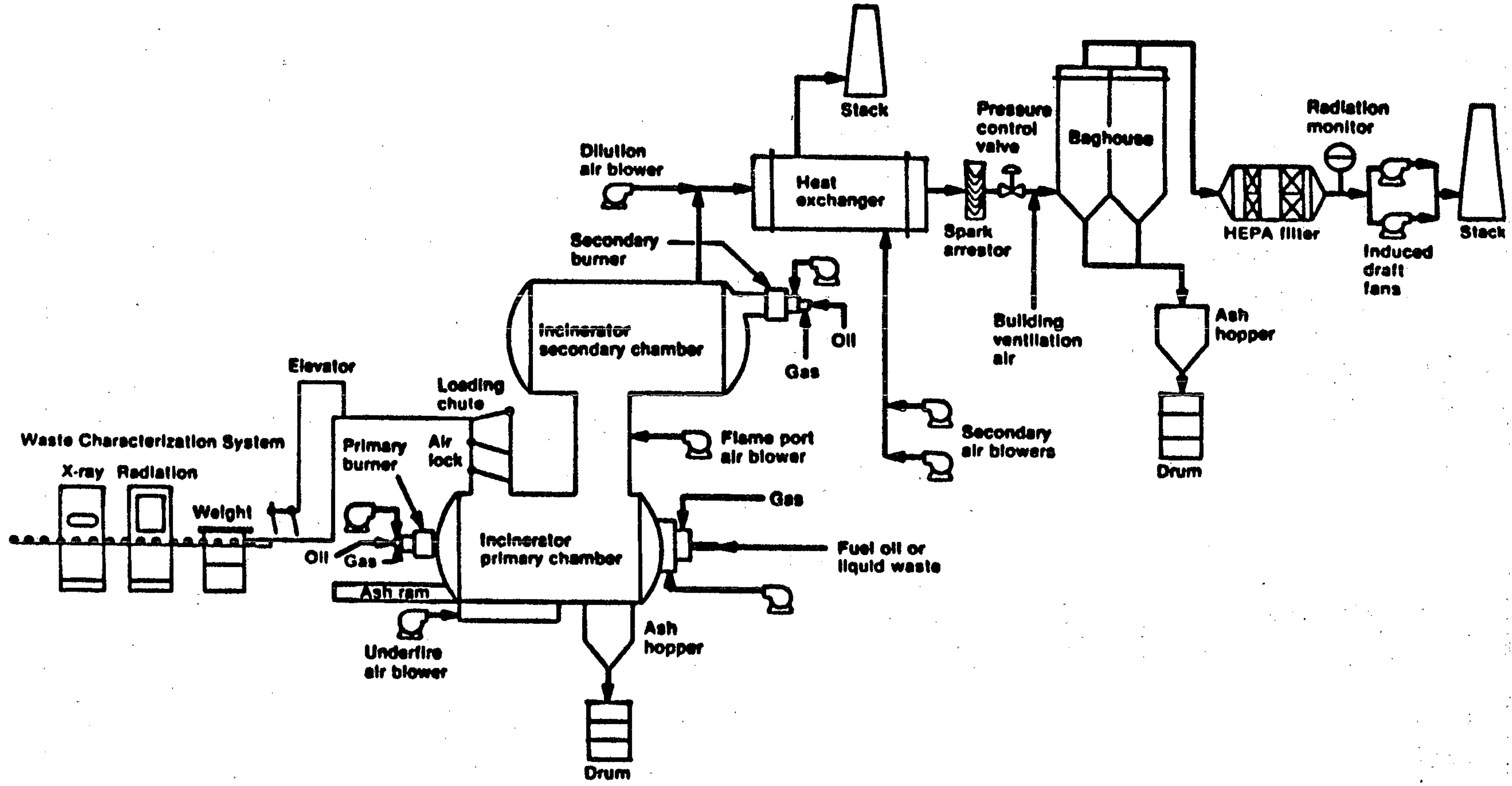


1. Multiple Energy Gamma Assay System (MEGAS)
2. Micro-dose x-ray waste package scanner
3. Waste receiving glovebox with air-lock entry
4. Side ram feeder
5. Main ram feeder
6. Combustion fuel/air supply glovebox
7. Incinerator ignition (primary) chamber
8. Inter chamber
9. Incinerator combustion (secondary) chamber
10. Incinerator chamber access gloveboxes
11. Quench column
12. High-energy venturi scrubber
13. Packed column scrubber
14. Off-gas demister
15. Off-gas superheater
16. HEPA filters (first and second stages)
17. Activated carbon adsorber
18. HEPA filter (third stage)
19. Off-gas monitoring (CO, CO_2, H_2O) station
20. Process exhaust blowers
21. Continuous stack sample system
22. Facility and process vent stack
23. Scrub-water primary coolant heat exchanger
24. Isolated secondary coolant loop heat exchanger
25. Scrub-water hydrocyclone particulate separator
26. Scrub-water recirculating sump tank
27. Scrub-water blowdown filters
28. Facility liquid sump tank and transfer system
29. Gravity ash-removal hopper
30. Ash-removal valves
31. Ash-removal drum system
32. Process instrumentation and control panels

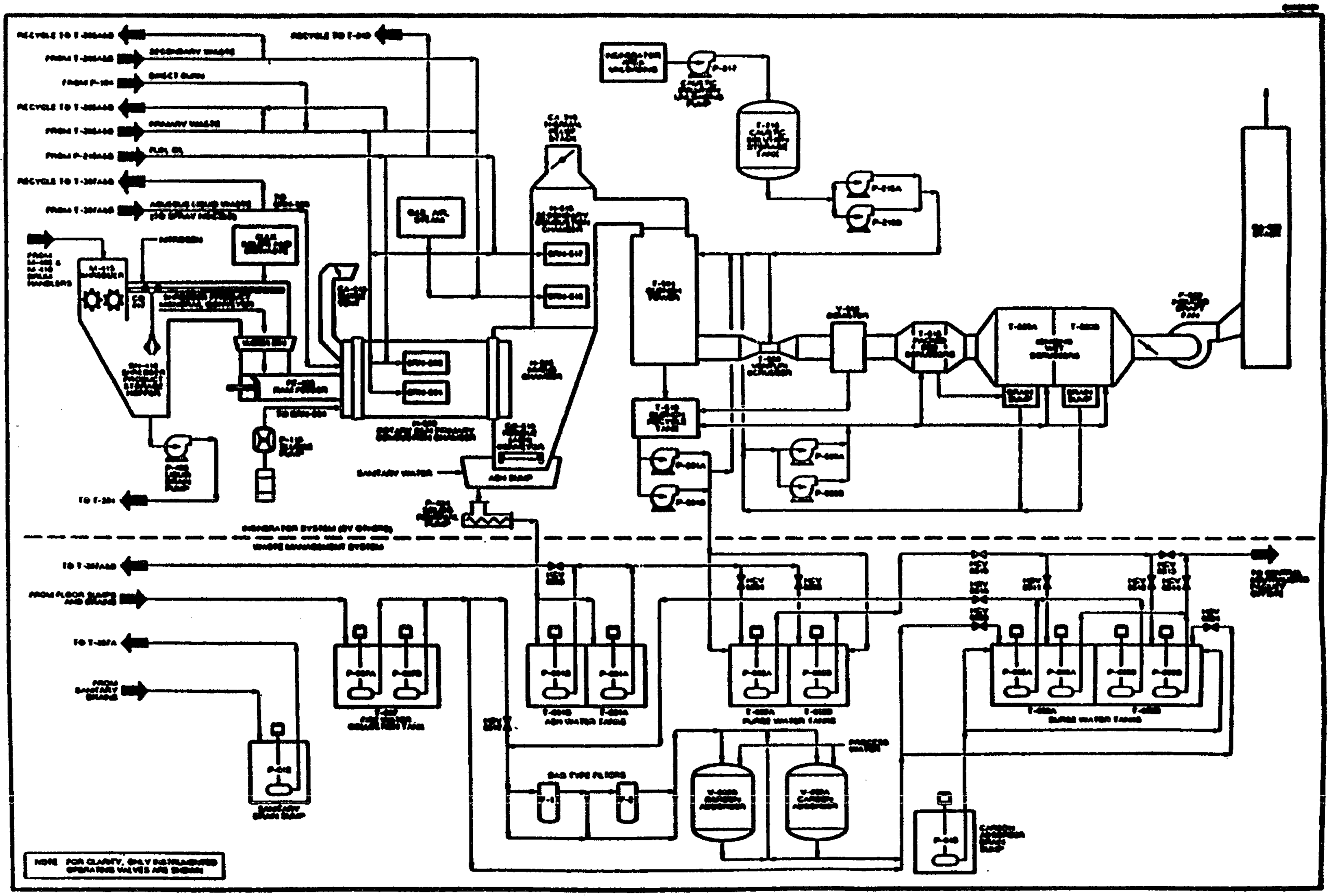
Transuranic and chemical waste incineration process.

Appendix C-3

Controlled Air Incinerator - Los Alamos National Laboratory



Appendix C-4
WERF Incinerator - Idaho National Engineering Laboratory



Appendix C-5
TSCA Incinerator - Oak Ridge Gaseous Diffusion Plant

APPENDIX D
Chemicals Approved for Incineration at DSSI

Appendix D

Chemicals Approved for Incineration at DSSI

Chemical Name	Hazardous Waste Code Number
1,1 Dichloroethane	U076
1,2 Dichloroethane	U077
1,1,1-Trichloroethane	F001/F002/U226
1,1,2-Trichloroethane	F002/U227
1,1,2-Trichlorotrifluorethane	F001/F002
1,2-Dichlorobenzene	F002/U070
1,4-Dioxane	U108/D001
2-butenal	U053
2-ethoxyethanol (ethylene glycol monethyl ether)	F005/U359
2-Nitropropane	F005/U171
Acetaldehyde	U001
Acetone	F003/U002
Acetonitrile	U003
Acetophenone	U004
Aniline	U012
Acrylamide	U007
Benzene	F005/U019
n-Butyl alcohol	F003/U031
Carbon Disulfide	F005/F002
Carbon Tetrachloride	F001/U211
Chlorobenzene	F002/U037
Chloroform	U044
m-Cresol	F004/U052
o-Cresol	F004/U052
p-Cresol	F004/U052
Cresylic acid	F004
Cumene	U055
Cyclohexane	U056
Cyclohexanone	F003/U057
o-Dichlorobenzene	F002/U070
m-Dichlorobenzene	F002/U071
p-Dichlorobenzene	F002/U072
Dichloroisopropyl ether	U027
Dipropylamine	U110
Ethanol	D001
Ethyl Acetate	F003/U112
Ethyl Benzene	F003
Ethyl Ether	F003/U117
Ethylene glycol	D001
Formaldehyde	U122
Furan	U124

Appendix D - Continued

Chemical Name	Hazardous Waste Code Number
Heptane	D001
Hexane	D001
Isoamyl alcohol	D001
Isobutyl alcohol	F005/U140
Isoctane/2,2,4-Trimethylpentane	D001
Methane, bromo-	U029
Methane, dibromo	U068
Methane, trichloro	U044
Methanol	F003/U154
Methylene Chloride	F002/U080
Methyl Ethyl Ketone	F005/U159
Methyl Isobutyl Ketone	F003/U161
Methyl Pyrrole	D001
Mineral Spirits	D001
Naphthalene	U165
Nitrobenzene	F004/U169
Nonane	D001
Octane	D001
Propanol	D001
Pentane	D001
Propane, 1,2-dichloro	U083
2-Propenal	F003
Propylene glycol	D001
Pyridine	F005/P075/U196
Tetrahydrofuran	U213
1,1,2,2-Tetrachloroethane	U209
1,1,1,2-Tetrachloroethane	U208
Tetrachloroethylene	F001/F002/U210
Toluene	F005/U220/D001
o-Toluidine	D001/U328
m-Toluidine	D001
p-Toluidine	D001/U353
Trichloroethylene	F001/F002/U228
Trichlorofluoromethane	F002/U121
Trichloromethane	U044/D001
m-Xylene	F003/U239/D001
o-Xylene	F003/U239/D001
p-Xylene	F003/U239/D001
Unlisted Ignitable Waste	D001
Spent Solvents	F001
Spent Solvents	F002
Spent Solvents	F003
Spent Solvents	F004
Spent Solvents	F005
Arsenic	D004
Barium	D005

Appendix D - Continued

Chemical Name	Hazardous Waste Code Number
Cadmium	D006
Chromium	D007
Lead	D008
Mercury	D009
Selinium	D010
Silver	D011
Endrin	D012
Lindane	D013
Methoxychlor	D014
Toxaphene	D015
2,4-D	D016
2,4,5-TP (silvex)	D017
Benzene	D018
Carbon Tetrachloride	D019
Chlordane	D020
Chlorobenzene	D021
Chloroform	D022
o-Cresol	D023
m-Cresol	D024
p-Cresol	D025
Cresol	D026
1,4-Dichlorobenzene	D027
1,2-Dichloroethane	D028
1,1-Dichloroethylene	D029
2,4-Dinitrotoluene	D030
Heptachlor (and its epoxide)	D031
Hexachlorobenzene	D032
Hexachlorobutadiene	D033
Hexachloroethane	D034
Methyl ethyl Ketone	D035
Nitrobenezene	D036
Pentachlorophenol	D037
Pyridine	D038
Tetrachloroethylene	D039
Trichloroethylene	D040
2,4,5-Trichlorophenol	D041
2,4,6-Trichlorophenol	D042
Vinyl Chloride	D043

APPENDIX E
Proposed Mixed Waste Acceptance Criteria for WERF Incinerator

ITEM	LIMIT/REQUIREMENT
SOLID - Operational	
Generally Prohibited Items	Not allowed*
Heating Value	No limit - value required
Halogen	Chloride - 1% by weight* Other halogens - no limit - value required
Sulfur	No limit - analysis required
Free liquids	Not allowed
Blended/Repackaged wastes	Must be compatible*
Water Content	No limit - not allowed as free liquid
Classified Waste	Security Plan*
Gases, Vapors, Liquids	Requires special evaluation*
Complexing and Chelating Agents	Requires special evaluation*
SOLID - Radiological	
Alpha Radionuclides	a. 0.5 nCi/g average for 24 hour period* b. 10 nCi/g maximum/box*
External Radiation on Contact	a. 10 mR/hr/box average* b. 200 mR/hr/shipping container*
Fissile Material	Trace quantities*
Tritium	0.285 mCi/lb*
Carbon-14	0.285 mCi/lb*
Heat Generation	Requires special evaluation*
External Contamination	a. 200 dpm/100 cm^2 beta/gamma b. 20 dpm/100 cm^2 alpha
Ignitability	Ignitable wastes allowed - flash point required*

* Case-by-case evaluation to be applied.

APPENDIX E (Continued)
Proposed Mixed Waste Acceptance Criteria for WERF Incinerator

ITEM	LIMIT/REQUIREMENT
Ignitability	Ignitable wastes allowed - flash point required*
Corrosivity	Corrosives not allowed
Reactivity	Reactives not allowed
Toxicity	Toxicity wastes allowed - constituent quantities required*
Listed Mixed Waste	Allowed according to permits*
Principal Organic Hazardous Constituents (POHCs)	POHCs must have heat of combustion greater than 432 Btu/lb
Polychlorinated Biphenyl	Must be less than 50 ppm
LIQUID - <u>Operational</u>	
Heating Value	>10,000 But/lb*
Halogen	Chloride - requires special evaluation* Other halogens - no limit - value required
Blended/Repackaged Wastes	Must be compatible*
Water Content	No immiscible layer allowed*
Gases, Vapors, Liquids	Requires special evaluation*
Viscosity	150 SSU
Particulate	≤100 microns particle size <0.1 weight % suspended particulate
Phosphates	No limit - value required
Ash content	≤1.2 weight %
Complexing and Chelating Agents	Requires special evaluation*
LIQUID - <u>Radiological</u>	
Alpha Radionuclides	Requires special evaluation*
External Radiation on Contact	a. 10 mR/hr/drum average* b. 200 mR/hr/shipping container*

* Case-by-case evaluation to be applied.

APPENDIX E (Continued)
Proposed Mixed Waste Acceptance Criteria for WERF Incinerator

ITEM	LIMIT/REQUIREMENT
Fissile Material	Trace quantities*
Tritium	0.285 mCi/lb*
Carbon-14	0.089 mCi/lb*
Internal Heat Generation	Requires special evaluation*
External Contamination	a. 200 dpm/100 cm^2 beta/gamma b. 20 dpm/100 cm^2 alpha
LIQUID - Hazardous	
Ignitability	Ignitable waste allowed - flash point required*
Corrosivity	Corrosives not allowed
Reactivity	Reactives not allowed
Toxicity	Toxicity wastes allowed - constituent quantities required
Listed Mixed Waste	Allowed according to permits*
POHCs	POHCs must have heat of combustion greater than 432 Btu/lb
Polychlorinated Biphenyl	Must be less than 50 ppm
CONTAINER/PACKAGES	
Solid Waste Package	Cardboard box ≤ 2' x 2' x 2'*
Package Preparation	Poly liner, tapes shut*
Solid Package Weight	60 lbs*
External Radiation	a. 10 mR/hr/box* b. 200 mR/hr/shipping container*
External Contamination	a. 200 dpm/100 cm^2 beta/gamma b. 20 dpm/100 cm^2 alpha
Special Solid Repackaging	Notify WROC Engineering*
Liquid Waste Package	DOT approved drums*

* Case-by-case evaluation to be applied.

APPENDIX E (Continued)
Proposed Mixed Waste Acceptance Criteria for WERF Incinerator

ITEM	LIMIT/REQUIREMENT
Package Loading, Integrity	Free of dirt, 2" headspace, 800 lb*
External Radiation	a. 10 mR/hr/drum average* b. 200 mR/hr/shipping container*
External Contamination	a. 200 dpm/100 cm^2 beta/gamma b. 20 dpm/100 cm^2 alpha
Special Liquid Repackaging	Notify WROC Engineering*
General Marking and Labeling	According to WWSB or MWSF WAC
Box Marking and Labeling for WERF	- Radiation reading - Hazard type and/or waste code - Chloride quantity in lbs
	SHIPPING
Palleting and Rigging	According to WWSB or MWSF WAC
Box Shipping Container	Cargo container*
General Documentation	According to WWSB or MWSF WAC
Documentation for WERF	- Form ID F 5480.1A - U.S. EPA Form 8700-22 - Manifest Attachment Sheet(s) - Certification Statement - LDR Notifications - Form EG&G 669 and 669R
	VARIANCE
Request for Variance	Special evaluation required*

* Case-by-case evaluation to be applied.

APPENDIX F
Radionuclide Inventory Determination
CIF Tank Farm

Appendix F
Radionuclide Inventory Determination CIF Tank Farm

Radionuclide	Inventory [Ci]	Dose/Unit Activity [rem/Ci]	100-Meter Dose [rem]
	(A)	(B)	(C=AxB)
H-3		1.57E-04	
Cr-51		4.35E-06	
Mn-54		1.07E-04	
Co-60		2.48E-03	
Ni-63		4.96E-05	
Zn-65		2.99E-04	
Se-75		1.36E-04	
Se-79		1.47E-04	
Kr-85		2.94E-07	
Rb-87		5.46E-05	
Sr-89		6.12E-04	
Sr-90*		2.15E-02	
Y-90		1.36E-04	
Y-91		7.28E-04	
Nb-95		7.54E-05	
Zr-95		3.15E-04	
Tc-99		1.24E-04	
Rh-106		1.08E-07	
Ru-106		7.28E-03	
Ag-110m		8.80E-04	
Cd-115m		1.08E-03	
Sb-125		1.63E-04	
Te-125m		1.11E-04	
I-129		2.98E-01	
Cs-134		7.80E-04	
Ba-137m		6.42E-07	
Cs-137*		5.29E-04	
Ce-144		5.79E-03	
Pr-144		7.27E-07	
Pr-144m		3.04E-08	
Pm-147		5.63E-04	
Sm-151		4.80E-04	
Eu-154		4.30E-03	
Eu-155		6.45E-04	

Radionuclide	Inventory [Ci]	Dose/Unit Activity [rem/Ci]	100-Meter Dose [rem]
	(A)	(B)	(C=AxB)
Th-232		2.65E+01	
U-233		2.15E+00	
U-234		2.15E+00	
U-235		1.99E+00	
U-236		1.99E+00	
U-238		1.99E+00	
Np-237		8.11E+00	
Pu-238		7.61E+00	
Pu-239*		8.44E+00	
Pu-240		8.44E+00	
Pu-241		1.65E-01	
Pu-242		7.94E+00	
Am-241		8.60E+00	
Am-243		8.60E+00	
Cm-244		4.47E+00	
Cf-252		2.15E+00	
Total Dose at 100 meters (Must be < 4.0 rem)			

* Waste identified only as alpha, beta, or gamma emitters should be conservatively treated as the following individual radionuclides:

Alpha - Pu-239
Beta - Sr-90
Gamma - Cs-137

APPENDIX G
Chemical Inventory Determination - CIF

Chemical	Quantity [kg]	Air Conc./ Unit Inventory [mg/kg m3][1]	IDLH or ERPG-2 [mg/m3]	Fraction IDLH or ERPG-2
	(A)	(B)	(C)	(A X B)/C
Acetonitrile		6.40E-02	6.84E+03	
Acrylamide[2,4]		1.39E-05	3.00E-01	
Acrylonitrile[4]		2.16E-01	1.11E+03	
Allyl alcohol		6.30E-02	3.63E+02	
Ammonium Sulfamate		2.97E-05	5.00E+03	
Aniline		5.88E-04	3.87E+02	
Arsenic		9.48E-06	1.00E+02	
Barium		1.57E-05	1.10E+03	
Benzene[4]		1.01E-01	9.75E+03	
Benzyl chloride		2.16E-03	5.26E+1	
Benzo pyrene		5.69E-08	7.00E+02	
Bis (2-chloroethyl) ether		1.97E-06	1.49E+03	
Bromoform[2]		2.58E-02	5.00E+01	
Cadmium		1.36E-05	5.00E+01	
Carbon disulfide[3]		3.00E+00	1.58E+02	
Carbon tetrachloride[4]		2.77E-01	1.92E+03	
Chlordane[4]		9.10E-10	5.00E+02	
Chlorinated benzene		6.34E-03	1.12E+04	
Chlorinated ethanes		2.42E+00	5.36E+04	
Chlorinated fluorocarbons		6.11E-01	3.51E+04	
Chloroacetaldehyde		1.41E-01	3.26E+02	
Chloroform[4]		4.54E-01	4.96E+03	
Chromium[2,4]		1.01E-05	1.00E+01	
Chrysene		3.43E-04	7.00E+02	
Cresols		1.04E-04	1.13E+03	
Creosote		1.11E-03	7.00E+02	
2,4-D, salts and esters		2.44E+00	5.00E+02	
Crotonaldehyde[3]		1.29E-01	2.91E+01	

Appendix G - Continued

Chemical	Quantity [kg]	Air Conc./ Unit Inventory [mg/kg m3][1]	IDLH or ERPG-2 [mg/m3]	Fraction IDLH or ERPG-2
	(A)	(B)	(C)	(AXB)/C
DDT[2,4]		9.39E-04	1.00E+01	
Dibutyl phthalate		1.34E-10	9.30E+03	
o-Dichlorobenzene		5.75E-04	6.11E+03	
p-Dichlorobenzene		1.03E-04	6.11E+03	
Dichlorodifluoromethane		2.42E+00	2.52E+05	
1,2-Dichloroethylene		3.29E-01	1.61E+04	
Dichloroethyl ether		5.74E-04	1.49E+03	
Dichloropropane		3.50E-02	9.40E+03	
Dieldrin[4]		1.64E-04	4.50E+02	
1,4 Diethyleneoxide		2.40E-02	7.32E+03	
Dimethylphthalate		4.11E-09	9.30E+03	
Dimethyl sulfate		1.01E-04	5.24E+01	
Dinitrotoluene		2.47E-06	2.00E+02	
Diphenyl		2.04E-03	3.00E+02	
Endrin		1.03E-04	2.00E+03	
Epichlorohydrin[3]		4.38E-02	7.70E+01	
2-Ethoxyethanol		2.52E-03	2.25E+04	
Ethylene dibromide[4]		1.99E-02	3.12E+03	
Ethylene dichloride		1.18E-01	4.11E+03	
Ethylene oxide		2.42E+00	1.46E+03	
Ethylidene dichloride		4.48E-01	1.65E+04	
Ethyleneimine		5.49E-01	1.79E+02	
Formaldehyde[3]		1.21E+00	1.25E+01	
Formic acid		5.92E-02	5.73E+01	
Heptachlor[4]		6.66E-08	7.00E+02	
Hexachlorobutadiene[3]		1.46E-04	1.16E+02	
Hexachloroethane[4]		3.06E-05	3.00E+03	
Hydrazine[4]		1.30E-02	1.06E+02	
Hydrogen cyanide		6.20E+00	5.60E+01	
Hydrogen fluoride[3]		1.21E+00	1.66E+01	
Isobutyl alcohol		3.42E-03	2.46E+04	

Appendix G - Continued

Chemical	Quantity [kg]	Air Conc./ Unit Inventory [mg/kg m3][1]	IDLH or ERPG-2 [mg/m3]	Fraction IDLH or ERPG-2
	(A)	(B)	(C)	(A X B)/C
Lead compounds		9.72E-06	7.00E+02	
Lindane		3.86E-10	1.00E+03	
Maleic anhydride[2]		1.33E-08	1.00E+01	
Mercury		8.79E-08	1.00E+01	
Methoxychlor[2]		2.96E-04	1.00E+02	
Methyl chloride[4]		2.42E+00	2.10E+04	
Methyl chloroform		1.94E-01	5.55E+03	
Methylene chloride		7.25E-01	1.77E+04	
Methyl ethyl ketone		1.00E-01	9.00E+03	
Methyl hydrazine		1.36E-01	9.60E+01	
Methyl iodide[3]		3.63E+00	2.95E+02	
Methyl isocyanate		3.67E+00	4.74E+01	
Methyl methacrylate		2.88E-02	1.66E+04	
Mineral spirits		5.70E-02	2.95E+04	
Naphthalene		1.33E-05	2.50E+03	
Nickel[2]		2.05E-05	1.00E+00	
p-Nitroaniline		3.46E-07	3.00E+02	
Nitrobenzene		2.40E-03	1.02E+03	
2-Nitropropane		1.04E-02	8.51E+03	
Parathion		4.17E-06	2.00E+1	
Pentachlorophenol		1.43E-07	1.50E+02	
Phenol[3]		1.17E-01	1.90E+02	
Phosgene[3]		1.21E+00	8.22E-01	
Phthalic anhydride		4.26E-08	1.00E+04	
Pyridine		1.03E-02	1.18E+04	
Selenium[2]		5.02E-05	2.00E+00	
Silver[2]		8.43E-05	1.00E-01	
Sodium cyanide		3.55E-05	5.00E+01	
Strychnine		9.45E-04	3.00E+00	

Chemical	Quantity [kg]	Air Conc./ Unit Inventory [mg/kg m³][1]	IDLH or ERPG-2 [mg/m³]	Fraction IDLH or ERPG-2
	(A)	(B)	(C)	(AXB)/C
1,1,2,2-Tetrachloroethane		7.30E-03	1.05E+03	
Tetrachloroethylene[4]		1.96E-02	3.45E+03	
Tetranitromethane		5.65E-02	4.08E+01	
Thallium compounds		1.18E-04	2.00E+01	
Toluene		2.78E-02	7.66E+03	
Toluene diisocyanate		6.33E-05	7.24E+01	
o-Toluidine		1.06E-04	4.46E+02	
Toxaphene[4]		2.41E-03	2.00E+02	
Tributyl phosphate		1.90E+00	1.38E+03	
1,1,2-Trichloroethane[4]		2.79E-02	2.78E+03	
Trichloroethylene[4]		9.72E-02	5.46E+03	
Trichlorofluoromethane		2.42E+00	5.71E+04	
Vanadium pentoxide		5.94E-05	7.00E+01	
Vinyl chloride		2.42E+00	2.60E+01	
Xylene		7.45E-03	4.41E+03	
Total Dose at 100 meters (Limit to < 0.5)				

1 Any additional unlisted hazardous chemicals must be evaluated by a methodology similar to what has been incorporated in this table for other hazardous chemicals.
2 Ten times the OSHA PEL value is used as the IDLH value for these chemicals.
3 Chemicals with listed ERPG-2 values.
4 An additional ICR Evaluation must be performed.