PRELIMINARY SAFETY ANALYSIS REPORT FOR OPERABLE UNIT 4
REVISION 0

04/19/94

FEMP-2337
FERMCO/PARSONS DOE-FN
100
REPORT

FEMP-2337
Revision 0

Preliminary Safety Analysis Report for Operable Unit 4

Prepared by

The Fernald Environmental Restoration Management Corporation
Under Contract No. DE-AC05-92OR21972
with the United States Department of Energy

and

PARSONS
Under Subcontract No. 2-21487
April 1994

FEMP-2337
Revision 0

Preliminary Safety Analysis Report for Operable Unit 4

AUTHORIZED BY: _____ 4/19/94

Don Ofte, President — Date

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Fernald Environmental Restoration Management Corporation
P.O. Box 398704
Cincinnati, Ohio 45239-8704

FEMP-2337
Revision 0

Preliminary Safety Analysis Report for Operable Unit 4

Prepared By:

Richard Zieminski, PARSONS, Project Manager — Date: 14 April 94

Approved By:

E.R. Schmidt, FERMCO, Manager, Safety Analysis Department — Date: 4/15/94

K.L. Alkema, FERMCO, Vice President, Regulatory Programs Division — Date: 4/15/94

D. Paine, FERMCO, Vice President, Environmental Safety and Health — Date: 4/15/94

For W.S. Pickles, FERMCO, CRU-4 Project Director — Date: 4/15/94

S. Cossell, FERMCO, Chairman, Independent Safety Review Committee — Date: 4/18/94

FEMP-2337
Revision 0

Preliminary Safety Analysis Report for Operable Unit 4

Prepared by

The Fernald Environmental Restoration Management Corporation
Under Contract No. DE-AC05-92OR21972
with the United States Department of Energy

and

PARSONS
Under Subcontract No. 2-21487
April 1994

FEMP-2337
Revision 0

Preliminary Safety Analysis Report for Operable Unit 4

AUTHORIZED BY: _____

Don Ofte, President Date

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Fernald Environmental Restoration Management Corporation
P.O. Box 398704
Cincinnati, Ohio 45239-8704

DISCLAIMER

This report was prepared in an account of work sponsored by an agency/Department of the United States Government. Neither the United States Government nor any agency/Department thereof, nor any of their employees, nor any of its contractors, subcontractors nor their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe upon privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency/Department thereof. The views and opinions of authors expressed herein do not state or reflect those of the United States Government, any agency/Department thereof, or its contractors.

Preliminary Safety Analysis Report for Operable Unit 4

Prepared By:

Richard Zieminski, PARSONS, Project Manager — Date

Approved By:

E.R. Schmidt, FERMCO, Manager, Safety Analysis Department — Date

K.L. Alkema, FERMCO, Vice President, Regulatory Programs Division — Date

D. Paine, FERMCO, Vice President, Environmental Safety and Health — Date

W.S. Pickles, FERMCO, CRU-4 Project Director — Date

S. Cossell, FERMCO, Chairman, Independent Safety Review Committee — Date

Preliminary Safety Analysis Report for Operable Unit 4

CONTENTS

Executive Summary ES-1

SECTION

1.0 Introduction 1-1
- 1.1 Facility Overview 1-4
- 1.2 Prime Contractors 1-10
- 1.3 Facility Life Cycle 1-12
- 1.4 Graded Approach 1-12
- 1.5 PSAR Organization 1-15
- 1.6 Items Requiring Further Development 1-15
- 1.7 References 1-18

2.0 Applicable Statutes, Rules, Regulations, and DOE Orders 2-1
- 2.1 Existing Facilities 2-1
- 2.2 New Facilities 2-1
- 2.3 References 2-6

3.0 Principal Health and Safety Criteria 3-1
- 3.1 Natural Phenomena Hazards 3-2
- 3.2 Nuclear Criticality Prevention Criteria 3-3
- 3.3 Radiological Protection Criteria 3-3
- 3.4 Hazardous Material Protection Criteria 3-3
- 3.5 Industrial Hazards Protection Criteria 3-3
- 3.6 Fire and Explosion Protection Criteria 3-3
- 3.7 Environmental Protection Criteria 3-4
- 3.8 Structures, Systems, and Components 3-4
- 3.9 References 3-5

4.0 Human Factors 4-1
- 4.1 Graded Approach 4-1
- 4.2 Human Factors Analysis 4-1
- 4.3 Project Human Factors Requirements 4-1
- 4.4 References 4-3

CONTENTS (Continued)

5.0 Site Characteristics 5-1
- 5.1 Location 5-1
- 5.2 Infrastructure 5-1
- 5.3 Controlled Areas 5-1
- 5.4 Natural Phenomena and External Events 5-1
- 5.5 Physical Characteristics 5-1
- 5.6 Previous Environmental Assessments 5-2
- 5.7 References 5-2

6.0 Facility Description and Operation 6-1
- 6.1 Existing Buildings and Structures 6-3
- 6.2 New Buildings and Structures 6-14
- 6.3 Operating Systems 6-16
- 6.4 Support Systems 6-27
- 6.5 Safety-Significant Structures, Systems, and Components 6-34
- 6.6 References 6-35

7.0 Codes and Standards 7-1
- 7.1 Existing Facilities 7-1
- 7.2 New Facilities 7-1
- 7.3 References 7-3

8.0 Hazard Analysis 8-1
- 8.1 Hazard Analysis for Segment "M" (K-65 Silos) 8-5
- 8.2 Hazard Analysis for Segment "N" (Silo 3) 8-16
- 8.3 Hazard Analysis for Segment "O" (Vitrification Pilot Plant) 8-25
- 8.4 Final Hazard Categorization of Segments M, N, and O 8-39
- 8.5 References 8-42

9.0 Analysis of Normal, Abnormal, and Accident Operations 9-1
- 9.1 Methodology 9-1
- 9.2 Grading 9-5
- 9.3 Classification of Analysis for Each Event 9-11
- 9.4 Accident Scenarios 9-11
- 9.5 EBA/DBA Conditions and Performance Criteria 9-30
- 9.6 Normal Operations 9-31
- 9.7 Summary and Conclusions 9-42
- 9.8 References 9-49

CONTENTS (Continued)

10.0 Inadvertent Criticality Protection 10-1
10.1 References 10-1

11.0 Radiation Protection 11-1
11.1 Requirements 11-1
11.2 Policy and Program 11-1
11.3 References 11-1

12.0 Hazardous Material Protection 12-1
12.1 Requirements 12-1
12.2 Chemical ALARA Policy and Program 12-1
12.3 References 12-2

13.0 Radioactive and Hazardous Material Waste Management 13-1
13.1 Requirements 13-1
13.2 Waste Forms and Quantities 13-1
13.3 Waste Management Process 13-2
13.4 References 13-2

14.0 Quality Assurance 14-1
14.1 Requirements 14-1
14.2 Assessment 14-1
14.3 Procedure 14-2
14.4 References 14-2

15.0 Conduct of Operations 15-1
15.1 Policies and Procedures 15-1
15.2 References 15-1

16.0 Emergency Preparedness 16-1
16.1 Requirements 16-1
16.2 Objectives 16-1
16.3 Functional Responsibilities 16-1
16.4 Event Assessment 16-2
16.5 Event Categorization 16-2
16.6 Event Notification 16-3
16.7 Facilities and Equipment 16-3
16.8 Training 16-3

CONTENTS (Continued)

16.9 Recovery 16-3
16.10 References 16-3

17.0 Management, Organization, and the Institutional Safety Provisions 17-1
17.1 Contractor Organization 17-1
17.2 Institutional Safety 17-3
17.3 Occurrence Evaluation 17-3
17.4 Staffing, Training, and Qualifications 17-4
17.5 References 17-4

18.0 Procedures And Training 18-1
18.1 Requirements 18-1
18.2 Procedures 18-1
18.3 Training 18-6
18.4 References 18-8

19.0 Initial Testing, In-Service Surveillance, and Maintenance 19-1
19.1 Requirements 19-1
19.2 Testing 19-1
19.3 Surveillance Testing and In-Service Inspection 19-11
19.4 Maintenance 19-11
19.5 References 19-12

20.0 Derivation of Technical Safety Requirements 20-1
20.1 Requirements 20-1
20.2 Discussion of Existing OSRs 20-2
20.3 References 20-2

21.0 Provisions for Decontamination and Decommissioning 21-1
21.1 Project Function 21-1
21.2 D&D of New Facilities 21-2
21.3 References 21-6

APPENDICES

A Silo and Existing Radon Treatment System Drawings
B Vitrification Facility Drawings
C Risk Assessment Report - RAR-93-0012-A-O

LIST OF ILLUSTRATIONS

FIGURES

1-1 Site Location
1-2 OU-4 Location at the FEMP
1-3 Existing and Proposed OU-4 Facilities
1-4 Block Diagram of Pilot Plant Activities
1-5 Vitrification Pilot Plant

6-1 Typical Cross-Section through Silos 1 and 2
6-2 K-65 Silo Modifications
6-3 Cross-Section of Silo 3

9-1 Safety Analysis Flow Chart
9-2 Risk Acceptance Curve for Off-Site Consequences
9-3 Risk Acceptance Curve for On-Site Consequences

11-1 Radiation Occupancy Zones

17-1 CRU-4 Management Organization Structure

TABLES

1-1 K-65 Silos Chronology of Events
1-2 DOE Order 5480.23/PSAR Cross Reference

2-1 Cross Reference of PSAR Section, DOE Order, and S/RID Functional Area for Existing Facilities
2-2 Cross Reference of PSAR Section, DOE Order, and S/RID Functional Area for New Facilities

3-1 Grading of Section 3 - Level of Detail Assigned

6-1 Grading of Level of Detail for Section 6 Topics
6-2 Construction Drawing List
6-3 New and Modified Structures and Systems
6-4 Summary of Silo Waste Materials
6-5 Vitrification Pilot Plant HVAC
6-6 Sample Locations

LIST OF ILLUSTRATIONS (Continued)

TABLES

8-1 Segmentation Guidelines
8-2 FEMP Segments
8-3 Maximum Contents of Vitrification Pilot Plant Components
8-4 Inventory of Radionuclides for Segments M, N, and O (Curies)
8-5 Inventory of Organic Material for Segments M, N, and O
8-6 Inventory of Inorganics for Segments M, N, and O
8-7 Additive Process Chemicals for Pilot Plant (Segment O)
8-8 Segment "M" Hazards Analysis Worksheet
8-9 Dispersion Analysis and Consequences for Segment M
8-10 Segment "N" Hazards Analysis Worksheet
8-11 Segment "N" Consequences of Loss of Containment (Low-Energy Event)
8-12 Segment N Consequences of Loss of Containment (High-Energy Event)
8-13 Segment "O" Hazards Analysis Worksheet
8-14 Consequences of Loss of Pilot Plant Containment due to Earthquake
8-15 Segment O Consequences of Loss of Containment in the Silo 3 Material Storage Bin (Low-Energy Event)
8-16 Segment O Loss of Containment of Thickener in the Pilot Plant (Low-Energy Event)
8-17 Segment O Consequences of Loss of Containment on RTS Canisters (Low-Energy Event)
8-18 FEMP Final Hazard Categorization
8-19 Recommended Hierarchy of Alternative Concentration Limit Parameters
8-20 Summary of Bounding Consequences for Segments M, N, and O

9-1 Results of the Grading Evaluation
9-2 Graded Subtopics for Segment "M," Silos 1 and 2
9-3 Graded Subtopics for Segment "N," Silo 3
9-4 Graded Subtopics for Segments "O," Vitrification Facility
9-5 Safety Analysis Classification
9-6 Effluent Release Limit for Silo 3 Material
9-7 Radiological Accident Consequences
9-8 Toxicological Consequences of Silo 3 (Segment "N") Accidents (mg/m^3)
9-9 Toxicological Consequences of Pilot Plant (Segment "O") Accidents (mg/m^3)

11-1 Radiation Protection Features
11-2 Shielding Requirements

12-1 Hazardous Material Protection Features

LIST OF ILLUSTRATIONS (Continued)

TABLES

15-1 Project-Specific Operations

18-1 Activities and Basic Procedural Tenets
18-2 System-Related Operational Training Requirements

19-1 Structures/Systems Subject to Maintenance

LIST OF ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AEDO	Assistant Emergency Duty Officer
AIHA	American Industrial Hygiene Association
ALARA	As Low As Reasonably Achievable
ARAR	Applicable or Relevant and Appropriate Regulation
ARF	Airborne Respirable Fraction
ASR	Auditable Safety Record
BAT	Best Available Technology
BDBA	Beyond Design Basis Accident
CEDE	Committed Effective Dose Equivalent
CEOSHP	Comprehensive Environmental Occupation Safety and Health Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COL	Check-off List
CRU	CERCLA/RCRA Unit
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DBA	Design Basis Accident
DCF	Dose Conversion Factor (radiation)
DCP	Design Criteria Package
DED	Deputy Emergency Director
DF	Dilution Factor
DOE	United States Department of Energy
EBA	Evaluation Basis Accident
ED	Emergency Director
EDO	Emergency Duty Officer
EEGL	Emergency Exposure Guidance Level
EIS	Environmental Impact Statement
EMS	Emergency Message System
EOC	Emergency Operations Center
EPCRA	Emergency Planning and Community Right-To-Know Act
ER	Emergency Response
ERPG	Emergency Response Planning Guideline
ERMC	Environmental Restoration Management Contractor
ERT	Emergency Response Team
ES&H	Environmental Safety & Health
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

FFCA	Federal Facilities Compliance Agreement
FHA	Fire Hazards Analysis
FN	Fernald Field Office (DOE)
FSAR	Final Safety Analysis Report
GET	General Employee Training
gpm	gallons per minute
HEPA	High-Efficiency Particulate Air
HF	Human Factors
HFSE	Human Factors Safety Evaluation
AWWT	Advanced Waste Water Treatment
IAWWT	Interim Advanced Wastewater Treatment
IDLH	Immediate Danger to Life and Health
IH	Industrial Health
ISR	Independent Safety Review
JAR	Job Analysis Report
JPM	Job Performance Measurement
LOC	Level of Concern
LLW	Low level waste
M&TE	Measuring and Testing Equipment
MAWS	Minimum Additive Waste Stabilization
MC&A	Material Control & Accountability
MMICS	Maintenance Management Information Control System
mph	miles per hour
MSDS	Material Safety Data Sheet
MVO	Motor Vehicle Operator
NAAQS	National Ambient Air Quality Standards
NAD	Nuclear Accident Dosimeter
NAS	National Academy of Sciences
NCS	Nuclear Criticality Safety
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollution Discharge Elimination System
NPH	National Phenomena Hazard
OBBC	Ohio Basic Building Code
OEB	Operational Excellence Board

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

ORR	Operational Readiness Review
OSHA	Occupational Safety and Health Administration
OSR	Operational Safety Requirement
OU	Operable Unit
PAG	Protective Action Guidelines
PEL	Permissible Exposure Limit
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
QAPD	Quality Assurance Program Description
QAPjP	Quality Assurance Project Plan
RAR	Risk Assessment Report
RCRA	Resource Conservation and Recovery Act
RDA	Radiation Detection Alarm
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSO	Remediation Support Organization
RTS	Radon Treatment System
SA	Safety Assessment
SAR	Safety Analysis Report
SARA	Superfund Amendments and Reauthorization Act
SARP	Safety Analysis Report for Packaging
S/RID	Standards/Requirements Identification Document
SSARR	Site Safety Analysis Reference Report
SRC	Significant Review Comment
SSC	Structure, System, or Component
STEL	Short-Term Exposure Limit
SWRB	Stormwater Retention Basin
TLV	Threshold Limit Value
TSR	Technical Safety Requirement
TSS	Technical Support Staff
TWA	Time Weighted Average
UBC	Uniform Building Code
UPS	Uninterruptible Power Supply
US EPA	United States Environmental Protection Agency
USQ	Unreviewed Safety Question
WAC	Waste Acceptance Criteria

EXECUTIVE SUMMARY

This Preliminary Safety Analysis Report (PSAR) provides the safety basis for the construction of the Operable Unit 4 (OU-4) Vitrification Pilot Plant at the Fernald Environmental Management Project (FEMP). The safety basis includes the design objectives and those measures necessary to ensure that the facilities will be constructed and operated in a safe manner and in compliance with applicable laws, regulations, and DOE Orders. The PSAR also addresses the safety of the existing Silos 1, 2, 3, and 4. Silos 1 and 2 were the subject of a previously approved SAR (Ref. ES.1) and this PSAR is intended to provide the annual update to the Silo 1 and 2 SAR. Based on the analysis contained in this PSAR, the risks associated with construction and operation of the vitrification pilot plant, the continued use of Silos 1, 2, and 3, as well as the calculated risks related to postulated accidents associated with these activities, are within the limits defined in the applicable regulations, DOE Orders, and proposed DOE-STD-3005-YR, "Evaluation Guidelines for Accident Analysis and Safety Structures, Systems, and Components (Ref. ES.2). This PSAR does not support the Silo 4 waste retrieval activities. Because Silo 4 does not pose a radiation hazard (Ref. ES.3), it and its associated activities are not within the scope of this PSAR.

The project covered by this PSAR supports the development of the OU-4 Pilot Plant Vitrification Program. The project includes the removal of radioactive material from Silos 1 or 2, and 3, their removal and transport to the Pilot Vitrification Plant, vitrification by a melter, and subsequent cooling and transport for on-site storage. This document does not evaluate the initial testing of the system with non-radioactive materials or subsequent storage of the materials. The purposes of this project are to enhance safety by removing radioactive materials from the silos, putting them in a safer form, and demonstrating the process for future, larger vitrification facilities.

The Site Safety Analysis Reference Report (SSARR) is a general reference document that provides generic or common information that is applicable to many projects at the FEMP in accordance with DOE Order 5480.23 "Nuclear Safety Analysis Reports." This PSAR refers to the SSARR, where appropriate, to eliminate redundancy between the FEMP SARs.

This PSAR implements the graded approach as required by DOE Order 5480.23. This PSAR is based on an approach described in a document prepared by the Westinghouse Hanford Company "Graded Approach for Safety Analysis Reports, WHC-SP-0960, Revision 1." The Westinghouse report was developed by safety analysts at several DOE sites and describes a topic by topic approach for implementing the graded approach philosophy of DOE Order 5480.23. In general, the grading is performed by evaluation of the hazard class, life cycle, complexity, and mission time and their relevance to each of the 21 topics in DOE Order 5480.23.

This PSAR is submitted in accordance with the requirement of DOE Order 5480.23 to obtain Program Secretarial Officer (PSO) approval of the PSAR prior to undertaking procurement of materials and components, construction and preoperational testing of DOE Nuclear Facilities. None of these

construction activities will involve Silos 1, 2, or 3. Although the Silos may be described in this PSAR, the actual performance of construction activities involving these Silos will be based on the Final SAR that will be submitted for approval and authorization prior to construction activities or operations involving radioactive material.

ES-1 Project Description

The Vitrification Pilot Plant Program includes the design, construction, and operation of a new facility for vitrifying residues from Silos 1 and 2 (which are known as the K-65 Silos) and Silo 3. The descriptions of Silo 4 and activities associated with this silo are provided for information only since these activities do not involve radioactive or hazardous materials.

Because Silo 4 does not pose a significant hazard, it and its associated activities are not within the scope of this PSAR.

ES-1.1 Pilot Plant

The OU-4 Pilot Plant Program is being developed to evaluate the use of vitrification technology for the treatment of residues in the K-65 Silos and Silo 3. Experience gained in this program will provide the basis for similar, larger-scale vitrification projects in the future. The operational knowledge and lessons learned in this task ensure the future safe operation of future vitrification projects. The Pilot Plant program will be conducted in two phases. Phase I involves the placement of surrogate material into Silo 4 and the testing of the equipment needed to remove the material. The Phase I Work Plan was approved by the DOE in February 1994. Phase II involves the construction and operation of the Pilot Plant. Phase II also includes the removal of material from the K-65 Silos and Silo 3. The Phase II Work Plan was submitted to the DOE in January 1994. This PSAR provides the preliminary safety basis for Phase II and will be the authorization for the Phase II construction activities.

ES-1.2 Silos 1 and 2

Silos 1 and 2 were constructed in 1952 and have been used since then for storing K-65 slurry residues from uranium ore processing. The structural features of the silos based on the original design provisions are shown in Appendix A on Preload Enterprises Drawing 51T20. A soil berm was placed around the silos to provide structural support and reduce the external radiation dose rate in the surrounding areas.

The cylindrical concrete wall is wrapped with wires and is tied by dowels to the dome ring at the top and base slab at the bottom. The wall and prestressed wires are covered by a protective coating of Gunite. The dome rises to a height of 9 feet, 4 inches above the wall line and the thickness varies from 4 inches at the apex to 8 inches near the dome ring.

The concrete floor slab is 4 inches thick and is supported on a built-up foundation consisting of compacted impervious clay fill with a layer of asphaltic concrete on top and a layer of stone and gravel on top of the asphaltic concrete. Tar paper is used on top of the stone gravel.

The silos are equipped with a slotted pipe underdrain system. The features of this system are shown on various drawings in Appendix A.

ES-1.3 Silo 3

Silo 3 was constructed in 1952 to store metal oxide residue from the FEMP refinery operations. Silo 3 is located south of the Waste Pit Area of the FEMP property adjacent to Silos 1 and 2. Silo 3 is the same size as Silos 1 and 2.

Silo 3 was designated to receive dry materials only. The waste placed in Silo 3 resulted from processing uranium ore concentrates and thus the waste contains some natural uranium. The FEMP refinery operations produced slurries which were dewatered in an evaporator and spray calciner to produce dry residues. The dried residues were then blown under pressure into Silo 3.

Silo 3 contains normal uranium, radium, thorium, silica, and other metal oxides. The source terms of radionuclides and hazardous materials contained in Silo 3 are described in Section 8.

ES-1.4 Silo 4

Silo 4 has never been used and is empty. It will be used to demonstrate the effectiveness of a waste removal and transport system for use during final remediation (see Subsection 6.3.2). As part of the demonstration, (1) a hole with a diameter of approximately 6-ft will be cut in the center of the dome and (2) a superstructure will be installed over Silo 4 to support the waste removal and transport equipment. The superstructure is discussed in Subsection 6.2.1.

ES-1.5 Radon Treatment System (Existing)

The existing radon treatment building contains two calcium sulfate beds, eight activated-carbon beds, and two fan units. The building is surrounded by concrete radiation shielding walls made of stacked solid unmortared blocks. The shielding reduces the gamma radiation dose rates from the radioactive decay of the radon-222 collected within the activated-carbon canisters. The existing Radon Treatment System (RTS) and planned RTS upgrades are discussed in Subsection 6.3.4.

ES-2 Safety Analysis Summary

The safety analysis consists of an evaluation of the hazards and potential accidents associated with the operation of the Vitrification Pilot Plant and continued use of Silos 1, 2, and 3.

A conservative analysis was performed as described in Sections 8, "Hazard Analysis," and 9, "Analysis of Normal, Abnormal, and Accident Operations." These analyses are conservative because:

1) The atmospheric dispersions models are based on stable conditions with low wind speed (Class F at 2 m/s).

2) Conservative values were used to represent the fraction of material that could become airborne.

3) The source terms are based on the upper 95th confidence limit on the mean concentration as listed in the *Operable Unit 4 Remedial Investigation Report* (Ref. ES.3).

These analyses indicate that the risks from potential credible accidents are within the proposed DOE Evaluation Guidelines in DOE-STD-3005-YR (Ref. ES.2) and are therefore acceptable.

The safety analysis concludes that there are no safety structures, systems, or components (SSCs) but that the following are safety-significant SSCs:

1) Shielding
2) Fire protection
3) Effluent monitoring
4) Building ventilation (portion of system which prevents the spread of hazardous materials)
5) Emergency message system
6) Building evacuation system

The need for safety SSCs and safety-significant SSCs is discussed in Sections 20 and 6, respectively.

The safety analysis was performed by determining the hazard category of each facility, analyzing potential accidents and normal operations and as described in the following subsections.

ES-2.1 Final Hazard Categorization

The FEMP site has been divided into segments for the purposes of hazard categorization. A segment has a boundary which an internal event (e.g., fire) cannot cross. Segments "A" through "L" are evaluated in other safety analysis documents. Silos 1 and 2 are Segment "M," Silo 3 is Segment "N," and the

Vitrification Pilot Plant is Segment "O." The basis for this segmentation is discussed in Section 8 of this PSAR and in the SSARR.

DOE Order 5480.23, "Nuclear Safety Analysis Reports," states that consequences of unmitigated releases of radioactive and/or hazardous materials shall be evaluated and classified as follows:

1) Category 1 Hazard - shows the potential for significant off-site consequences
2) Category 2 Hazard - shows the potential for significant on-site consequences
3) Category 3 Hazard - shows the potential for only significant localized consequences

In accordance with FEMP Procedures and DOE requirements, a hazard analysis was conducted in a manner that did not consider the effect of mitigators nor did it consider the probability of an accident occurring (see Section 8, "Hazard Analysis").

The final hazard category was determined by comparing the radiological and toxicological consequences of the unmitigated hazards for hazard categorization presented in Subsection 8.4. Based on the results, see Section 8, the Final Hazard Categories are:

1) Segment M (Silos 1 and 2) - Category 3
2) Segment N (Silo 3) - Category 3
3) Segment O (Vitrification Pilot Plant - Category 3

ES-2.2 Analysis of Accidents and Abnormal Operations

Silos 1, 2, and 3 were designed and constructed in the 1950s and were therefore not built to current standards. For this reason, the accidents associated with the silos are classified as Evaluation Basis Accidents (EBAs). However, since the Pilot Plant is a new facility, Design Basis Accidents (DBAs) are used to evaluate the Pilot Plant. During an EBA, the silo maintains its integrity and mitigates the release. For more severe events (events with pressure, wind speed, ground accelerations, etc.), which exceed the Evaluation Criteria, the silo dome is assumed to collapse and not provide any mitigation of the release.

The accidents were classified into internal events, which may be caused by operation and equipment within the buildings, and externally induced events, which may be caused by other outside elements. For each accident, radiological doses and chemical uptakes were determined for on-site workers and off-site receptors located at the nearest boundary of the site.

Risk is the combination of two components in an accident analysis. The first component is the frequency of an event occurring, expressed in events per year. The second component is the consequence of the event. This is expressed in 50-year lifetime Committed Effective Dose Equivalent (mrem) for radiological hazards and as concentration (mg/m^3) of a substance for chemical hazards. The radiological

accidents are plotted on the risk acceptance curve and the toxicological consequences are compared to tabulated acceptable values.

Figures ES-1 and ES-2 illustrate the radiological dose and frequency of natural phenomena and accidents. The x-axis for a given accident is its expected frequency and the y-axis is the corresponding radiological dose for that accident. The horizontal step function lines represent the DOE Evaluation Guidelines for accidents. So long as an accident is below this line, the risk (frequency times dose) is acceptable. Distinct curves for off-site general public (Figure ES-1) and on-site personnel (Figure ES-2) are based on DOE-STD-3005-YR, *Definitions and Criteria for Accident Analysis* (Ref. ES.2)

Tables 9-8 and 9-9 show the toxicological consequences of accidents associated with Segments N (Silo 3) and O (Vitrification Pilot Plant). There are no toxicological consequences identified for Segment M (Silos 1 and 2) due to the bentonite layer emplacement. The only consequences from Segment O are radiological due to the radon release.

The risks are acceptable when compared to criteria for risk acceptance from proposed DOE-STD-3005-YR. The consequences are acceptable when using the 95th percentile concentration values for all chemicals except for the on-site exposure due to cobalt from Silo 3 which is evaluated using the 50th percentile concentration. Cobalt presents an acceptable risk when evaluated at this level. The reason cobalt is close to an unacceptable risk is due primarily to a lack of acute exposure data and emergency concentration guidelines. Cobalt is evaluated using concentration based numbers which are developed from long term exposures (i.e. Threshold Limit Values) which tend to be overly conservative when applied to acute exposure scenarios.

ES-2.3 Normal Operation

The Pilot Plant Vitrification Facility has not been constructed. There are no operational data available on which to base the analysis of normal operations. The operational safety-related requirements for the pilot plant are summarized in Section 9. The confirmation of the assessment of the design will be finalized following further tests of the charcoal effectiveness to adsorb radon on a large, active flow-through system. In addition, the pilot plant is intended to be used to collect data to determine the potential source terms and hazards associated with vitrification of the wastes within Operable Unit 4. This data will be used in the design of the full scale remediation facility.

The uncertainty associated with the system meeting the requirements for normal operations is acceptable because appropriate controls will be in place to monitor releases from the vitrification process and because the presently installed site environmental monitors determine the amount of radon at the site boundary. The presently installed monitors are for the entire FEMP site and not just the vitrification pilot plant.

1 RTS Failure
2 Seg. M (Silos 1 and 2) Natural Degradation
3 Seg. N (Silo 3) Natural Degradation
4 Loss of Containment (Surge Bin)
5 Loss of Containment (Thickener)
6 Seg. M (Silos 1 and 2) Snow
7 Seg. M (Silos 1 and 2) EBA Earthquake
8 Seg. M (Silos 1 and 2) Tornado (Severe)
9 Seg. M (Silos 1 and 2) Earthquake (Severe)
10 Seg. N (Silo 3) Snow
11 Seg. N (Silo 3) EBA Earthquake
12 Seg. N (Silo 3) Tornado (Severe)
13 Seg. O (Pilot Plant) Earthquake
14 Seg. O (Pilot Plant) Off-gas System Failure

Figure ES-1 - Radiological Risk Acceptance Curve for Off-Site Consequences

1 RTS Failure
2 Seg. M (Silos 1 and 2) Natural Degradation
3 Seg. N (Silo 3) Natural Degradation
4 Loss of Containment (Surge Bin)
5 Loss of Containment (Thickener)
6 Seg. M (Silos 1 and 2) Snow
7 Seg. M (Silos 1 and 2) EBA Earthquake
8 Seg. M (Silos 1 and 2) Tornado (Severe)
9 Seg. M (Silos 1 and 2) Earthquake (Severe)
10 Seg. N (Silo 3) Snow
11 Seg. N (Silo 3) EBA Earthquake
12 Seg. N (Silo 3) Tornado (Severe)
13 Seg. O (Pilot Plant) Earthquake
14 Seg. O (Pilot Plant) Off-gas System Failure

Figure ES-2 - Radiological Risk Acceptance Curve for On-Site Co-Located Worker Consequences

ES-3 Technical Safety Requirements

Operational Safety Requirements (OSRs) were created and approved as part of previous safety analyses and assessments. These OSRs will remain in effect until they are converted to TSRs, as appropriate, and issued concurrently with the FSAR.

ES-4 Conduct of Operations

Staffing: The minimum and normal staffing requirements are to be developed based on operating procedures developed.

Procedures: To be developed.

Training: Training for the overall project and for specific activities will be performed to prepare the workers for the project. Specific training programs are to be developed.

Administrative Controls: Institutional controls provide programs which augment the basic project activity. In this project, administrative controls include hazardous material work permits, radiation work permits, Operational Readiness Reviews, and As Low As Reasonably Achievable (ALARA) radiation exposure reviews.

ES-5 Commitments

To support the safe operation of the facility, the following commitments of this SAR shall be completed.

Table ES-3 Commitments

Requirement	Description	Reference Text in SAR
H&SP	Completed Project Specific Health and Safety Plan	11
Human Factors	A design review by a Human Factors engineer.	4
Shielding	Provided as described to meet dose rate limits of Section 3	11
Training	Training to be identified and programs developed and completed	18
ALARA	ALARA review of project for compliance with Section 3	11
Start-Up	Operability testing prior to hot operations	6
Carbon Tests	Radon adsorption tests using carbon filters	9
Air Modeling	Normal Operations requires air modeling to ensure compliance with regulatory requirements. Pending results of current radon tests air modeling shall be done.	9
FHA	Completed Fire Hazards Analysis per DOE 5480.7A	Table 8-9
Procedures	Procedures as identified in Section 18	18
ORR	Operational Readiness Review completed prior to operations	N/A
Successful Non-radioactive Operations	Successful operation and vitrification of surrogate material prior to radioactive operations.	6
Performance Categorization	Perform Final Facility Categorization per DOE 5480.28 and DOE-STD-1021-YR to develop Performance Categories for the structures, systems and components to determine effects of lower Category equipment on higher Category equipment	6
Permitting	Obtain government permits cited in WP-18-0007, *Operable Unit 4 Pilot Plant Phase I Treatability Study Work Plan*	N/A
Administrative Controls	Administrative controls imposed by safety requirements	Table 20-1

ES-6 References

ES.1) PARSONS, November 1991. "Silos 1 and 2 Facility Safety Analysis Report, Rev. 2."

ES.2) United States Department of Energy, February 1994. "Evaluation Guidelines for Accident Analysis and Safety Structures, Systems,. and Components." Proposed DOE-STD-3005-YR.

ES.3) United States Department of Energy - Fernald Field Office, August, 1993. "Remedial Investigation Report for Operable Unit 4 - Draft Final."

SECTION 1

INTRODUCTION

The Fernald Environmental Management Project (FEMP) established operations in 1951 under the orders of the Atomic Energy Commission (one of the United States Department of Energy's [DOE's] predecessor agencies) to produce uranium metal and other materials for DOE and Department of Defense facilities. The FEMP is located near Fernald, Ohio, approximately 20 miles northwest of Cincinnati, Ohio (see Figure 1-1). The production facilities at the FEMP are presently shut down in preparation for environmental remediation of the entire site.

The project covered by this Preliminary Safety Analysis supports the design of the OU-4 Pilot Plant Vitrification Program. The project includes the removal of radioactive material from Silos 1 or 2, and 3, the residues transport to the Pilot Vitrification Plant, vitrification by a melter, and subsequent cooling and transport for on-site storage. Not included in this document are the initial testing of the system with non-radioactive materials or subsequent storage of the materials. The purposes of this project are to enhance safety by removing radioactive materials in the silos and putting them in a safe form, and demonstrating the process for future larger vitrification facilities. The Pilot Plant is being constructed as a study under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to evaluate the application of vitrification treatment technology at this site. In addition to providing the safety basis for the pilot plant, this PSAR provides the annual update of the previously approved Facility Safety Analysis Report (SAR) for Silos 1 and 2 (Ref. 1.1) and, as such, will supersede that document. If the accident analysis had identified the need for Technical Safety Requirements (TSRs), the new TSRs would have replaced the existing operational safety requirements. However, as discussed in Sections 9 and 20, TSRs are not required for the safe operation of the Pilot Plant or the continued use of the silos. The approval of this PSAR, as well as the subsequent Final Safety Analysis Report (FSAR), will bring OU-4 into compliance with DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 1.2) and DOE Order 5480.22, "Technical Safety Requirements" (Ref. 1.3).

There have been prior studies and reports prepared under CERCLA which have evaluated the potential risks and hazards for CERCLA purposes. The RI/FS drafts and the Phase II Work Plan have been submitted to the US EPA for approval. The Phase I Work Plan has been approved by the US EPA. This PSAR is intended to develop the safety basis for Silos 1, 2, 3, and the Vitrification Pilot Plant per DOE Order 5480.23.

Because of the relatively short duration of the CERCLA/RCRA Unit 4 (CRU-4) Pilot Plant Program, this PSAR is based on the approved Preliminary (Title I) Design information. Even though PSARs are usually based on the Final Design (Title II), this expedited approach is appropriate because the new vitrification facility is a Category 3 Hazard, is a simple operation, and does not involve any unique

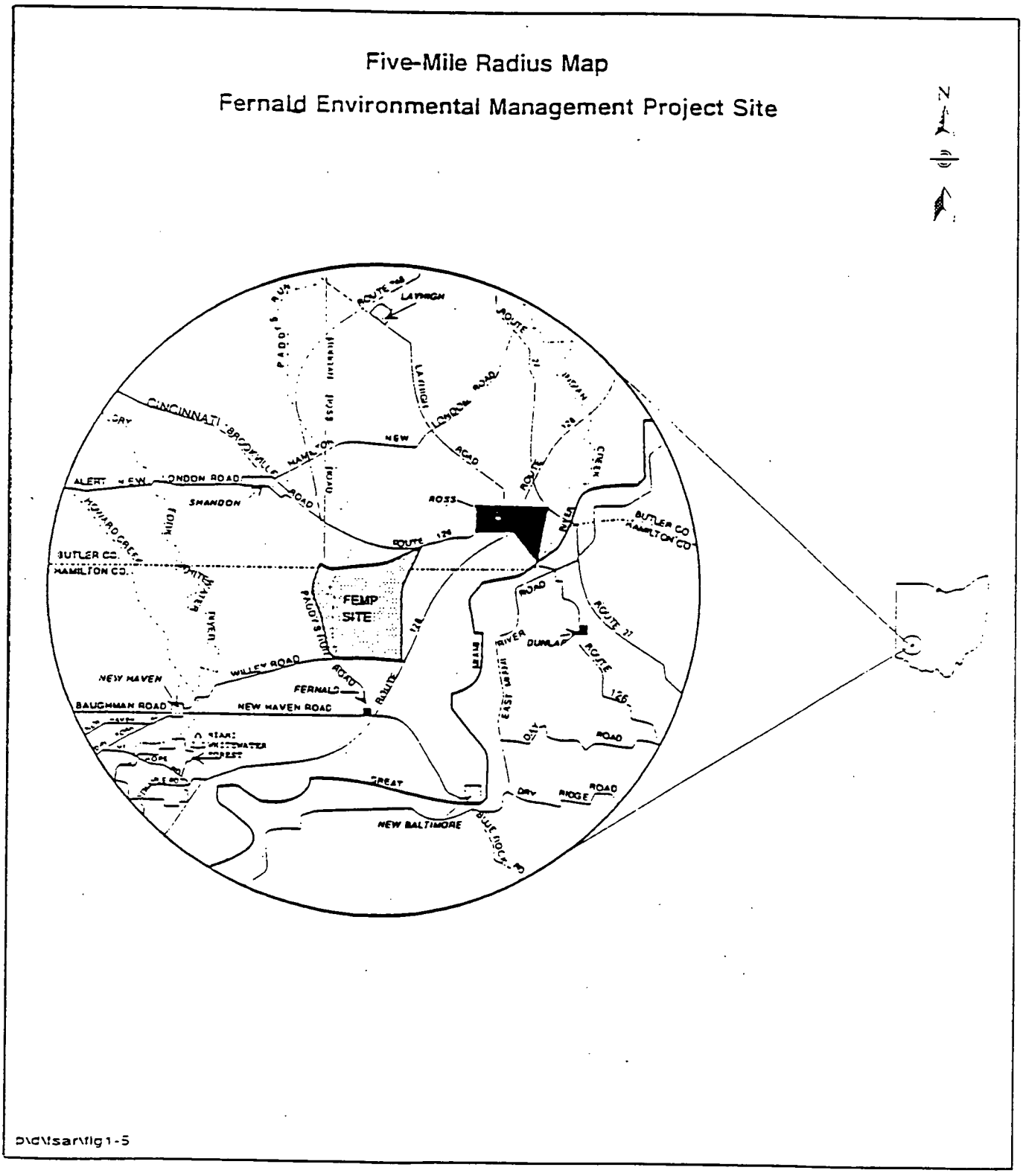


Figure 1-1 - Site Location

hazards that have not been encountered at other DOE or industrial sites.

This PSAR is intended to evaluate the hazards associated with the Pilot Plant, the residue removal activities, and the continued use of Silos 1, 2, and 3. The PSAR does not support the Silo 4 waste retrieval activities. A safety analysis of Silo 4 (Ref. 1.4) indicates that the Silo 4 activities are non-nuclear and no further analysis is required. A description of the Silo 4 activities is included in this report to tie together all pilot plant-related activities.

This PSAR was prepared in accordance with the FEMP SAR Implementation Plan (Ref. 1.5) and, as such, refers extensively to the Site Safety Analysis Reference Report (SSARR) (Ref. 1.6). The SSARR is a general reference document that provides information that applies to many projects at the FEMP in accordance with DOE Order 5480.23. As such, the SSARR will form an integral part of the safety basis for this program.

A FSAR will be prepared during the construction phase to reflect the final design configuration for the OU-4 Pilot Plant Program. The FSAR will be prepared in accordance with DOE Order 5480.23 as it is clarified in proposed DOE-STD-3009-YR, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports* (Ref. 1.7).

The OU-4 Pilot Plant Program consists of the following key goals:

1) Installation of a pump support structure over Silo 4 as part of the residue removal demonstration.

2) Successful removal of a 6-foot-diameter (approximately) section from the center of the Silo 4 dome as part of the residue removal demonstration.

3) Successful demonstration of hydraulic waste removal from Silo 4 using surrogate K-65 material (sand) and bentonite clay.

4) Successful demonstration of pneumatic waste removal of 10 tons of residue (metal oxides) from Silo 3. This material will be stored in a surge bin for use during vitrification.

5) Successful demonstration of hydraulic waste retrieval of 20 tons of K-65 residue from Silo 1 or 2. The material will be piped to the pilot plant thickener tank.

6) Successful upgrade of the closed-loop Radon Treatment System (RTS) for use with the K-65 Silos during residue removal.

7) Successful vitrification of residue contained in the K-65 Silos and Silo 3 on a 24-hour basis and the formation of 1 metric ton of glass product per day (the days may not be consecutive).

8) Successful operation of the vitrification facility off-gas treatment system. The system will remove SO_x and radon gas.

The following information will be compiled during pilot plant operation to ensure successful design and operation of a full-scale vitrification facility:

1) Correct balance of materials, process parameters, and design data to produce glass acceptable for long-term storage

2) Radon gas release rate during waste removal and vitrification to properly size carbon beds needed to ensure off-gas meets air release requirements

If vitrification is selected as the treatment technology of choice by the United States Environmental Protection Agency (US EPA) in the OU-4 Record of Decision, a full-scale vitrification plant will be built requiring either modification of the PSAR or preparation of a new SAR. The 30 metric tons of vitrified material will remain on site in interim storage until the ROD is issued. Upon announcement of the Record of Decision (ROD), vitrified material will be prepared for off-site disposal (if the material meets waste acceptance criteria [WAC]), or be prepared for further treatment (if vitrified material does not meet the WAC).

1.1 Facility Overview

OU-4 is located near the western boundary of the FEMP, west of the production area and south of the waste pit area (Figure 1-2). The locations of the existing facilities and proposed Pilot Plant are shown in Figure 1-3. The proposed OU-4 Pilot Plant facilities lie outside the OU-4 boundaries within OU-5. The Risk Assessment Work Plan Addendum (Ref. 1.8) identified the OU-4 boundaries as the following Ohio state plane coordinates: North 480221.5191-481033-2719 and East 1378329.1786-1378641.5890. Figure 1-4 is a block diagram of the Pilot Plant Program activities.

OU-4 consists of four silos, an existing RTS associated with Silos 1 and 2, and the Radon Treatment Building. A detailed description of the facilities is provided in Section 6 of this report.

1.1.1 Silos 1 and 2

Silos 1 and 2, also known as the K-65 Silos, are located south of the OU-1 waste pit area. The K-65 Silos are large, cylindrical concrete tanks that were designed for temporary storage of residues from uranium ore processing. These silos were constructed in 1952 and have been used since then for storage of radium bearing residues from pitchblende uranium ore processes at the FEMP, Lake Ontario Ordnance Works (now known as the Niagara Falls Storage Facility), and the Mallinckrodt Chemical Works.

0926.mi(2215,ws315) po53@ws315. Fri Dec 3 07:00:41 CST 1993

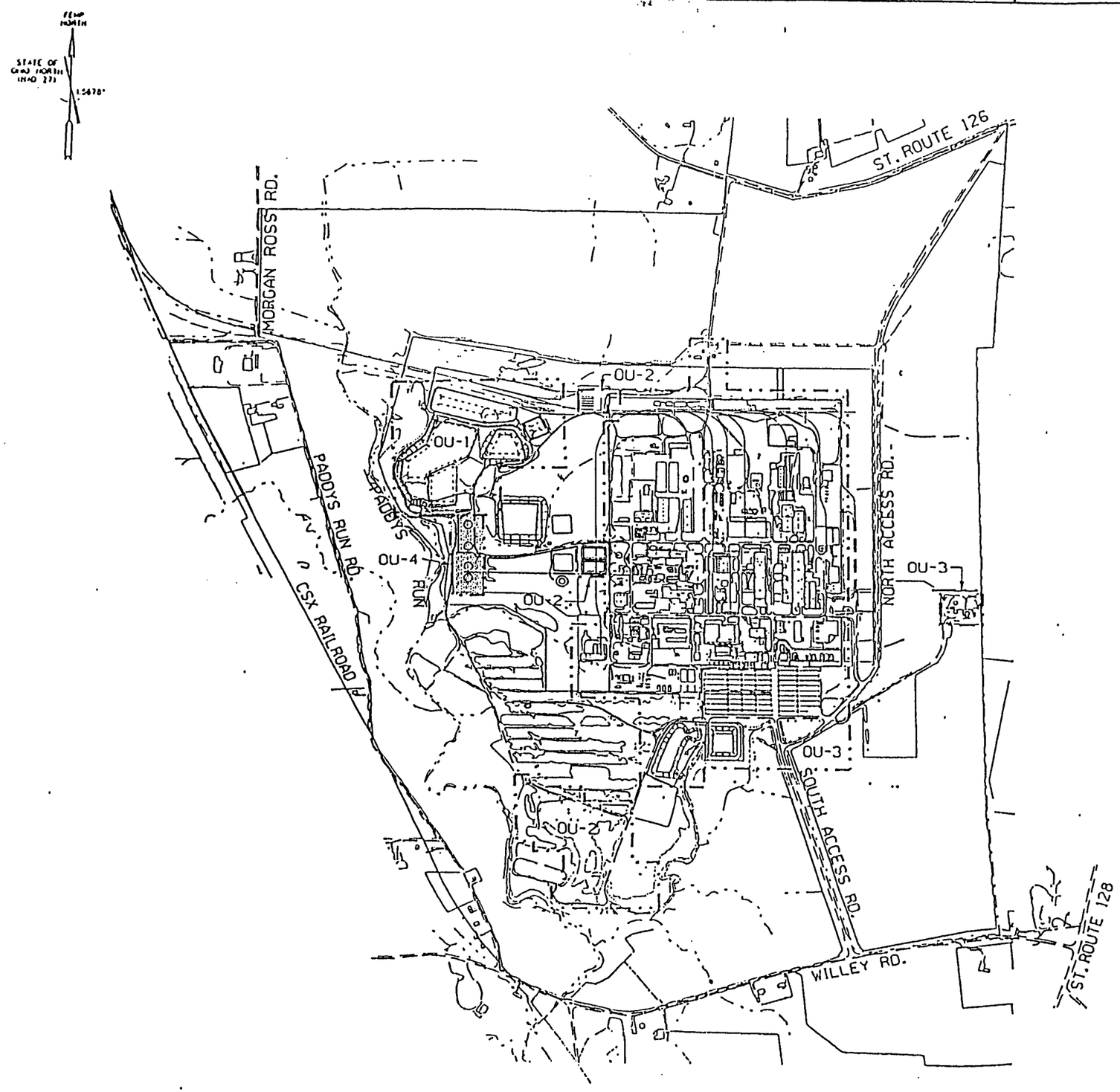


Figure 1-2 - OU-4 Location at the FEMP

1. OU IS OPERABLE UNIT

2. OU-5 INCLUDES GROUNDWATER, SURFACE WATER, SOILS, FLORA, AND FAUNA IN THE DEFINED OU AREAS AND THE UNDEFINED AREAS

LEGEND

— · — SITE BOUNDARY

— · · — OU BOUNDARY

0	SAFETY ANALYSIS REPORT		

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. • OWS, T, WAH, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

SAFETY ANALYSIS SUPPORT PROJECT - PHASE 1
OU3 / POD3

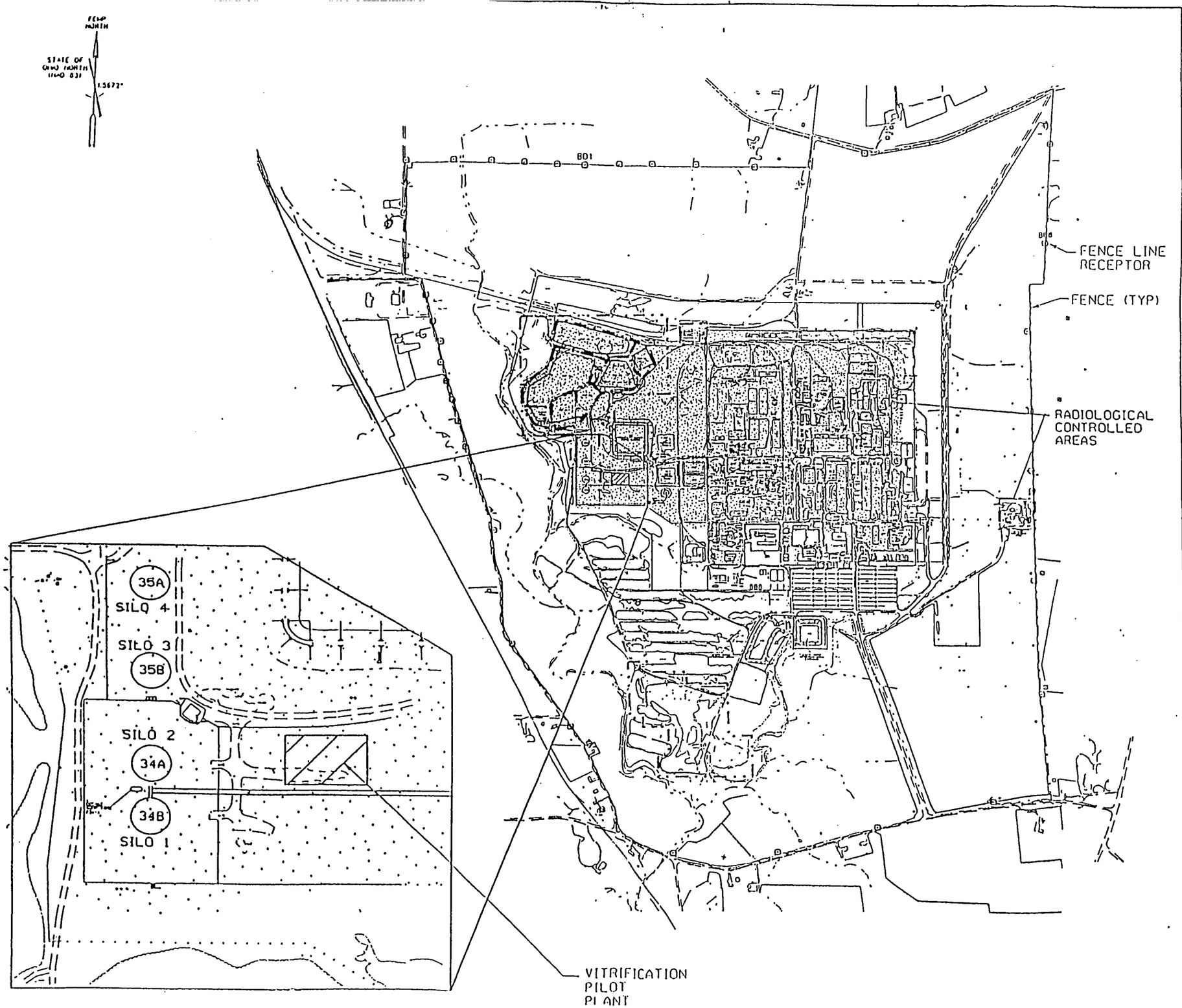
SITE PLAN
FEMP SITE

VDS 1.1.1.1.1.1.1
00-90701

SK-X-00926

0

12474.m(2216.ws315) po85@ws315. Fri Dec 3 07:21:51 CST 1993



NOTES

1. OU = OPERABLE UNIT

2. OU-5 INCLUDES GROUNDWATER, SURFACE WATER, SOILS, FLORA, AND FAUNA IN THE DEFINED OPERABLE AREAS AND THE UNDEFINED AREAS

LEGEND

- SITE BOUNDRY
- OU BOUNDRY
- FENCE LINE RECEPTOR
- RADIOLOGICAL CONTROLLED AREA

PRELIMINARY
NOT FOR CONSTRUCTION

A ISSUED FOR 90% DESIGN REVIEW - TITLE I

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. - OHLS, T, UAH, P.C. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

VITRIFICATION PILOT PLANT DESIGN
CRUH - ONE METRIC TON

SAFETY ASSESSMENT
SITE PLAN
RADIOLOGICAL AREA

J. LOCKE 10-27-93

VBS 1.1.1.1.1.31
00-50701
SK-X-02474
A

Figure 1-3 - Existing and Proposed OU-4 Facilities

Pilot Plant Program Block Flowchart

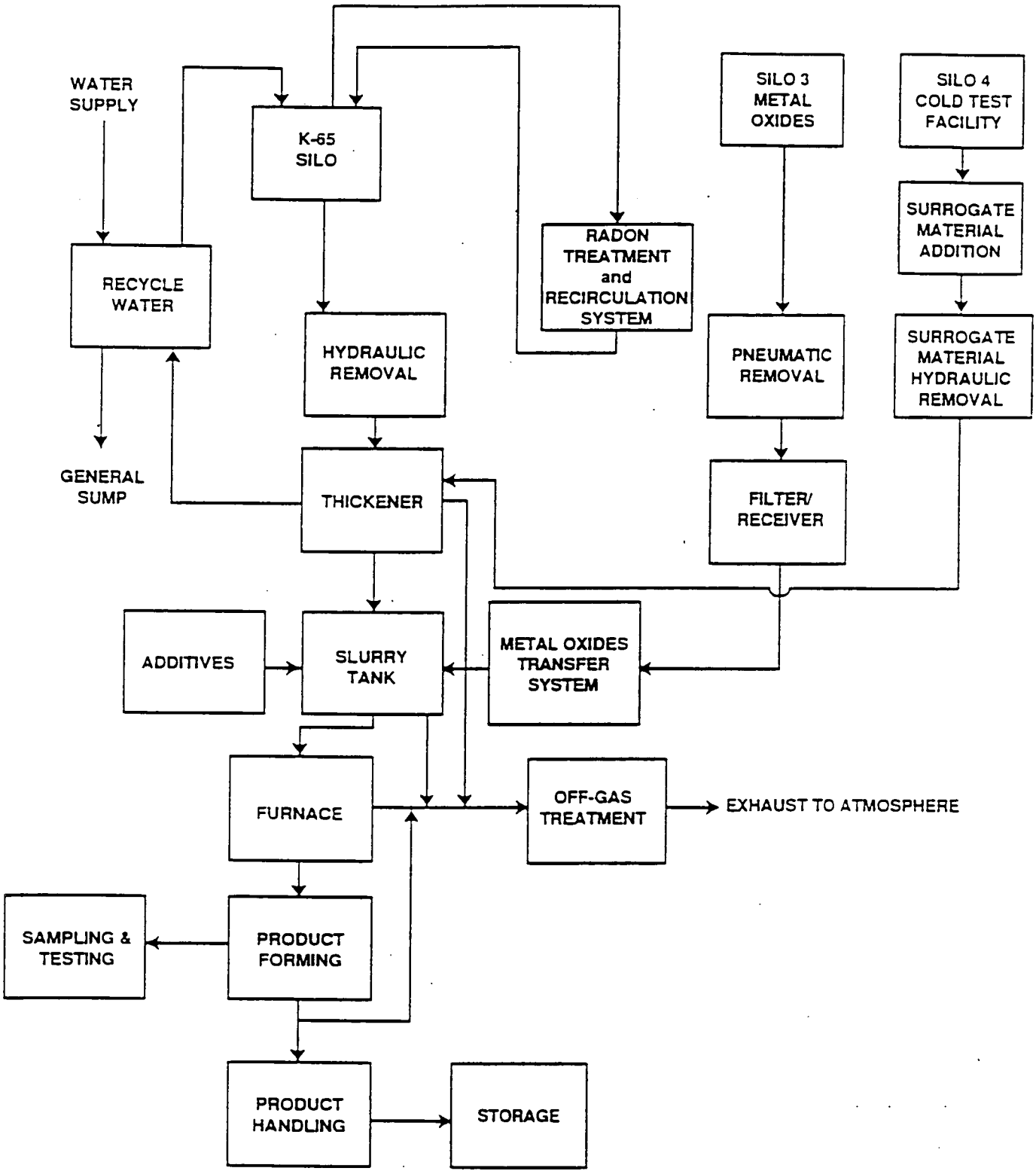


Figure 1-4 - Block Diagram of Pilot Plant Activities

By 1963, the exterior surface of the silos had suffered major deterioration and large areas of the concrete walls had degraded enough to expose the post-tensioning wires. Subsequently, strands of the wires were severely corroded and eventually broke. Repairs to the damaged surface began in 1964 when a waterproof sealant was applied to the external walls. In addition, an earthen embankment was built to the top of the walls. This embankment reinforced the hoop strength which had been reduced by the degradation of the post-tensioning wires. The embankment significantly reduced radon emission and gamma radiation from the silos. The recommendations of subsequent structural investigations have resulted in the construction of a 30-foot-diameter temporary steel and wood dome covering a 20-foot-diameter weak spot on top of the existing domes. In addition, a neoprene membrane was placed over the outside of the dome to minimize radon emanation and to prevent water seepage into the silo dome cracks. Table 1-1 lists the chronology of the construction and use, the various modifications, and major studies made on the silo structures.

Table 1-1 - K-65 Silos Chronology of Events

Date	Milestone or Event
1951	Construction begins
1952	Construction complete
1958	Silos filled to capacity
1964	Repairs made to silos and earthen berm added with 1:1.5 grade
1979	Vents sealed
1983	Berms resloped to 1:3 grade
1985	Camargo non-destructive tests
1986	Protective covers added to center 20 feet
1986	Neoprene membranes added to dome top
1987	RTS constructed
1987	Foam coating applied to domes
1989	DOE inspections
1989	Bechtel performed further analysis
1991	Bentonite placed on the K-65 residue within Silos 1 and 2

1.1.2 Silo 3

Silo 3 was constructed in 1952 to store metal oxide residue from the FEMP refinery operations. Silo 3 is located just north of Silos 1 and 2 and south of Silo 4. Silo 3 is a free-standing, prestressed concrete, domed silo with an approximate 80 foot diameter, 27 foot height at the top of the wall, and a 4-inch-thick concrete floor over an 8-inch layer of gravel. Below the gravel is a 2-inch-thick layer of asphaltic concrete underlain by approximately 18 inches of compacted clay. The domed roof tapers from 8 inches

thickness at the silo walls to a 4 inch thickness at the apex, which is 36 feet high at the top of the dome. In 1992, the dust collector was removed from the Silo 3 dome.

Silo 3 was designated to receive dry materials only. The waste placed in Silo 3 resulted from processing uranium ore concentrates. The FEMP refinery operations produced slurries which were dewatered in an evaporator and spray calcined to produce dry residues. The dried residues were then blown under pressure into Silo 3. Silo 3 material contains normal uranium, radium, thorium, silica, and metal oxides as they occurred in the ore.

1.1.3 Silo 4

Silo 4 is located just north of Silo 3 in the OU-4 area. Silo 4 was never used and contains no radioactive or hazardous material. Silo 4 presents no unique hazards and is therefore, addressed at the appropriate level of detail in the PSAR. Silo 4 will be used during the Pilot Plant Program for demonstration purposes only.

1.1.4 Radon Treatment Building

The RTS building is approximately 24 feet long by 22 feet wide and is surrounded by stacked, unmortared solid concrete block a total of 32 inches thick. It houses the desiccant (calcium sulfate) and activated carbon canisters.

1.1.5 Radon Treatment System

The RTS is located in the Radon Treatment Building. The RTS operates with a blower, two calcium sulfate canisters, eight activated carbon canisters, and the associated piping and valves to circulate air to and from the K-65 Silos. The blower is located outside the RTS building to minimize personnel dose. The RTS will be upgraded as part of the Pilot Plant Program.

The RTS was constructed in 1987 to reduce the radon concentrations and, as a result, the dose rate at the silo dome surface. The reduction of dose rate enabled the silo dome surface to be classified as a radiation area instead of a high radiation area since the dose rates were less than 100 mR/hr after the RTS is operated.

The RTS has not been used to control the dose rate since the application of the bentonite has reduced dose rate levels to less than 100 mR/hr. The RTS was not built to the design criteria in effect at the time of construction and is not in compliance with present design criteria.

1.1.6 Vitrification Facility

Vitrification transforms waste solutions, slurries, moist powders, and/or dry solids into a chemically durable glass form. The feed used in the process can be either combustible or noncombustible. Organics are decomposed and oxidized in the melter plenum while the inorganic residue melts and drains into a molten glass pool. The hazardous inorganic constituents actually become part of the chemical structure of the glass matrix, not merely encapsulated in the waste form. As a result, the glass waste form is expected to pass the US EPA's Toxicity Characteristic Leaching Procedure (TCLP) as nonhazardous.

The vitrification facility (Figure 1-5) consists of residue removal and transport systems, feed preparation, furnace melter, vitrified product former (gem forming), product discharge handling and containerizing system, off-gas treatment, as well as structures and support systems required for operation of the vitrification systems.

Material will be removed by hydraulic methods from the K-65 Silos and by a pneumatic method from Silo 3. The K-65 material will be slurried to a thickener via piping. The Silo 3 material will be transported first to a surge bin and then to the slurry tanks for preparation. The K-65 and Silo 3 materials will be prepared, vitrified, and formed into a glass product suitable for appropriate storage.

1.2 Prime Contractors

The DOE owns the FEMP. It is currently managed by the Fernald Environmental Restoration Management Corporation (FERMCO).

1.2.1 Existing Facilities

Silos 1, 2, 3, and 4 were designed by Preload Engineering, Inc., and were constructed by Catalytic Construction Company during 1951 and 1952. National Lead of Ohio, Inc. was the operating contractor at the time.

The RTS was designed and constructed in 1987 by Westinghouse Environmental Management Company of Ohio (WEMCO).

1.2.2 Vitrification Pilot Plant

FERMCO has contracted the Ralph M. Parsons Company (PARSONS) as the prime architect-engineer for the Vitrification Pilot Plant. FERMCO is responsible for the construction and operation of the Pilot Plant.

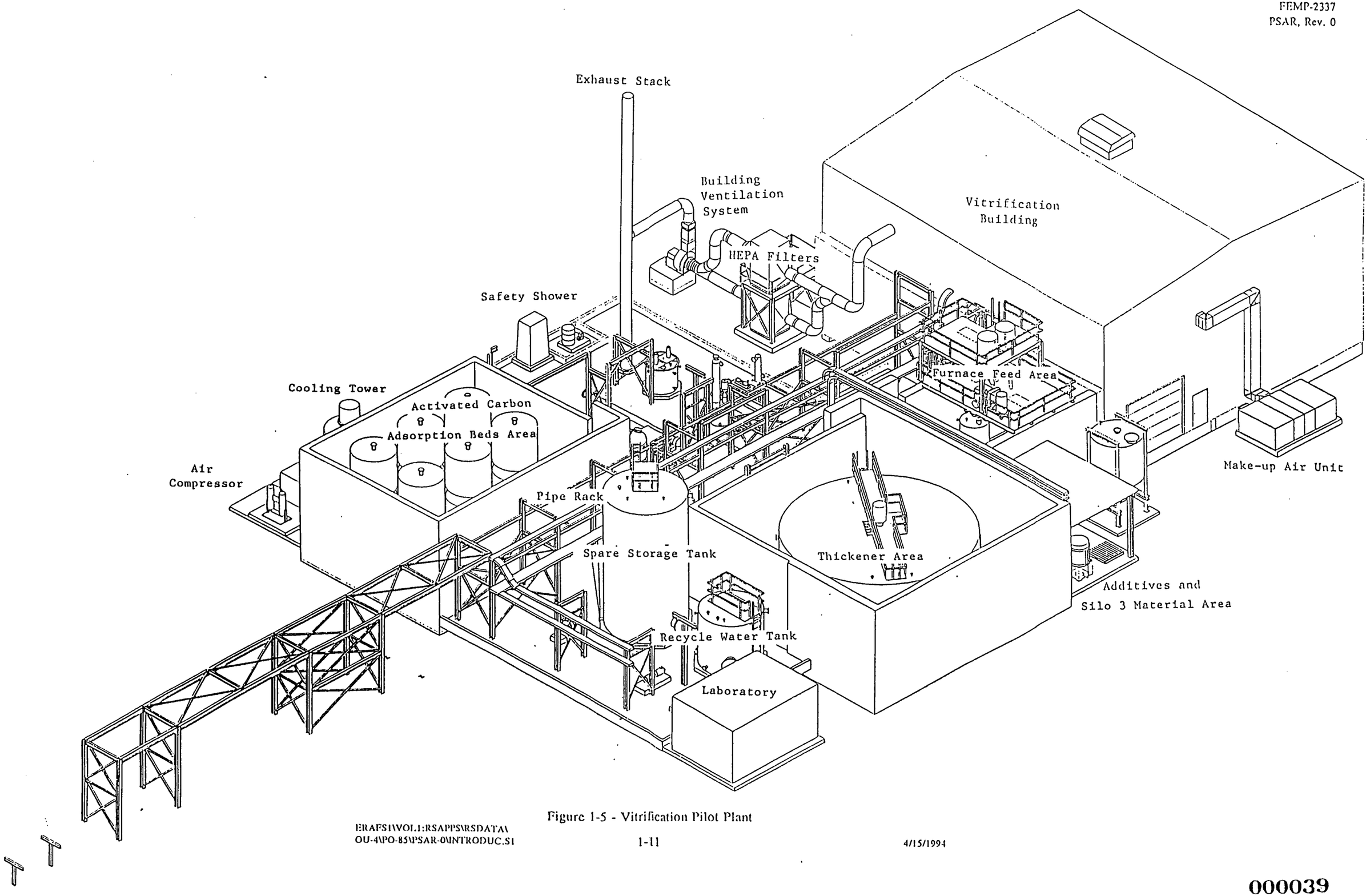


Figure 1-5 - Vitrification Pilot Plant

full.m(5258.ws499) p085@ws499. Wed Mar 23 17:49:39 EST 1994

1.3 Facility Life Cycle

This project includes existing silos, the existing Radon Treatment Building and RTS (to be upgraded), and new vitrification facilities which are to be constructed. The FSAR will be completed prior to construction activities on Silos 1, 2, and 3 and operation of the Pilot Plant with radioactive material from the silos, but after construction of the Pilot Plant and completion of Phase I activities.

1.3.1 Existing Facilities

Existing facilities in OU-4 will be remediated under CERCLA. The facilities which currently store radioactive material will be demolished as part of site remediation. The demolition of the silos is not part of the Pilot Plant Program and is not evaluated in this PSAR. The final schedule has not been determined, but remediation will not begin prior to 1995.

1.3.2 New Facilities

The Vitrification Pilot Plant is currently in Title II design. The Pilot Plant will be constructed in 1994 and will operate for a period of less than 1 year.

An equipment support structure will be constructed over Silo 4 to demonstrate the removal process with non-radioactive material.

1.4 Graded Approach

DOE Order 5480.23, "Nuclear Safety Analysis Reports," encourages the development of SARs using a graded approach. WHC-SP-0960, "Graded Approach for Safety Analysis Reports," Revision 1 describes an approach to "grading" the level of safety analysis and amount of detail that should be included in Safety Analysis Reports.

The approach establishes four "grading factors." These grading factors are the following:

1) Hazard classification of the facility (i.e., general use - 4, low - 3, moderate - 2, high - 1)
2) Complexity of the facility (i.e., simple, complex)
3) Life cycle of the facility (i.e., construction, operation, decommissioning)
4) Mission time of the facility (i.e., short - less than 1 year, long - greater than 1 year)

1.4.1 OU-4 Pilot Plant Program Grading Factors

The OU-4 pilot plant program PSAR has the following grading factors:

1) Hazard Category
   (1) Silos 1, 2 - Category 3
   (2) Silo 3 - Category 3
   (3) Silo 4 - Below Category 3 (non-radiological facility)
   (4) Vitrification Pilot Plant - Category 3

2) Complexity - Simple (for all)

3) Life Cycle
   (1) All Silos - Operation
   (2) Vitrification Pilot Plant - Construction

4) Mission Time
   (1) All Silos - Long
   (2) Vitrification Pilot Plant - Short

1.4.2 PSAR Sections Subject to Grading

WHC-SP-0960 identifies the following sections that are subject to graded levels of detail using the "grading factors" listed above:

Section 3 - Principal Health and Safety Criteria
Section 4 - Human Factors
Section 5 - Site Characteristics
Section 6 - Facility Description and Operation
Section 7 - Codes and Standards
Section 9 - Analysis of Normal, Abnormal, and Accident Conditions
Section 19 - Initial Testing, In-Service Surveillance, and Maintenance
Section 20 - Derivation of Technical Safety Requirements
Section 21 - Provisions for Decontamination and Decommissioning

1.4.3 Level of Detail Definitions

WHC-SP-0960 defines the five "levels of detail" to be used in those sections of the SAR that are considered "gradable."

1.4.3.1 Level I

Level I applies to a systematic, quantitative description sufficient to understand the numerical and logical basis associated with the item, activity, or system and used in the development of the safety analysis.

1) Detailed description of item, activity, or system and required functions, outcomes, or acceptance criteria

2) Detailed description of scope and content; purpose of action, function, or activity; and how it works or how it is performed

Typical items that might be included in Level I descriptions are as follows:

1) Safety related functional requirements
2) Safety related design criteria
3) One-line diagrams
4) Detailed physical descriptions
5) Operating modes
6) Detailed flow sheets
7) Detailed operating sequences

1.4.3.2 Level II

Level II applies to a systematic, qualitative description sufficient to fully understand the activity, item, or system presented and the basis for its safety application.

1) Sufficient to define the content and purpose of the activity, item, or system and required functions, outcomes, or acceptance criteria

2) Sufficient to provide a basic understanding of the principles of the item, activity to be performed, or performance of the system

Typical items that might be included in Level II descriptions are as follows:

1) Safety related functional requirements
2) Safety related design criteria
3) Block diagrams
4) General arrangements
5) Operating modes

1.4.3.3 Level III

Level III applies to a qualitative overview sufficient to provide a general understanding of the item, activity, or system. This would be a generalized description of the item, activity, or system and its basic content, operation, performance, and purpose.

1.4.3.4 Level IV

Level IV applies to an identification of the item, activity, or system and its basic content and purpose.

1.4.3.5 Level V

Level V applies when no information is necessary on the item, activity, or system.

1.4.4 Determining Final Level of Detail

The final overall "grade" or level of detail for a subtopic can be assigned once the grading factors (hazard category, complexity, life cycle, and mission time) have been determined for a structure, system, or component (SSC). The overall level of detail is the highest number taken from the level of detail numbers assigned each grading factor. Using Table 9-2, subtopic "Derivation of Principal Safety Criteria," as an example with the following grading factors/(level of detail from table) assigned: hazard category - 3/(IV), complexity - simple/(III), life cycle - construction/(II), and mission time - short/(III), would assign a final overall grade of IV for that subtopic.

1.5 PSAR Organization

This PSAR is structured in accordance with the format and sequence specified in DOE Order 5480.23, Attachment 1, and in draft *Project Safety Analysis Report Guide* (Ref. 1.9). Each section of this document corresponds to a similar section in the SSARR which has the same number and includes generic sitewide information on the same topic.

Correspondence between this document and DOE Order 5480.23, Attachment 1, is indicated in Table 1-2.

1.6 Items Requiring Further Development

The following items will be developed for later revisions of the SAR. Commitments to be fulfilled to support design and operation are cited in Subsection ES-5:

1) Preparation of the FSAR for the Pilot Plant Program per DOE Order 5480.23.

2) Preparation of the Fire Hazards Analysis of the Pilot Plant Program

Table 1-2 - DOE Order 5480.23/PSAR Cross Reference

DOE 5480.23, Attachment 1 Requirements	Topic	PSAR Section
1a	Facility Overview	1.1
1b	Prime Contractors	1.2
1c	Facility Life Cycle	1.3
1d	Structure of SAR	1.5
2	Applicable Statutes, Rules, Regulations and Orders	2
3a	Site Status	5
3b	Site Description	SSARR
3c	Environmental Threats	5.4
3d	Site Characteristics	5.5
3e	Site Parameters	SSARR
4a	Description of Safety Systems	6.5
4b	System Design	6
4c	Safety Features	6
5	Hazard Analysis and Facility Classification	8
6a	Safety Criteria	3
6b	Support Systems	6
6c	Process Systems	6
6d	New Facility Criteria	3,6
6e	Logic of Criteria Derivation	SSARR, DCP
7a	Wastes Generated	13.1
7b	Waste Process, Sources, and Treatment	13.1
8	Criticality Protection	10
9	Radiation Protection	11
10	Hazardous Material Protection	12
11	Analysis of Normal, Abnormal, and Accident Conditions	9

Table 1-2 - DOE Order 5480.23/PSAR Cross Reference (Continued)

DOE 5480.23, Attachment 1 Requirements	Topic	PSAR Section
12a	Contractor Organization	17.1
12b	Organization Interfaces	17
12c	Safety Culture	17.2
12d	Configuration Control	17.2
12e	Occurrence Reports	17.3
12f	Staffing and Qualification	17.4
13a	Emergency, Operation, and Surveillance/ Maintenance Procedures	18.1
13b	Procedure Validation	SSARR
13c	Human Factor in Procedures	SSARR
13d	Training Program	18.2
14	Human Factors	4
15	Initial Testing, In-Service Surveillance, and Maintenance	19
16	Technical Safety Requirements	20
17a	Conduct of Operations	15
17b	Safety Programs	SSARR
18	Quality Assurance	14
19	Emergency Preparedness	16
20	Decontamination and Decommissioning	21
21	Applicable Facility Design Codes and Standards	7

1.7 References

1.1) PARSONS, November 1991. *Silos 1 and 2 Facility Safety Analysis Report*, Rev. 2.

1.2) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

1.3) United States Department of Energy, February 1992. DOE Order 5480.22, "Technical Safety Analysis Reports."

1.4) Westinghouse Environmental Management Company of Ohio, April 1992. *Silo 4 Safety Assessment 92-1002.*

1.5) United States Department of Energy, January 1993. *Implementation Plan for Safety Analysis at the Fernald Environmental Management Project.*

1.6) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

1.7) United States Department of Energy, March 1994. *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Reports*, Draft. DOE-STD-3009-93.

1.8) United States Department of Energy, 1991. *Risk Assessment Work Plan Addendum*. FEMP.

1.9) PARSONS, September 1993. *Project Safety Analysis Report Guide*, Rev. C.

SECTION 2

APPLICABLE STATUTES, RULES, REGULATIONS, AND DOE ORDERS

This section includes the information required by DOE Order 5480.23 (Ref. 2.1), Attachment 1, Item 2. The applicable statutes, rules, regulations, and DOE Orders common and generic to all projects at the FEMP are included in Section 2 of the SSARR (Ref. 2.2).

The Vitrification Pilot Plant project is being undertaken as a treatability study under CERCLA. As such, the project will attain compliance with pertinent statutes and regulations to the extent practicable (see 40 Code of Federal Regulations [CFR] 300.400[g]). In addition to the statutes and regulations, other Federal and State non-regulatory advisories, criteria, or guidance (known in CERCLA parlance as To-Be-Considered [TBC]) may, as appropriate, be considered in formulating the project. The applicable statutes, regulations, and TBCs with their implementation are contained in the project Design Criteria (Ref. 2.3).

2.1 Existing Facilities

Because the silos were designed and constructed in the mid 1950s, they are not required to fully comply with current DOE Order and regulatory requirements for a low-hazard facility. The RTS was not built to the rules, regulations, and DOE Orders in effect at the time of construction in 1987.

DOE Orders and regulations and Standard/Requirements Identification Documents (S/RIDs) govern and control the requirements for the topics addressed in this PSAR. The S/RIDs, which are broken into 24 functional areas, are included in RM-0016, *The Management Plan* (Ref. 2.4). The DOE Orders and the S/RIDs for existing facilities are included in Table 2-1.

2.2 New Facilities

During the OU-4 Pilot Plant Program, new facilities will be designed, constructed, and operated in accordance with the DOE Orders specified in Table 2-2, and the rules and regulations specified in the Design Criteria.DOE Orders govern and control the topics addressed in this PSAR. The S/RIDs, which are broken into 24 functional areas, are included in RM-0016, *The Management Plan* (Ref. 2.5). The DOE Orders and S/RIDs for new facilities are included in Table 2-2.

Table 2-1 - Cross Reference of PSAR Section, DOE Order, and S/RID Functional Area for Existing Facilities

Topic	Compliance[1] (PSAR Section)	DOE Order	S/RID Functional Area[2]
Maintenance Management Programs	19	4330.4A	7
Occurrence Reporting and Utilization of Operations Information	16	5000.3B	11
General Environmental Protection Program	5	5400.1	5
Hazardous and Radioactive Waste Management Program	13	5400.3	17
Radiation Protection of the Public and the Environment	11	5400.5	14
Environmental, Safety, and Health Programs for DOE Operations	17	5480.1B	10,11
Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substance, and Hazardous Wastes	FEMP Procedures QP-12.04 PP-0314	5480.3	12
Contractor, Industrial Hygiene Program	12	5480.10	10
Radiation Protection for Occupational Workers	11	5480.11	14
Conduct of Operations Requirements for DOE Facilities	15	5480.19	11
Personnel Selection, Qualifications, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities	18	5480.20	16
Unreviewed Safety Question	All	5480.21	9
Technical Safety Requirements	20	5480.22	9
Nuclear Safety Analysis Reports	All	5480.23	9
Natural Phenomena Hazards Mitigation	8	5480.28	2

Table 2-1 - Applicable DOE Orders for Existing Facilities (Continued)
Cross Reference of PSAR Section, DOE Order, and S/RID Functional Area for Existing Facilities (Continued)

Topic	Compliance[1] (PSAR Section)	DOE Order	S/RID Functional Area[2]
Occupational Safety and Health Program for DOE Contractor Operated Facilities	15	5483.1A	10
Emergency Management System	16	5500.1A	3
Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness, and Response Program for DOE Operations	16	5500.3	3
Quality Assurance	14	5700.6C	8,13

[1] Unless otherwise noted
[2] The S/RID Functional Area, taken from RM-0016, Management Plan

Table 2-2 - Cross Reference of PSAR Section, DOE Order, and S/RID Functional Area for New Facilities

Topic	Compliance[1] (PSAR Section)	DOE Order	S/RID Functional Area[2]
Occupational Safety and Health	17	3790.1A	10
Maintenance Management Programs	19	4330.4A	7
Occurrence Reporting and Utilization of Operations Information	16	5000.3B	11
General Environmental Protection Program	5	5400.1	5
Hazardous and Radioactive Waste Management Program	13	5400.3	17
Radiation Protection of the Public and the Environment	11	5400.5	14
Environmental, Safety, and Health Programs for DOE Operations	17	5480.1B	10,11
Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substance, and Hazardous Wastes	FEMP Procedures QP-12.04 PP-0314	5480.3	12
Fire Protection	6	5480.7A	6
Contractor, Industrial Hygiene Program	12	5480.10	10
Radiation Protection for Occupational Workers	11	5480.11	14
Conduct of Operations Requirements for DOE Facilities	15	5480.19	11
Personnel Selection, Qualifications, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities	18	5480.20	16
Unreviewed Safety Question	All	5480.21	9
Technical Safety Requirements	20	5480.22	9

Table 2-2 - Applicable DOE Orders for New Facilities (Continued)
Cross Reference of PSAR Section, DOE Order, and S/RID Functional Area for New Facilities (Continued)

Topic	Compliance[1] (PSAR Section)	DOE Order	S/RID Functional Area[2]
Nuclear Safety Analysis Reports	All	5480.23	9
Natural Phenomena Hazards Mitigation	8	5480.28	2
Startup and Restart of Nuclear Facilities	19	5480.31	18
Occupational Safety and Health Program for DOE Contractor Operated Facilities	15	5483.1A	10
Emergency Management System	16	5500.1A	3
Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness, and Response Program for DOE Operations	16	5500.3	3
Quality Assurance	14	5700.6C	13
General Design Criteria	3	6430.1A	2
Graded Approach for Safety Analysis Report	All	WHC-SP-0960[1]	N/A

[1] Unless otherwise noted
[2] The S/RID Functional Area, taken from RM-0016, Management Plan

2.3 References

2.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

2.2) FERMCO, November 1993. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

2.3) PARSONS, 1993. *Design Criteria for the CRU-4 Pilot Plant Program*, Rev. 0.

2.4) FERMCO, December 1993. *The Management Plan*. RM-0016.

SECTION 3

PRINCIPAL HEALTH AND SAFETY CRITERIA

The grading of topics in Section 3 is determined by the safety analysis for this project and the recommendations of WHC-SP-0960, *Graded Approach to Safety Analysis Reports* (Ref. 3.1). As recommended, the level of detail considers the hazards, complexity, and life cycle of the project. Table 3-1 lists the level of detail assigned to the principal safety and health criteria for the Systems, Structures, and Components (SSCs) in the Pilot Plant Program. Subsections 1.5 and 9.1 of this PSAR describe the logic used in determining the level of detail.

Table 3-1 - Grading of Section 3 - Level of Detail Assigned

Subtopic	Level of Detail
List of safety criteria references	IV
Facility equipment and systems safety criteria (all SSCs)	IV
Process equipment and engineered systems safety criteria (all SSCs)	IV
Logic used for selection of criteria - Silo 3 - Remaining SSCs	 III III

Each of the following subsections summarizes the information for the Pilot Plant Program that is required by Attachment 1, Items 2 and 6 of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 3.2). Sections 3 and 5 of the SSARR (Ref. 3.3) summarize the sitewide principal safety and health criteria.

The selection of criteria is based on the statutes, rules, regulations, and DOE Orders identified in Section 2 of this PSAR. The criteria are selected to ensure protection of the workers, the public, and the environment.

The SSARR is referred to in each subsection of the PSAR, as appropriate. If additional criteria apply, then a discussion of the additional criteria is given in each subsection. Principal health and safety criteria for SSCs are discussed in the appropriate subsections of Section 6 of this PSAR.

3.1 Natural Phenomena Hazards

3.1.1 Performance Category

The performance goal annual probabilities of unacceptable damage given in Table 3-2 of the Design Criteria Package have been prescribed to be substantially equivalent with (1) the goals of model building code provisions for SSCs in Performance Category (PC) 1 and PC 2 and (2) the goals intended by nuclear power plant seismic criteria for SSCs in PC 4.

The preliminary natural phenomena hazard performance category for the pilot plant vitrification facility, hydraulic removal system, and radon treatment system is PC 2 based on the methods of DOE-STD-1021-93 (Reference 3.4). The interface with Silo 3 has been preliminarily categorized as a PC 2, based on the criteria in DOE-STD-1021-93.

3.1.2 Missile Protection Criteria

Missile protection (wind, tornado, and external sources) criteria are discussed in Section 3 of the SSARR.

3.1.3 Flood Design Criteria

The OU-4 Pilot Plant Program structures are not located in the 100-, 500-, or 2,000-year floodplain. The facilities may be susceptible to puddling by the inability of local drainage to handle intense short-term rainfall.

3.1.4 Seismic Design

Seismic design criteria are discussed in Section 3 of the SSARR. Based on a 0.13 g peak ground acceleration (PGA) (Table 3-4 of the SSARR), the return period for this earthquake at the FEMP is 1.25E+3 years (Figure 5-4 of the SSARR).

3.1.5 Loads and Load Combinations

The loading criteria are discussed in Section 3 of the SSARR. Measures taken to ensure that loads are within acceptable limits (e.g., crane loading) are discussed in Section 20 of this PSAR.

3.1.6 Subsurface Hydrostatic Loadings

Subsurface hydrostatic loading criteria are not required for the OU-4 Pilot Plant Program.

3.2 Nuclear Criticality Prevention Criteria

The SSARR addresses nuclear criticality prevention criteria. Compliance with these criteria for the Vitrification Pilot Plant is discussed in Section 10 of this PSAR.

3.3 Radiological Protection Criteria

Radiological protection criteria are discussed in Section 3 of the SSARR. Additional design criteria exist for radon source term emissions for an interim storage facility. These criteria are contained in 40 CFR 61 Subpart Q, "National Emission Standards for Radon Emissions from Department of Energy Facilities," and DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (Chapter IV, 6.b). The limits associated with these design criteria are as follows:

1) No source shall emit more than 20 pCi/m^{2}s of radon-222, as an average for the entire source, into the air.

2) The above-background concentration of radon-222 in air above an interim storage facility must not exceed 100 pCi/l at any point, an annual average of 30 pCi/l over the facility, or an annual average of 3 pCi/l at or above any location outside the site.

The rationale for selection of design criteria for radon emissions is to comply with the ARARs to adequately protect public health and safety.

3.4 Hazardous Material Protection Criteria

Hazardous material protection criteria are addressed in Section 3 of the SSARR.

3.5 Industrial Hazards Protection Criteria

Industrial hazards protection criteria are discussed in Section 3 of the SSARR. Industrial hazards and their preventative/mitigative measures are addressed in the Project Health and Safety Plan.

3.6 Fire and Explosion Protection Criteria

General fire and explosion protection criteria are discussed in Section 3 of the SSARR. Criteria, if any, specific to the SSCs are discussed in Section 6 of this document.

3.7 Environmental Protection Criteria

3.7.1 Gaseous and Particulate Effluent

Environmental protection criteria for gaseous and particulate effluent treatment systems at the FEMP are discussed in Section 3 of the SSARR. Criteria for the control of radon-222 emissions are discussed in Subsection 3.3 of this document. Additionally, Ohio Administrative Code 3745-31-05(A)(3) requires the use of Best Available Technology (BAT) for the control of process emissions.

BAT for radon emissions will be satisfied by the use of the RTS. BAT for sources of radionuclide particulate emissions is the use of HEPA filtration. Both of these control systems are included in the overall design of the OU-4 Pilot Plant.

3.7.2 Liquid Effluent

General environmental protection criteria for liquid effluent treatment systems are discussed in Section 3 of the SSARR. Specific criteria, if any, are discussed in Section 6 of this document.

3.7.3 Monitoring and Alarm System

General environmental protection criteria for monitoring and alarm systems are discussed in Section 3 of the SSARR. Radon monitoring criteria are discussed in Section 6 of this document.

3.7.4 Waste Handling and Storage Systems

General environmental protection criteria for waste handling and storage systems are discussed in Section 6 of the SSARR. Specific criteria, if any, are discussed in Section 6 of this document.

3.8 Structures, Systems, and Components

The criteria for the Pilot Plant Program are discussed in Section 6 of this document.

3.9 References

3.1) Westinghouse Hanford Company, February 1993. *Graded Approach for Safety Analysis Reports*. WHC-SP-0960, Rev. 1.

3.2) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

3.3) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

3.4) United States Department of Energy, July 1993. *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components, DOE-STD-1021-93.*

SECTION 4

HUMAN FACTORS

Section 4 of the SSARR (Ref. 4.1) summarizes the generic information applicable to the entire site that is required by Attachment 1, Items 13b, 13c, and 14 of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 4.2). This information includes criteria and compliance, human factors associated with existing facilities, and human factor considerations for new facilities.

Each of the following subsections identify human factor considerations and levels of detail associated with the OU-4 Pilot Plant Program.

4.1 Graded Approach

The depth of human factors analysis should consider the importance of the function, the importance of operator response, life cycle, and the duration of the activity. Therefore, changes to the pilot plant design and the RTS upgrade resulting from human factors concerns shall be considered where cost-benefit or risk-tradeoff analyses indicate justification for expenditures. Existing SSCs, such as the silos, will incorporate human factors concerns only when applicable to the Pilot Plant Program and where cost-benefit or risk-tradeoff analyses indicate justification for expenditures.

4.2 Human Factors Analysis

The needs and requirements of the system operator were systematically examined as an integral part of the design process. Decisions concerning which system functions to allocate to a human versus a machine shall be determined by analyses of the system functions required, impact of error or no action on safety, and a comparison of human requirements/capabilities and equipment requirements/capabilities to meet the separate system functions. Factors that will be considered during the function allocation decision process include system performance criteria, safety, cost, maintainability, scheduling, and training. For functions allocated to an operator, there will be a systematic analysis of those vital activity tasks that must be performed by the operator to satisfactorily complete the function, given a proposed system design.

Operator task analysis results shall be the basis for establishing operator information needs.

4.3 Project Human Factors Requirements

An effective climate control system will maintain temperature at an acceptable level between the human and his or her working environment as specified in DOE Order 6430.1A. The temperature in the control room will be maintained at a nominal 72 degrees F degrees. The change rooms will be heated in the

winter but no climate control will be applied in the summer. The furnace area, electrical, and mechanical rooms will be controlled such that National Electrical Manufacturers Association (NEMA) equipment ratings are not exceeded (65-100 degrees F).

Acoustic design will minimize noise level to ensure that the limits of DOE Order 5480.10 are not exceeded, to ensure that verbal communications are not impaired, to ensure that auditory signals are readily detectable, and to minimize auditory distraction that can cause operator error.

Vibration shall be reduced to the extent practical to minimize operator irritation.

The arrangement of controls and displays shall promote efficient use of task-related components, rapid location of any given component, and maximum operator awareness of plant conditions. Components shall be grouped together on the basis of specific criteria appropriate to the required task.

Personnel who work in a hazardous environment shall have convenient access to protective equipment including proper garments, emergency showers and eye washes, and other protective equipment necessary for the completion of their work. Provisions shall be made for access to and maintenance of protective equipment.

Operator displays shall provide only the information about system status and parameter values that is needed to meet task requirements. Displays shall indicate whether they reflect demand versus actual status. Variables important to the adequacy of displays include letter size, font, contrast, viewing distance and angle, lighting, color, and complexity of the task. Failure of a display of any type shall be easily recognized and shall not immediately affect system performance while the operator evaluates the impact of the failure on the system and performs the required response/corrective actions.

A control display operator shall be able to rapidly locate each component on a display. Measures shall be taken to reduce operator information overload. Each control device shall provide the appropriate control capability, range, and sensitivity for necessary control settings and manipulations. Control operating characteristics shall conform with operator expectations. Selection of a control device shall fulfill any control requirements described in the task analysis of system functions. Selection of a control device shall consider whether a discrete or continuous function is present, the compatibility relationship between the control and any corresponding displays, the ease with which the function of control can be identified, the ease of identifying the control actuation mode provided by the control, the forces necessary to activate the control, and the tactile and/or visual feedback provided by control actuation.

An effective audio-visual annunciator system shall alert personnel to a problem or abnormal condition and shall provide sufficient time to respond appropriately to the problem. Each warning shall be easily distinguishable from other alarms, but shall not be a distraction. Any specific warning shall have only one meaning. When there are many annunciator alarms, priority coding shall be used to assist in

determining message significance. False and nuisance alarms shall be minimized. Set point determination shall allow sufficient time for the operator to respond.

A communication system shall allow the users to transmit and receive information accurately and conveniently with minimum distraction from the user's other tasks. A user requirement analysis shall be performed to determine which types of communication are the most appropriate, and what characteristics the selected system shall have.

The surveillance, testing, and maintenance of a system and its restoration to operational effectiveness shall be achieved at a minimum cost with a minimum level of support service.

4.4 References

4.1) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

4.2) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

SECTION 5

SITE CHARACTERISTICS

Section 5 of the SSARR addresses site characteristics. This section and Section 5 of the SSARR provide information to meet the requirements of Attachment 1, Item 3, of DOE Order 5480.23 (Ref. 5.1).

5.1 Location

The four silos are located south of the waste pit area (see Figure 1-2). The new vitrification facilities will be constructed east of the silos (see Figure 1-3).

5.2 Infrastructure

This project will use existing transportation routes, potable water, process water, fire water, final wastewater treatment, and electrical utility/service. Subsection 6.4.3 discusses the electrical power requirements and the project's interfaces with the site electrical distribution system. Subsection 6.4.5 discusses the use of existing FEMP process and potable water, Subsection 6.4.7 discusses the project interfaces with the general sump, and Subsection 6.4.10 describes the use of existing FEMP firewater.

5.3 Controlled Areas

The existing radiologically controlled areas will be used and are shown in Figure 1-3.

5.4 Natural Phenomena and External Events

Natural phenomena and external events are addressed in Section 5 of the SSARR .

5.5 Physical Characteristics

The physical characteristics of the site are summarized in Section 5 of the SSARR .

Per 100-, 500-, and 2,000-year floodplain determination sitewide, OU-4 is above the 2,000-year floodplain (Ref 5.2). The location of OU-4 above the floodplain does not imply that the area is not subject to flooding by localized ponding. The area may be susceptible to flooding by the inability of water which falls in the area to run off.

5.6 Previous Environmental Assessments

A Remedial Investigation/Feasibility Study (RI/FS) report has been submitted to EPA (Ref. 5.3). The FS includes the Proposed Plan (PP) and incorporates National Environmental Policy Act (NEPA) values. A Site-Wide Environment Impact Statement (EIS) was attached to the OU-4 PP/FS that addresses cumulative impacts of the leading alternatives for each OU.

5.7 References

5.1) United States Department of Energy. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

5.2) PARSONS, September 1993. *100- and 500-Year Sitewide Floodplain Determination.*

5.3) United States Department of Energy, September 1993. *Draft Feasibility Study Report for Operable Unit 4.*

SECTION 6

FACILITY DESCRIPTION AND OPERATION

The description of buildings, systems, and operations in this section provides the information required by Attachment 1, Item 4, of DOE Order 5480.23 (Ref. 6.2). Modified and existing Structures, Systems, and Components (SSCs) are described to a depth commensurate with their importance to the project and to the safety analysis. Some SSCs which traditionally are safety class may be treated with less importance because they are not applicable or do not have a safety impact on this project (e.g., emergency power supply, containment barriers, and nuclear criticality). This section also includes information concerning SSC-related health and safety criteria which are intended to meet the requirements of Attachment 1, Item 6, of DOE Order 5480.23.

This section describes the health and safety criteria and design features for those SSCs that are part of the OU-4 Pilot Plant Program. These sections are subdivided as follows:

1) Existing Buildings and Structures
2) New Buildings and Structures
3) Operating Systems
4) Support Systems

DOE Order 5480.23, Nuclear Safety Analysis Reports, states that the topics addressed in a SAR should be commensurate with their importance. A report published by the Westinghouse Management and Operating Contractors, WHC-SP-0960, Graded Approach for Safety Analysis Reports (Reference 6.1) suggests guidance in complying with DOE Order 5480.23 with respect to the grading of topics. In Table 6-1 each of the topics is evaluated by numerically grading the prime considerations associated with that item, activity, or system. The considerations evaluated include the hazard associated with an item, activity, or system, its Life Cycle (construction or operation), and Mission Time. Hazard Category, as described in DOE Order 5480.23, is used for classifying the hazard, although 5480.23 considers facilities, not systems or topics. For the PSAR all topics addressed are for construction, whereas for the later revision of the SAR, the FSAR, all topics considered will be for the operation of the facility. The average grade evaluates the previous criteria and other subjective criteria (importance to production and importance to operating personnel).

Table 6-1 identifies the level of detail assigned to each subsection as defined in Section 1.4 of this report. The level of detail is defined as follows:

Table 6-1 - Grading of Level of Detail for Section 6 Topics

Topic	Hazard Category	Life Cycle Construction Operation		Mission Time		Grade for PSAR
	3	PSAR	FSAR	Short	Long	
Facility Description and Operation						
Silo 1 and 2	III	III	-	-	-	III
Silo 3	III	III	-	-	III	III
Silo 4	V	III	-	-	-	V
RTS Building	IV	III	-	-	-	IV
Support Structure Pre-Fab Vitrification Building	V	III	-	-	V	V
Systems Descriptions						
Hydraulic Waste	III	III	-	III	-	III
Retrieval and Dewatering	III	-	-	III	-	III
Feed Preparation	III	III	-	III	-	III
Furnace	III	III	-	III	-	III
Containerization	III	III	-	III	-	III
Off-Gas Treatment	III	III	-	III	-	III
Wastewater Treatment	III	III	-	III	-	III
Electrical	III	III	-	III	-	III
Instrument Air	III	III	-	III	-	III
Ventilation	III	III	-	III	-	III
Drawings	III	II	-	-	III	III
Performance	V	II	-	-	-	V
Configuration Commitment	V	III	-	-	-	V

Level I-A description of the item, activity, system sufficient to understand the numerical and logical basis used in the safety basis. The items included might include the following:

1) Safety related function requirement
2) Design criteria
3) One line diagrams
4) Detailed physical description
5) Flow sheets with operating modes
6) Detailed operating sequences

Level II- A description sufficient to understand the basis for its safety application. The description should define the content of the item, activity, or system in sufficient detail to define its content purpose, functions, acceptance criteria and a basic understanding of its principles, and might include the following:

1) Safety related function requirements
2) Safety related design criteria
3) Block diagrams
4) General arrangements
5) Operating modes

Level III-An overview description sufficient to provide general understanding of the item, activity or system. This would be a generalized description of its basic content, operation, performance, and purpose.

Level IV-Identification of the item, activity, or system and its basic content and purpose.

Level V-No information is necessary on the item, activity, or system.

6.1 Existing Buildings and Structures

The following subsections describe the health and safety criteria, material inventories, and design features for Silos 1, 2, 3, and 4 and the existing Radon Treatment Building.

6.1.1 Silos 1 and 2 (K-65)

6.1.1.1 Health and Safety Criteria

Safety class structures are needed when accident consequences could exceed the evaluation guidelines provided in proposed DOE-STD-3005-YR (Reference 6.3). There are no safety-class safety criteria for

the K-65 Silos since credit was not taken for an SSC to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents."

The health criteria and industrial safety criteria for the K-65 Silos are identified in Section 3 of this PSAR. Health and safety criteria common to the site are identified in the SSARR. The design features used to meet applicable criteria are discussed below. Sections 11 and 12 discuss the radiological and hazardous materials protection programs, respectively, of this project.

6.1.1.2 Description

Contents

Silos 1 and 2 are used for the storage of the K-65 radium-bearing residues formed as byproducts of pitchblende ore and yellowcake processing. From 1953 to 1955, the FEMP refinery processed pitchblende ore from the Belgian Congo (Ref. 6.4). Pitchblende ore contains all of the decay products in the uranium decay series. No chemical separation or purification was performed on the ore prior to its arrival at the FMPC. From 1956 to 1960, the refinery feed stock consisted of uranium concentrates (yellowcake) from Canada and the United States. The yellowcake residues contained uranium decay products, including radium-226 and thorium-230, in amounts that varied with the process. However, in the processing of the uranium concentrates, most of the uranium was removed (Reference 6.5).

From 1952 to 1958, waste raffinates were pumped into the silos where the solids would settle and the free liquid would be decanted through a series of ports at various levels in the silo wall. Settling and decanting continued until the silos were filled to approximately 4 feet below the top of the vertical wall in Silo 1 and 6 feet in Silo 2. The underdrain and leachate collection system is shown in Figure 6-1.

Tables 8-4, 8-5, and 8-6 tabulate the radionuclide inventory, organic inventory, and inorganic inventory of Silos 1 and 2, Silo 3, and the Vitrification Pilot Plant. Table 6-4 summarizes the volume and moisture contents of the silos.

Structural

The K-65 Silos are 80 feet in diameter (internal), 36 feet high to the center of the silo dome, and 27 feet high to the top of the vertical walls. The walls are 8-inch-thick concrete, as is the outer part of the domes, which reduces to 4 inches in thickness at the center. As part of the design, the exteriors of the K-65 Silos were coated with 3/4-inch of pneumatic mortar (Gunite). They are surrounded by an earthen embankment to a height of approximately 26 feet. The foundations of the K-65 Silos contain slotted pipe underdrains in an 8-inch gravel layer and are underlain by asphaltic concrete and compacted clay (see Figure 6-1).

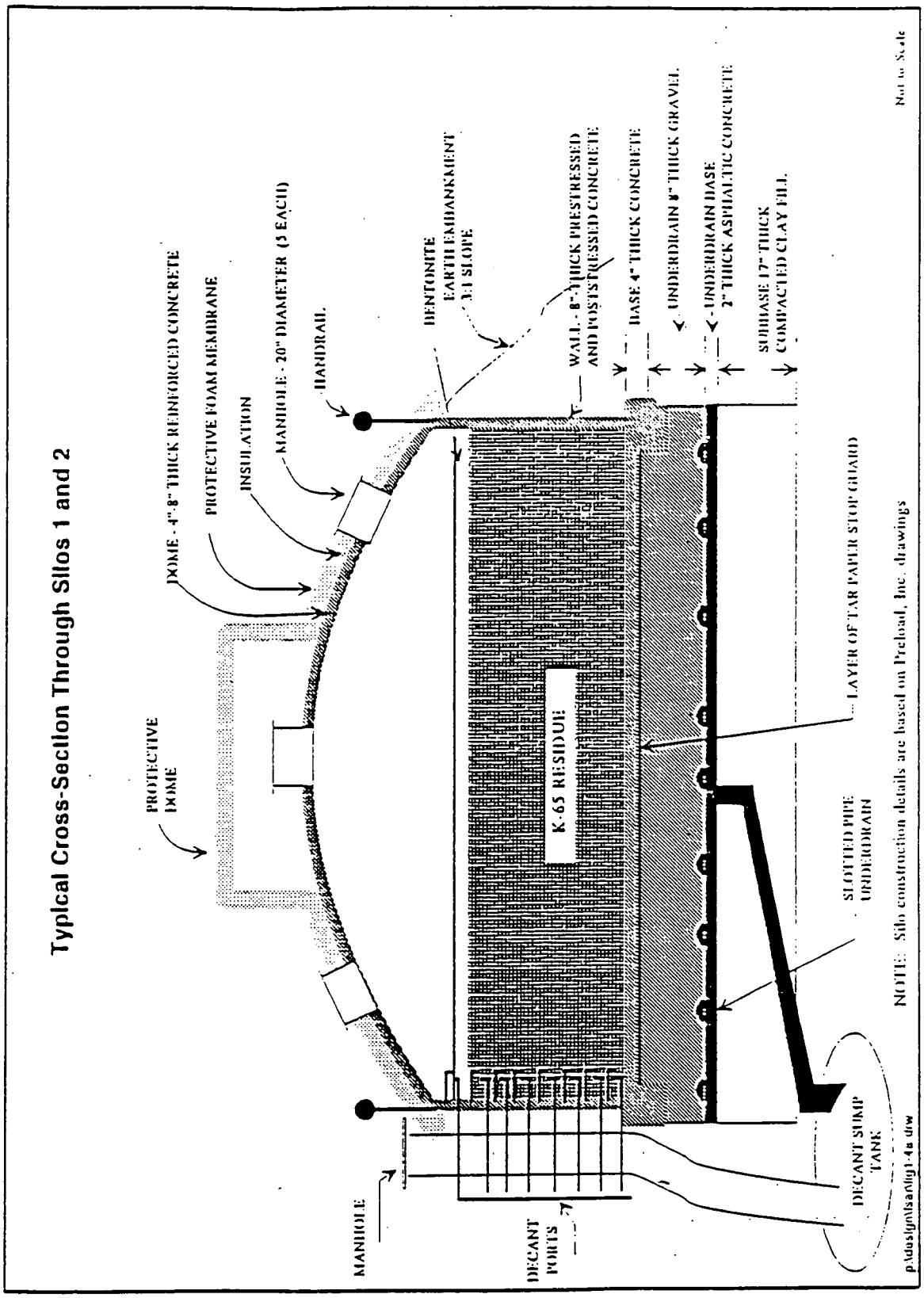


Figure 6-1 - Typical Cross-Section through Silos 1 and 2

The K-65 Silos were constructed in 1952 and have been used since then for storing K-65 slurry residues from uranium ore processing. The structural features of the silos based on the original design provisions are shown on Preload Enterprises Drawing 51T20. This drawing and other design and construction drawings cited in Table 6-2 are included in Appendix A.

The concrete floor slab is 4 inches thick and is supported on a built-up foundation consisting of 1-foot, 5-inch thick, compacted impervious clay fill with a 2-inch layer of asphaltic concrete on top and an 8-inch thick layer of stone and gravel on top of the asphaltic concrete. A layer of tar paper is used on top of the stone gravel. Preload drawing SIT20.3 illustrates the silo foundations.

In the 1960s, prestressing wires were deteriorating and corrective actions were required to maintain the integrity of the K-65 Silos. These actions included repairing the walls and constructing a berm on a 1.5:1 slope. In the early 1980s, the berm was enlarged to a 3:1 slope. The soil used in the construction of the first berm was obtained from the area directly south and southwest of Silo 1. The soil used in the repair of the berms was obtained from the site of the Bio-Surge Lagoon (Reference 6.6).

In 1985, a structural assessment was performed on the K-65 Silos (Reference 6.7). This assessment revealed that the walls and base slab were structurally stable and could function as containment for the dewatered solids for a period of 10 to 15 years, but the center 20-foot section of the domes was determined to be structurally unsound. To protect the center section, an action was implemented that included the placement of steel and plywood covers over the center portion of the domes. In 1987, 3 inches of rigid polyurethane foam topped by a 45-mil waterproof (neoprene), ultraviolet-resistant, urethane-finish coating was placed over the domes to provide weather protection and insulation. During the installation process, a temporary radon removal and treatment system was designed and installed to reduce radiation exposure to the workers. The RTS was not designed in accordance with any applicable design criteria. The various modifications done to the K-65 Silos are shown schematically in Figure 6-2.

The engineering drawings available for Silos 1 and 2 are listed in Table 6-2 and are included in Appendix A.

Bentonite Cap

In 1992, the radon emission was reduced by applying a residue surface sealing bentonite slurry layer to Silos 1 and 2. Bentonite provides an inert sealing layer over the residue increasing the diffusion time required for radon-222 to enter the headspace (silo ullage). Since radon-222 has a short half-life in comparison to the diffusion time across the bentonite, the radon that enters the headspace is reduced. Additionally, the bentonite clay provides shielding from gamma radiation and forms a protective layer for the residues in the event of a dome collapse. The effectiveness of bentonite in reducing off-site exposure is addressed in Subsection 6.4.9.

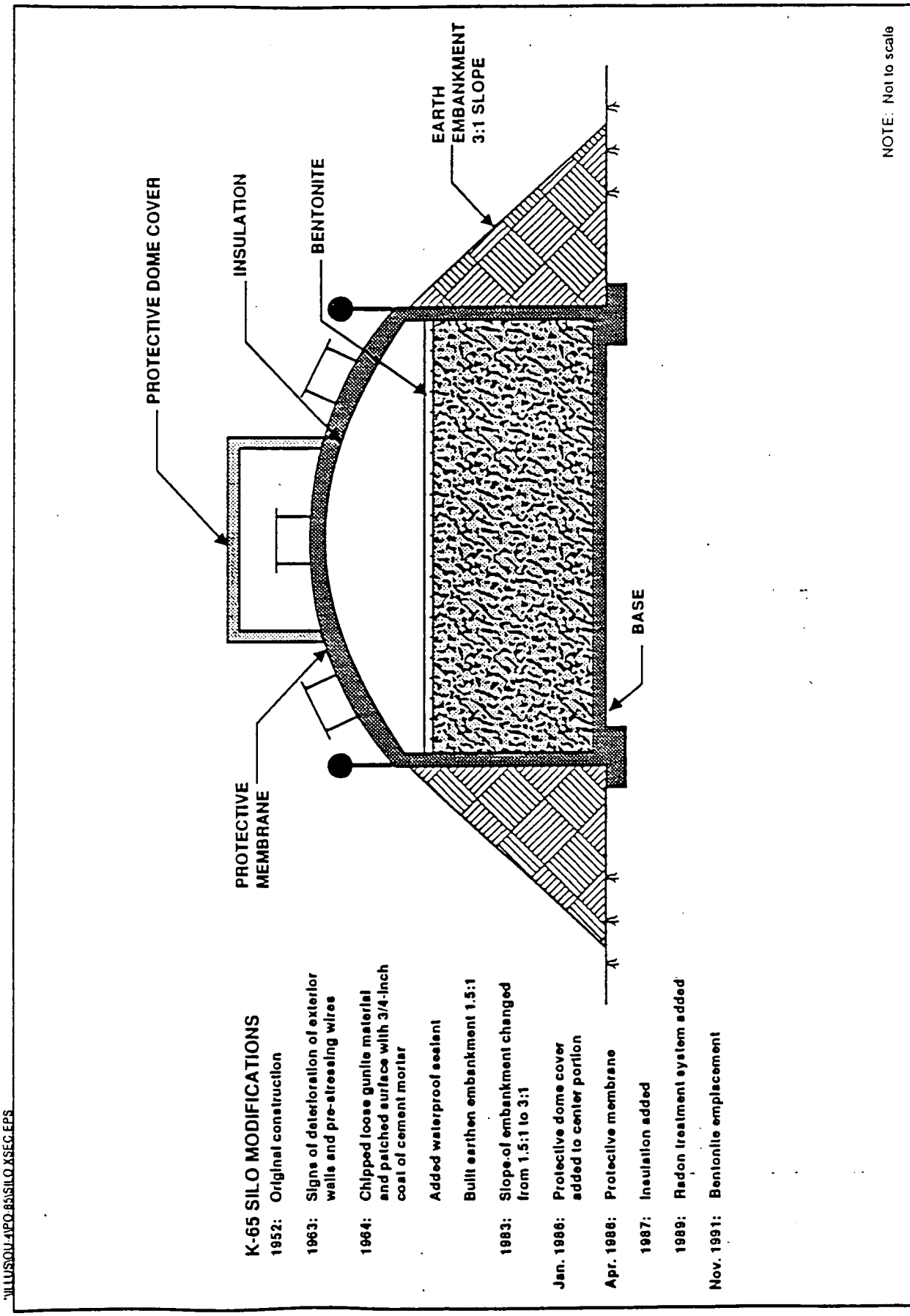


Figure 6-2 - K-65 Silo Modifications

Table 6-2 - Construction Drawing List
(see Appendix A)

Drawing No.	Date	Title	Company
51T20-3	7/3/51	Two 125,000 cf Slurry Storage Tanks - Type K65	Preload Enterprises, Inc.
51T20-6	7/16/51	Two 125,000 cf Slurry Storage Tanks - Type K65	Preload Enterprises, Inc.
51T20-8	9/20/51	Two 125,000 cf Slurry Storage Tanks - Type K65	Preload Enterprises, Inc.
51T29-5	10/26/51	Two 125,000 cf Tanks - Details	Preload Enterprises, Inc.
51T29-6	11/19/51	Anchor Bolts for Pipe Supports, 2-125,000 ft^3, K65 & Metal Oxide Tanks	Preload Enterprises, Inc.
51T29-7	2/13/52	Two Metal Oxide Tanks	Preload Enterprises, Inc.
3034-A-01-A	1/21/52	Concrete - K-65 Slurry Line Trench Plan, Elevation & Details	Catalytic Construction Co.
3034-A-02-A	3/13/52	Structural Pump Pit & Flange Access Compartment for Decant Tank - K65 Storage Area	Catalytic Construction Co.
40A-5500-E-00036, Rev. 1	2/6/89	Pole-Mounted Electrical Distribution System for the Waste Pit Area	Westinghouse Materials Company of Ohio
3034-H-53-A	3/3/52	General Layout - K-65 Storage Area	Catalytic Construction Co.
3034-H-55-A	3/3/52	Trench Piping Plan	Catalytic Construction Co.
3034-H-56-A	3/3/52	Trench Piping Sections	Catalytic Construction Co.
3034-H.G.A.F. Co 5 sA	4/8/52	Sheet Metal Flashing	George A. Fuller Co.
3034-C-3011-A	4/4/52	Plot Plan - Lighting and Power Outside Tanks Drum Handling Building K-65 Storage Area	Catalytic Construction Co.
34X-5500-S-00108	12/16/85	Site, Demo, and Location Plans	Camargo Assoc. Ltd.
34X-5500-S-00109	12/16/85	Dome Plant & Details	Camargo Assoc. Ltd.
34X-5500-P-0125	3/11/91	RTS Piping Layout Plan	Westinghouse Environmental Management Company of Ohio (WEMCO)
34X-5500-P-0127	3/11/93	RTS Improvements - Details	WEMCO

Decant Sump System

The Decant Sump System was designed to collect the liquid that accumulated on the K-65 slurry in the silos and to collect any liquid that accumulated under the silos. Liquid was drained off daily into the system as the Silos were being filled. Currently, the decant portion is buried in the berm and the active part of the system consists of an underdrain subsystem which conducts water from Silos 1 and 2, to a 9,000 gallon Decant Sump Tank. A 30-inch diameter corrugated galvanized pipe which provides access from the top of the berm to the tank was added when the berm was constructed. The liquid content of the Tank has been removed. The tank is periodically monitored to ensure that it receives no liquid from the Silos and that it remains empty.

Source Term

The source terms of radionuclides and hazardous materials contained in the silos are described in Section 8. The only source of airborne radioactive material during normal conditions is radon that escapes the confinement of the silos. The average airborne concentration of radon in air has been measured at the silo fenceline. Access to the area inside the fence is restricted and is posted as a radiological exclusion zone.

6.1.1.3 Radiation and Hazardous Material Protection Design Features

There are several features associated with the K-65 Silos that are related to reducing radiation exposure of personnel and the general public. These features are shielding, low permeable exterior coating, the RTS (when operating), and monitoring stations. The RTS is discussed in Subsection 6.3.3. The monitoring stations are discussed in Subsection 6.4.9. The silos meet the criteria for radon concentrations in the workplace per DOE Order 5480.11 (Reference 6.8) and for the environment off site per DOE Order 5400.5 (Reference 6.9). However, the silos do not meet the radon flux criteria specified in 40 CFR 61, Subpart Q (Reference 6.10). As provided for by 40 CFR 61.19, compliance with the radon flux standard is being negotiated with the US EPA as part of the Radon NESHAPS Agreement for the FEMP. Based upon these negotiations, it is expected that compliance with the flux standard will be deferred until the remediation of the OU-4 Silos is completed.

The K-65 Silos are surrounded with a berm made of soil. The primary purpose of the soil berm is to counterbalance the load from the silos' contents. The berm also reduces the direct gamma radiation dose rate and amount of radon that escapes from the silo through the side walls. The berm slows the diffusion of radon so that a significant portion of the radon decays within the berm. Consequently, some of the soil in the berm is contaminated with radon-222 decay daughters.

The foam and urethane coating provide protection from weathering. The insulation minimizes the daily temperature changes within the silo dome head space. The daily temperature difference has been

guaranteed by the foam's manufacturer to be less than 4 degrees C (Reference 6.11). By minimizing the temperature fluctuations, the expansion of the gas in the dome headspace is minimized, thus, reducing the release of radon to the atmosphere due to the changing volume of the gas with temperature.

The bentonite cap is discussed in Subsection 6.1.1.2 and its effectiveness in Subsection 6.4.9.

6.1.2 Silo 3

6.1.2.1 Health and Safety Criteria

Safety class structures are needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.3). Since credit was not taken for the structure, system, or component to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents," there are no safety-class safety criteria for Silo 3.

Health and safety criteria common to the site are addressed in the SSARR. Criteria specific to this project are discussed in Section 3 of this PSAR.

The design features used to meet applicable criteria are discussed below. Sections 11 and 12 discuss the radiological and hazardous materials protection programs, respectively, of this project.

6.1.2.2 Description

Silo 3 was constructed in 1952 to store metal oxide residue from the FEMP refinery operations. Silo 3 is located south of the Waste Pit Area of the FEMP property. Silo 3 is a freestanding, prestressed concrete, domed silo approximately 80 feet in diameter, 27 feet high at the top of the wall, with a 4-inch-thick concrete floor over an 8-inch layer of gravel. Below the gravel is a 2-inch-thick layer of asphaltic concrete underlain by approximately 17 inches of compacted clay. Unlike the K-65 Silos, Silo 3 has no underdrain system. The domed roof tapers from 8 inches thick at the silo walls to 4 inches thick at the apex, which is 36 feet high at the top of the dome (Figure 6-7). All other construction details are identical to those of Silos 1 and 2.

Silo 3 was designed to receive dry materials only. The waste placed in Silo 3 resulted from processing uranium ore concentrates and thus the waste contains some natural uranium. The FEMP refinery operations produced slurries which were dewatered in an evaporator and calciner to produce dry residues. The dried residues were then blown under pressure into Silo 3.

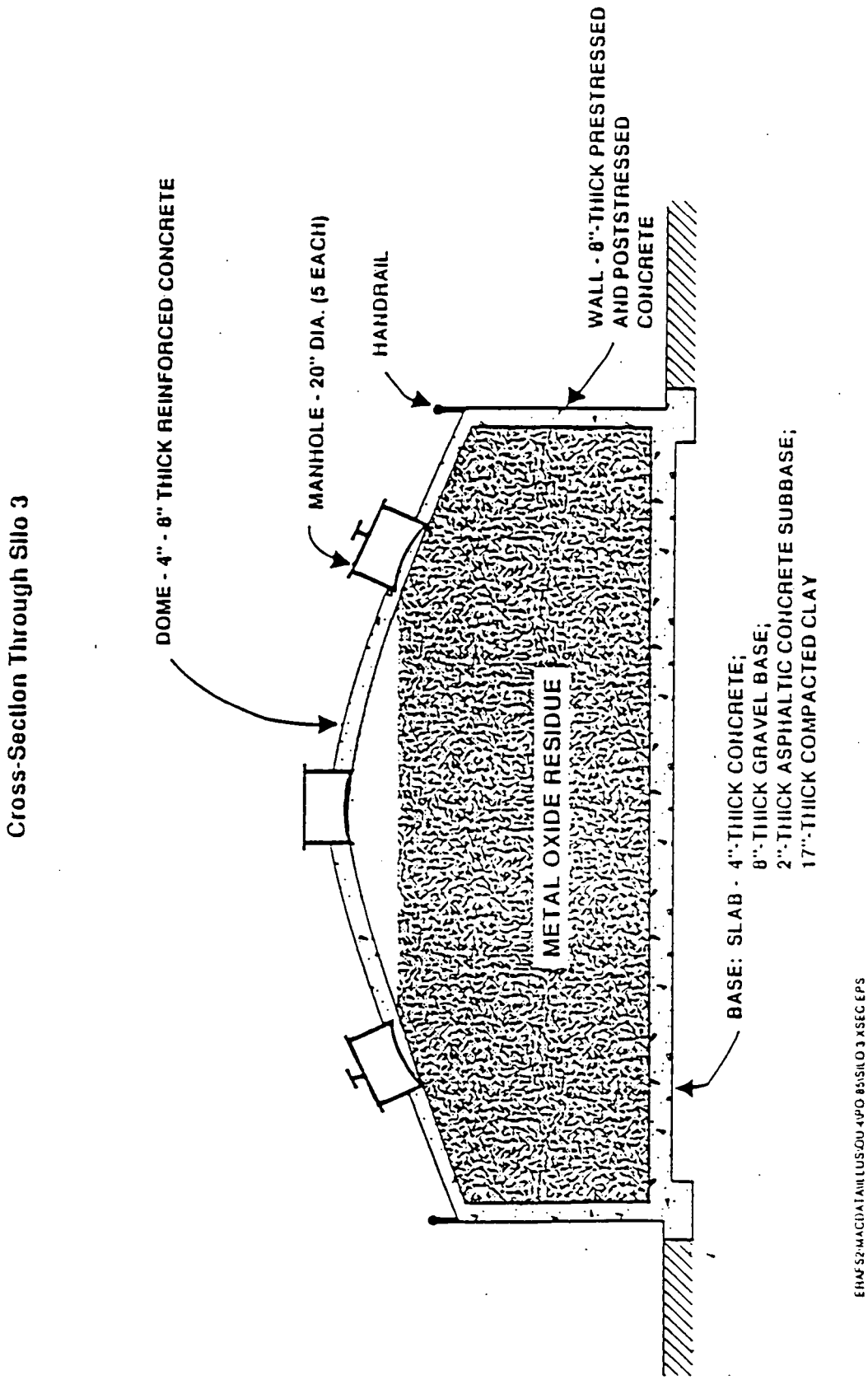


Figure 6-3 - Cross-Section of Silo 3

Silo 3 contains normal uranium, radium, thorium, silica, and other metal oxides. Tables 8-4, 8-5, and 8-6 tabulate the radionuclide inventory of Silos 1 and 2, Silo 3, and the Vitrification Pilot Plant. Table 6-4 summarizes the volume and moisture contents of the silos.

Silo 3 Removal Action

During a December 10, 1991 Silo 3 dome inspection, structural deterioration of the dust collector sidewalls was observed. DOE-FN, as the lead agency, found that a removal action to remove the dust collector and to seal the resultant openings was prudent. The DOE-FN deemed that the threat of airborne release of fugitive metal oxide dust required an expedited removal action pursuant to the US EPA Superfund Removal Procedures, OSWER Directive 9360.0-03B.

In accordance with the requirements of the Amended Consent Agreement, under CERCLA 120 and 106(a), between the DOE-FN and the US EPA, the Silo 3 Removal Action was implemented to protect human health and the environment from the imminent threat of an airborne release of metal oxide dust form Silo 3. Though this removal action was not formally called an emergency, it was considered an "expedited" removal action. Planning and scheduling activities began on December 12, 1991. This removal action was initiated on December 20, 1991. Planned work activities ensured that all penetrations through the dome were immediately covered with temporary seals until a permanent cap or gasketed steel plate was installed. Removal of the dust collector and permanent sealing of all obvious open pathways was completed on January 8, 1992.

The waste generated from the removal action was containerized and managed in accordance with project management procedures, and in a manner consistent with RCRA regulations which were determined to be relevant and appropriate requirements. The material was stored in a controlled holding area until the final determination was made. The waste generated by this removal action was characterized as non-hazardous by a RCRA waste determination. The Silo 3 Removal Action is considered complete. Shipment of the waste resulting from this removal action to an approved off-site disposal facility was initiated on October 9, 1992.

6.1.3 Silo 4

6.1.3.1 Health and Safety Criteria

Safety class structures are only needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.3). Silo 4 is empty and will be partially filled with inert surrogate material. Therefore, there are no safety-class safety criteria for Silo 4.

The health criteria and industrial safety criteria for Silo 4 are identified in Section 3.

Standard industrial hazard protection, which is not addressed in the safety analysis, is the prime concern during the Silo 4 waste removal and transport demonstration. Because the testing associated with the transfer is not a radioactive non-routine hazard, the Silo 4 testing does not form part of this PSAR.

6.1.3.2 Description

Silo 4 has never been used and is empty. The construction details are identical to Silo 3. It will be used to demonstrate the effectiveness of a waste removal and transport system (see Subsection 6.3.2). As part of the demonstration, (1) a hole approximately 6 feet in diameter will be cut in the center of the dome and (2) a superstructure will be installed over Silo 4 to support the waste removal and transport equipment.

6.1.4 Structural Analysis of Silos 1, 2, 3, and 4

A recent analysis, performed in the fall of 1993, was based on the internal forces and elastic displacements of thin shells (Reference 6.11). The analysis was completed for the silos as part of the ongoing OU-4 remediation effort. The allowable stress design method as permitted by ACI 318 (Reference 6.12) was used for evaluating the stresses in all four silos. Silo material properties and data from the 1986 NDT results by Camargo and Associates (Reference 6.13) were used in this analysis.

Based on the results of structural analyses performed to date and the assumptions made as part of those analyses, including an assessment of the applicability of the original design criteria, the structural integrity of the silos should not be affected by the proposed 7-foot-diameter opening at the center of the dome. Based on 1993 NDT results, the four silos are structurally sound (Reference 6.21).

A final natural phenomena analysis and performance categorization is required for Silos 1, 2, 3, and 4 per DOE Order 5480.28.

6.1.5 Radon Treatment Building

6.1.5.1 Health and Safety Criteria

Safety class structures are only needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.3). Since credit was not taken for the structure to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents," there are no safety-class safety criteria for the Radon Treatment Building.

The health criteria and industrial safety criteria for the Radon Treatment Building are identified in Section 3.

The design features used to meet the applicable criteria are discussed below. Section 11 presents the radiation protection features of this project.

The preliminary performance categorization for the vitrification facilities is in the DCP. The final performance categorization must be completed prior to operations per DOE Order 5480.28.

6.1.5.2 Description

The existing radon treatment building is a metal building surrounded by concrete blocks which contains two calcium sulfate beds, eight activated-carbon beds, and two fan units. These fans were abandoned in place and replaced by a single unit outside of the building. The building is surrounded by 32-inch-thick concrete radiation shielding walls of stacked, interlaced, solid, unmortared concrete stretcher blocks. Other equipment includes the valves and piping used to transport air from and back to the silos. The valves can be operated from outside the shielding walls by means of actuating rods that go through the shielding. The shielding reduces the gamma radiation dose rates from the radioactive decay of the materials collected within the activated-carbon canisters. The existing RTS and planned RTS upgrades are discussed in Subsection 6.3.3.

6.2 New Buildings and Structures

Table 6-3 lists the process flow diagrams, process and instrumentation drawings, material handling, mechanical utilities, and building and equipment layout drawings for new and modified structures and systems. The drawings are located in Appendix B.

Table 6-3 - New and Modified Structures and Systems
(See Appendix B)

Drawing No.	Rev.	Title
94X-5900-E-00415	1	Electrical - Single Line Diagram Pilot Plant
94X-5900-F-00278	1	Process - Process Flow Diagram Hydraulic Waste Retrieval and Dewatering
94X-5900-F-00279	1	Process - Process Flow Diagram Feed Preparation and Vitrification
94X-5900-F-00280	1	Process - Process Flow Diagram Off-Gas Treatment
94X-5900-F-00493	1	Process - Process Flow Diagram Silo 3 Pneumatic Waste Removal
94X-5900-F-00700	1	Process - Process Flow Diagram Silo Radon Treatment System
94X-5900-G-00544	1	Civil - Site Plan
94X-5900-H-00511	0	Air Flow and Control Diagram Pilot Plant
SKM02041	-	Configuration Sketch Agitated Joule-Heated Vitrification Furnace
Note: All drawings listed were not cross-checked for accuracy and are assumed to be correct.		

6.2.1 Prefabricated Vitrification Building

6.2.1.1 Health and Safety Criteria

Safety class structures are needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.3). Therefore, there are no safety-class safety criteria for the Prefabricated Vitrification Building since credit was not taken for the structure to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents." Consideration for the prefabricated vitrification building affecting components with a greater performance category per DOE Order 5480.28 is made.

The health criteria and industrial safety criteria for the Prefabricated Vitrification Building are identified in Section 3. The design features used to meet the applicable criteria are discussed below.

6.2.1.2 Description

The building shall meet the requirements for a temporary structure built as a Category 3 non-reactor nuclear facility per DOE Orders 6430.1A and 5480.23. The building is designed to shelter electrical equipment, the furnace, the operations control center, and a support area.

The building is designed for a maximum design life of 30 years and a minimum design life of 1 year and is classified as Type 2B construction. It is categorized to be used as Factory Occupancy, Moderate Hazard, with an approved fire suppression system.

6.3 Operating Systems

The OU-4 Pilot Plant Program includes the Silo 3 Pneumatic Waste Removal System, Hydraulic Surrogate Waste Removal, the Vitrification Pilot Plant, and Silos 1 and 2 Headspace Radon Treatment System. The vitrification pilot plant includes the K-65 Silos Waste Retrieval and Dewatering, Feed Preparation, Furnace, Containerization, Off-Gas Treatment, and Wastewater Treatment systems.

6.3.1 Silo 3 Pneumatic Waste Removal (Drawing No. 94X-5900-F-00493)

6.3.1.1 Health and Safety Criteria

Safety class structures are only needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.3). Therefore, there are no safety-class safety criteria for the Silo 3 Pneumatic Waste Removal System since credit was not taken for the system to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents."

6.3.1.2 Description

The major components of the Silo 3 Pneumatic Waste Removal System include a portable vacuum blower with HEPA filter, filter/receiver, and a surge bin.

As illustrated in Drawing 94X-5900-F-00493, a pneumatic transfer system which is mounted on a flatbed trailer transports Silo 3 material and air from the Silo to a receiver unit where the residue falls into a surge bin. After 10 tons of material have been transferred to the surge bin, the trailer with the surge bin is moved from its location on a pad near the Silo to the Vitrification Plant for processing. The volume of the tank is about 1/40 of the total contents of the Silo. Air without the entrained material is returned to the Silo by the portable vacuum blower. A HEPA filter in the vacuum blower inlet protects the blower's bearing from erosion and decreases the possibility of outleakage of radioactive particulate.

The inlet and the outlet piping enters the Silo through sealed (i.e., bagged) manways which prevent outleakage to the atmosphere. The outlet from the silo is connected to one of four peripheral manways. The elevation and horizontal location of the vacuum nozzle is controlled by a worker on the dome. The vacuum nozzle and the air return nozzle are connected to 3-inch rubber hoses. The return nozzle from the bin enters the silo through the center manways. A small compressor is connected to the filter receiver to periodically blow the material off the bags within the filter.

6.3.2 Vitrification Pilot Plant

Table 6-4 lists the waste materials present in the silos and is included as background information only. The operating systems designed as part of the OU-4 Pilot Plant Program will only treat a small portion of those waste materials for the K-65 Silos and Silo 3. The pilot plant will process K-65 material (20 tons) and Silo 3 material (10 tons) on a continuous basis, at 1 metric ton of product per day (the days may not be consecutive).

Table 6-4 - Summary of Silo Waste Materials

Component	Location	In Situ Waste (cubic yds)	Density (pcf)	Dry Solids (tons)	Moisture Content Weight %
BentoGrout	Silo 1	465 (1)	71.4 (4)	112 (5)	75 (5)
Cover	Silo 2	411 (1)	77.1 (4)	137 (5)	68 (5)
K-65 Residue	Silo 1	4,291 (1)	128 (4)	9,700 (3)	30 (3)
	Silo 2	3,720 (1)		(Silo 1 + 2)	
Dry Calcine	Silo 3	5,200 (2)	63 (4)	4,200 (3)	5 (3)

Notes:
(1) Reference 6.14
(2) Reference 6.15
(3) Reference 6.16
(4) Reference 6.17
(5) Per application data

6.3.2.1 Health and Safety Criteria

Safety class structures are only needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.3). Since credit was not taken for the structure

to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents," there are no safety-class safety criteria for the Vitrification Pilot Plant process systems.

The health criteria and industrial safety criteria for the vitrification process systems are identified in Section 3.

The design features used to meet the applicable criteria are discussed below. Sections 11 and 12 discuss the radiological and hazardous materials protection programs, respectively, of this project.

6.3.2.2 Hydraulic Waste Retrieval and Dewatering (Drawing No. 94X-5900-F-00278)

The major components of the Hydraulic Waste Retrieval and Dewatering system include a pilot plant silo residue removal pump, thickener tank, thickener mechanism and rake, residue slurry pump (and spare), recycle water tank, recycle water pump (and spare), containment sump pump, flocculant addition components including flocculant tank, flocculant tank agitator, and flocculant tank pump.

As illustrated in Drawing 94X-59000-N-00502, the residues are removed from Silos 1 and 2 by means of hydraulic removal. A pump is lowered through a manhole into the silo by an overhead crane and recycled process water is used to slurry the silo material. The line inlets through the dome manhole are sealed (i.e., bagged) to minimize outleakage from the silo. After completion, the manhole and the bentonite penetrations are restored to their original condition. In keeping with good radiological practices, the RTS (Subsection 6.3.3) is used to reduce radon in the head volume (the space between the bentonite cover and the concrete dome cover) prior to accessing the dome.

This slurry is pumped to the thickener for dewatering. The thickener has a motorized rake, inlet connections for additives and water, and outlets which vent to the off-gas system and for the two residue slurry discharge pumps. The thickener allows the solids in the slurry to settle to produce a 50 percent solids underflow, and an overflow that is essentially water. The air operated diaphragm pumps for the thickener underflow discharge to the slurry tanks (Feed Preparation System). If the moisture content of the pump discharge is unsatisfactory, or if feed is not required at Feed Preparation (Subsection 6.3.2.3), the slurry is recycled back to the Thickener Tank. The Dewatering System and the Feed System are capable of providing the maximum process flow requirements of the melter. A nominal 20 tons of silo material will be processed.

The Thickener Tank overflow goes to the Recycle Water Tank for reuse as described in this section. Both the slurry line from the silo to the thickener, and the recycle water from the Recycle Water Tank to the slurry pump at the silo are double-walled to provide secondary containment.

The residue's moisture content will be determined by the operational requirements and the need to minimize wastewater. Process water will be supplied by the FEMP utilities. The quality of the water used during the removal operations will be maintained within process and/or regulatory limits by sampling the recycle water streams and providing for the required make-up or bleed volumes. Recycle water will be reused to the maximum extent possible by the various system processes. A bleed-off of the recycle water line will be sent through a wastewater filter, then onto the building sump to reduce the buildup of dissolved solids in the Recycle Water System. The wastewater filters are discussed in Subsection 6.3.2.7. Building sump water is pumped to the High Nitrate Tank.

As discussed in Section 11, shielding is added to the major components and piping to reduce dose rates to personnel to ALARA. Tanks are diked, when necessary, to control spills contamination. The thickener and recycle water tanks exhaust to the Off-Gas Treatment system described below. Drawing Nos. 94X-5900-N-00502 and 94X-5900-N-0269, not included in this PSAR, are the piping and instrumentation drawings for waste removal and dewatering, respectively.

6.3.2.3 Feed Preparation and Vitrification (Drawing No. 94X-5900-F-00279)

The major components of the Feed Preparation system include a bag dump station, dust collector, two filter/receivers, portable vacuum blower with HEPA filter, Silo 3 surge bin, slurry tanks, slurry tank agitators, and slurry tank pumps.

The feed preparation system will receive conditioned residues from K-65 Silos via the thickener and unconditioned residue from Silo 3 via the surge bin. Feed material will be transported to a slurry tank (two installed) and mixed with additives. The additives will consist of soda ash (sodium carbonate) and test quantities of other additives to be used for testing and trial purposes. The residue/additive mixture will be transported to the furnace for vitrifying. Addition of recycle water to the slurry tanks will ensure the proper percentage of solids in the vitrification feed material. The process parameters are shown on the process flow diagram 94X-5900-F-00279.

As discussed in Section 11, shielding is added to the major components and piping as necessary to reduce dose rates to ALARA. Tanks are diked, when necessary, to control spill contamination. Dust from the additives is prevented from entering the environment by the use of a dust collector. The filter/receiver exhausts through a HEPA filter to minimize release of feed material to the environment during the transport of feed to the slurry tanks. The slurry tanks and the furnace exhaust to the Off-Gas Treatment system described below. The piping and instrumentation for the additive transfer are shown in Drawing No. 94X-5900-N-00529 and 94X-5900-N-00530, which are not part of this PSAR.

6.3.2.4 Furnace (Sketch No. SKM02041)

The vitrification of radioactive and hazardous wastes has undergone thorough investigation since the 1950s. The DOE has accumulated many years of operating experience with the vitrification process, and several other countries have experience. The US EPA has proposed vitrification as the best demonstrated available technology for high-level radioactive mixed waste and for arsenic-containing hazardous wastes.

The major difference from commercial glass furnaces is that most commercial units do not have a completely contained molten pool. The furnace design is not complete and all pressure transients have not been defined. The furnace and the associated off-gas system should be capable of discharging all anticipated pressure transients resulting from non steady-state gaseous releases from the furnace. The current design does not permit water into the furnace except through the normal slurry feed point. A rupture of the cooling line would result in water leaking to the furnace exterior, not injection into the furnace. Treatment of gases is addressed in Subsection 6.3.2.6.

The feed into the furnace is monitored and sampled. The occurrence of an exothermic reaction would only result in a reduced electrical input and no increased explosion hazard.

The pilot plant furnace will operate at a nominal rate of 1 metric ton of glass product per day for a total of approximately 30 days of operation. The operating days may not necessarily be consecutive. The subcomponents of the furnace are shown in Sketch SKM02041.

<u>Major Components of Furnace</u>

1) Furnace Assembly
   - (1) Outer Furnace Containment Shell
   - (2) Refractories and Insulation
   - (3) Electrodes
   - (4) Glass Discharge Chamber with Plenum Heaters
   - (5) Melting Chamber Electrodes (Bath Heaters)
   - (6) Bottom Drain, Sulfate Drain, and Glass Discharge Spout
   - (7) Removable Lid Assembly with Connections for Feed, Off Gas, Viewing Cameras, Instrumentation, and Agitator
   - (8) Slurry Feeding Mechanism and Controls

2) Agitator Assembly
   - (1) Liquid Cooled Shaft/Impeller Assembly
   - (2) Drive Train Including Electric Motor, Gear Box, Couplings, and Bearings
   - (3) Agitator Support Structure with Adjustable Retraction Assembly

3) Cooling Systems for the Following Major Components
   (1) Outer Furnace Shell
   (2) Agitator Shaft/Impeller
   (3) Feed Nozzle (if required)
   (4) Skimmer
   (5) Bottom Drain Valve Mechanism

4) Instrumentation

5) Controls
   (1) Furnace
   (2) Agitator
   (3) Cooling Systems

Furnace Design Requirements

The following are the operating requirements for furnace design; the pilot plant operating conditions will be varied within the following ranges to determine optimum melting rates, temperatures, and formulations to satisfy the vitrification requirements:

Minimum Operating Life	1 year
Design Life	3 years
Operating Temperature	1,100 - 1,350 degrees C
Operating Rate (Nominal)	1 metric ton/day of vitrified material
Furnace Design Temperature	1,400 degrees C
Feed Solids Content	50 percent by wt. approx.
Feed Moisture Content	50 percent by wt. approx.
Feed Rate	1 - 5 gpm of slurry (intermittent flow)
Feed Temperature	2-26 degrees C
Available Feed Pressure	Up to 5 psig
Feed Slurry Density	80-100 lb/ft^3
Bath Surface Area	9 ft^2 (Nominal)
Bath Volume	27 ft^3 (Nominal)
Furnace Pressure (Draft)	-0.5 to -0.25" W.C.
Particle Size Analysis of Silo Materials	See Appendix B of Ref. 6.18

In addition to these design requirements, the overall design of the furnace allows for operation both with and without the agitator. The overall design is suitable for remote operation but hands-on maintenance. As discussed in Section 11, personnel are shielded from the radiation of the furnace during operation.

Furnace Description

Since the silo materials contain heavy metals which may settle out, the furnace has the capability of draining heavy metals or conductive sludges from the floor or lower portion of the furnace. The furnace has one bottom drain tap with manual remote on-off control. Any material drained from the furnace will be properly stored on site until final disposition can be determined.

Since the silo materials contain sulfates, a molten salt or surface scum layer may form on the top of the melt surface, particularly when no agitation is applied. A drain tap which employs a water-cooled skimmer and provides manual remote on-off control is provided for removing this layer when necessary. The location of this drain is slightly below the height of the normal melt level as shown in sketch SKM02041. Any material surface scum skimmed from the furnace will be properly stored on site until final disposition can be determined.

In addition, the design provides a tapping mechanism to permit manual remote shut-off of molten product discharge from the melting chamber to the tapping chamber. Normal operation will be continuous overflow through the discharge chamber.

Silo material is a source of hazardous and radioactive particulates and gases (i.e., radon and VOCs). Consequently, a furnace lid with access/instrument ports seals the furnace (as air-tight as practicable) to provide containment of the furnace off-gases and particulates. The furnace is exhausted to the off-gas treatment system discussed in subsection 6.3.3.6. The lid includes connections for a slurry feed nozzle, an exit nozzle for the off-gas, access ports to accommodate electric heaters for melter start-up and plenum heating, access ports for thermowells, a pressure tap, nozzles for remote viewing capability, and an access port for the agitator assembly. The lid accommodates remote viewing capability at a minimum of 4-inch diameter flanged nozzles and tubes at two locations, the melting chamber and the discharge chamber. The view ports are positioned to allow full view of the melt surface and the pour spouts and risers. Remote viewing will be by closed circuit television cameras.

The agitator assembly is electrically insulated from the metal shell of the furnace and designed to prevent short-circuiting the electrodes. The assembly has a cooling system to maintain the necessary structural strength of the agitator shaft and impeller. The cooling is provided to the assembly by using a rotary gland seal.

The agitator assembly is designed to perform the following functions:

1) Mix the molten material as a means of improving the vitrified material matrix while maintaining the cold cap.

2) Prevent the settlement of heavy metals and the formation of a sulfate layer.

3) Homogenize the molten vitrified material by thoroughly mixing the melter contents.

The agitator support structure assembly is designed to accommodate and support the drive train assembly. The agitator shaft enters the furnace through an opening flange located on the furnace lid. The support structure allows for raising and lowering of the entire assembly to position the propeller in the molten material pool. The support structure is electrically insulated from the outer furnace shell. Provisions are made in the furnace design to allow for the removal of the entire agitator assembly from service without removing the furnace lid.

Cooling systems are provided for:

1) The agitator
2) The outer furnace shell excluding the lid
3) The feed nozzle
4) The sulfate drain skimmer
5) Bottom drain valve

Instrumentation will be provided for the following parameters:

1) Temperature measurement of:
   (1) Molten bath (up to 1,400 degrees C)
   (2) Plenum
   (3) Off-gas at exit
   (4) Each drain/pour point
   (5) Discharge chamber
   (6) Cooling fluid inlets and outlets

2) Differential pressure measurement of the furnace relative to the atmosphere.

3) Monitoring of the furnace parameters including the following:
   (1) Power to electrodes
   (2) Current through electrodes
   (3) Voltage across electrodes
   (4) Skimmer position
   (5) Opening/closing all drain/pour points
   (6) Melt bath level
   (7) Slurry feed rate

4) Monitoring of agitator parameters including:
   (1) Speed
   (2) Position

As discussed in Section 11, shielding is added to the furnace and furnace piping to reduce dose rates to ALARA.

6.3.2.5 Containerization

The vitrified material will be continuously discharged from the melter to the gem-making machine. A steady cylindrical stream of free-falling molten glass from the melter is cut into individual globules of molten glass. The globules fall onto a smooth, non-stick surface to form elongated, domed gems with a flat bottom at a variable rate of 200 to 2,000 grams/minute. The gem-making machine forms shiny, smooth glass 4-gram gems, typically hemispherical or semi-elliptical, 2 centimeters in the longest axis (squashed marble). The molten glass temperature is 1,000 to 1,350 degrees C and the external temperatures about 60 degrees C. To maintain the radiation doses ALARA, the machine will have remote controls and instrumentation/video. After initial cooling, the gems are placed into drums for additional cooling, storage, and transport. Because the purpose of this vitrification activity is to investigate glass forming techniques, the gem making portion of the machine may be passed altogether and the molten glass directly discharged into a container.

The glass, when tested by Toxicity Characteristic Leachate Procedure or by Extraction Procedures toxicity criteria, is nonhazardous. Bench testing indicates that the vitrified material will have a specific gravity of about 3.6 and will have undergone a volume reduction of 65 percent. The release of radon from the glass is essentially nil.

6.3.2.6 Off-Gas Treatment (Drawing No. 94X-5900-F-00280)

The major components of the off-gas treatment system are a quench tower, quench tower pump (and spare), desiccant tower, desiccant condensate pump, carbon bed vessels, one HEPA filter (one standby HEPA filter), exhaust fan, exhaust stack, caustic metering pump, packed tower scrubber, scrubber recirculating pump (and spare), scrubber collection tank, mist eliminator, and a venturi scrubber.

The melter off-gas is treated to meet emission standards and to limit radon release. The contaminant concentrations in the off-gas are based on the list and concentrations of constituents in Attachment 2 of the Design Criteria Document. The off-gas is treated to meet all ARARs identified in the Design Criteria Document. The treated off-gas is exhausted to the atmosphere and continuously monitored for regulatory compliance.

The furnace plenum temperature is expected to be a minimum of 800 degrees F. The VOCs will decompose at this temperature. Those VOCs that do not decompose by the time the furnace off-gas is cooled in the quench tower will collect on the carbon beds. Any buildup of VOCs is not expected to be sufficient to cause combustion.

The maximum radon inventory in the off-gas system is estimated to be 4 Ci based on the 1 ton per day K-65 material process rate.

Furnace off-gas that has been cooled and scrubbed mixes with off-gas from the thickener, recycle tank, and slurry tanks. The mixed off-gas passes through a desiccant tower, carbon bed vessels, HEPA filters, and the exhaust stack. The condensed water vapor containing dissolved desiccant is collected in the bottom of the desiccant tower and transferred to the building sump. The building sump is discussed in Subsection 6.4.7.

Shielding is added to the major components and piping (or duct work) as needed to reduce dose rates to ALARA.

Minimum amounts of CO_2 from the VOCs will be discharged to the atmosphere through the off-gas system. NO_X and SO_2 are reduced to below regulatory limits by the off-gas treatment system. The furnace treatment for hazardous wastes containing arsenic results in no significant arsenic effluent. Although the material being processed is well characterized, the product of the process known, and a proven off-gas design installed, the purpose of this project is to verify that the design and operation of the off-gas system is correctly understood and modeled. A radon sampler and an isokinetic air sampling system for particulate are installed in the discharge to ensure that the effluent to the environment is satisfactory and that the facility functions as designed.

6.3.2.7 Wastewater Treatment (Drawing No. 94X-5900-F-00278)

The Wastewater Treatment System contains two wastewater filters with backwash connections. As discussed in Subsection 6.3.2.2, a recycle water bleed line is connected to the wastewater filters. The filters are used to reduce suspended solids in the recycle water.

When needed, the wastewater filters are backwashed using process water. The filters are backwashed into the thickener. The process water supply is discussed in Subsection 6.4.5. The piping and instrumentation for the Wastewater Treatment System are shown on Drawing No. 94X-5900-N-00274, which is not a part of this PSAR. Building sump water is pumped to the High Nitrate Tank.

The filtered wastewater generated during facility operations is transferred from the pilot plant to the building sump. The building sump is discussed in Subsection 6.4.7.

6.3.3 Silo Radon Treatment System

6.3.3.1 Health and Safety Criteria

Safety-class systems are only needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.1). Therefore, there are no safety-class safety criteria for the RTS since credit was not taken for the system to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analyses of Normal and Abnormal Operations and Accidents."

The health criteria and industrial criteria for the RTS are identified in Section 3.

The design features used to meet applicable criteria are discussed below. Section 11 discusses the radiological program of this project.

6.3.3.2 Original Design Description

The RTS, installed in 1987, is currently abandoned in place but could be operated with appropriate authorization. It was designed to reduce the radiation dose at the silo dome surface on an as-needed basis. This radiation is produced by the radioactive decay of the residues in the K-65 silos.

To operate the RTS, an air flow path is established through the four peripheral manholes from the silo through the RTS and back into the silo. The air from the silo first passes through the calcium sulfate beds which remove the moisture from the air. The air then passes through a minimum of two activated-carbon beds which remove the radon from the air by adsorption and return the filtered air to the silo. The radon remains trapped on the carbon filters.

The RTS is designed as a closed recirculating system so that the radon from the silo air will be continuously adsorbed in the activated-carbon beds. The design time required to circulate the volume of the silo dome head is 48 minutes and 38 minutes for Silos 1 and 2, respectively.

The RTS design assumed a 1,000 cubic foot per minute flow with an initial radon content in the silo dome headspace of 37 Ci and a one-time, 10-volume turnover for each silo. It was estimated that at least 0.4 Ci remains in the silo domes following operation of the RTS because of the continual generation of radon gas from within the residues.

Previous RTS piping improvements are shown on Drawing Nos. 34X-5500-P-00125 and 34X-5500-P-0127 (not included in this PSAR). The radon treatment building is discussed in Subsection 6.1.5 and houses the existing RTS with the exception of the replacement fan unit and piping to/from the silos.

6.3.3.3 RTS Upgrade Description

The upgraded RTS will limit silo radon emissions during K-65 material removal operations. This system will be provided for Silo 2. The RTS, at some future time, may be realigned to Silo 1. Drawing Nos. 94X-5900-N-00497, 94X-5900-N-00500, and 94X-5900-N-00501 (not part of this PSAR) identify the piping and instrumentation in the RTS upgrade. The existing carbon beds, adsorption containers, and building will be reused. New piping will be installed to replace existing RTS piping. Gas from the headspace is drawn through carbon filters and returned to the silos. The radon is adsorbed by the carbon filters.

6.4 Support Systems

The OU-4 Pilot Plant Program includes the building HVAC, electrical power, instrument air, water supply, cooling water, building sumps, sampling, monitoring, and fire protection support systems. These systems are required to be operable, as a minimum, for the duration of vitrification pilot plant operation. The electrical power and fire protection systems may be required to be operable until the pilot plant is decontaminated and decommissioned.

6.4.1 Health and Safety Criteria

Safety class structures are only needed when accident consequences could exceed the acceptance criteria provided in proposed DOE-STD-3005-YR (Reference 6.1). Therefore, there are no safety-class safety criteria for the OU-4 Pilot Plant Program Support systems since credit was not taken for the system to prevent or mitigate the consequences of an accident in the analysis of Section 9, "Analysis of Normal and Abnormal Operations and Accidents."

6.4.2 Vitrification Pilot Plant HVAC (94X-5900-H-00511)

As noted in Drawing No. 94X-5900-H-00511, the HVAC system is designed to minimize the possibility for contamination of the area and the exterior. The area most susceptible to airborne contamination, the furnace area, is maintained at a negative pressure of -0.3 inch wg to ensure that air flow is from areas of lower contamination to areas of higher contamination. The furnace area exhaust is filtered, discharged through a high stack (12 feet higher than the vitrification process area structure), and monitored for radon and particulates. The stack is designed and located not to fall on adjacent facilities. Fire causes the system to shut down and the areas to be isolated. The system does not control humidity. Other operational and control features are illustrated and discussed in Drawing No. 94X-5900-H-0511 which forms a part of this PSAR. In the case of a flow failure, both supply and exhaust systems will be automatically shut down after a time delay and an alarm will annunciate. The salient features of the HVAC design are summarized in Table 6-5.

Table 6-5 - Vitrification Pilot Plant HVAC

Area	HVAC Features	Temperature
Furnace	Supply with heating/cooling Exhaust fan with filters Exhaust discharge through stack and monitored for radon/particulates -0.3 inch wg maintained Both supply and exhaust fans stop with loss of supply or exhaust flow	50 - 100 degrees F
Control Room	2 HVAC units	nominal 72, degrees F
PPE Change and Storage	Supply with heating/cooling Exhaust same as Furnace Area -0.1 inch wg maintained	72 degrees F, minimum
Electrical Equipment	Supply with heating/cooling Exhaust Local electric heater	50 degrees F, minimum
Battery Room	Supply with heating/cooling Exhaust Local electric heater	72 - 96 degrees F

6.4.3 Electrical Power

Section 6 of the SSARR discusses the site's electrical distribution system.

6.4.3.1 Silos and Radon Treatment Building and System (Drawing No. 3034-C-3011-A)

There are electric power sources for lighting around the silos and for operation of the RTS. A light pole exists on the fence perimeter in each of the four cardinal directions.

6.4.3.2 Vitrification Pilot Plant Building and Systems (Drawing No. 94X-5900-E-00415)

The projected load requirements for the pilot plant are 1000 kVA. Electrical power will be supplied from the FEMP 13.2 kV distribution system. Two 3-1/C 350 kcmil, 15 kV power cables, one normal, one alternate, will be extended from two of the primary feeders, F2B and F4B in manhole 220, underground in concrete encased ducts. The two circuits are each capable of delivering approximately 9000 kVA. Should the normal primary feeder to the Pilot Plant be lost, the alternate feed can be energized before the glass within the insulated furnace solidifies. The circuits will serve a 2000 kVA, 13.2 kV - 480 V unit substation which is existing, government-owned equipment on the FEMP site.

Dual primary circuits (normal, alternate) are considered adequate redundancy for all except process or other loads designated for generator backup. No safety class electrical equipment is required. In the event of a loss of normal power, all loads except battery backed-up lighting, battery backed-up fire protection equipment, and process control system instrumentation backup Uninterruptible Power Supply (UPS) for backed-up process control systems will lose power. The Vitrification Pilot Plant diesel generator will be manually started to serve process equipment. The 150 kW, 480 VAC generator provides power to the following loads from Motor Control Center 5-MCC-33B:

Thickener Mechanism and Rakes	5-TH-02
Scrubber Pumps	5-SB-07/22B
Slurry Tank Agitator	5-AG-05A and B
Quench Tower Pump	5-PM-23B
Recycle Water Pump	5-PM-09B
Cooling Tower Pump	5-PM-28A
Off-Gas Exhaust Fan	5-FA-25A
Air Compressor Package	5-CM-44
Instrument Panel	IP-1-1
Backup Power Distribution	DP-4 (110 VAC)

The above equipment minimizes the process consequences to equipment damage and permits an orderly shutdown until power is restored.

The diesel generator is located outside of the building, north of the control room. The diesel supplies the UPS. An orderly shutdown is enabled by a 15-minute battery power supply to the UPS batteries for critical control systems.

6.4.4 Compressed Gases (Drawing No. 94X-5900-N-00275)

The instrument air system consists of an accumulator, compressor, two desiccant tanks, and three filter lubricator regulators.

The instrument air system supplies air to the slurry pumps, spare storage tank pump, diaphragm-operated flow valves, additive filter/receiver, bag dump station, Silo 3 filter/receiver, and the additive/Silo 3 diverter valves. Instrument air passes through a filter lubricator regulator prior to entering the residue slurry pumps, slurry tank pump, and the spare storage tank pump.

The instrument air capacity is 220 scfm. The compressor is rated for 260 scfm at a pressure of 100 psi. The instrument air system is not acceptable as breathing air. Loss of the instrument air system will cause the following:

1) Loss of flow through the slurry tank pump
2) Loss of flow through the residue slurry pumps
3) Loss of pressure to the instrument air system piping
4) Plugging in the pumps and piping

The instrument air compressor package may be powered by the diesel generator. With a loss of power, instrument air and the air power will be restored. The associated air operated valves and air operated residue slurry pump will remain operational, thus preventing plugging of the lines. If the compressor itself fails, the plant breathing air line from the site can be jumpered into the instrument air system to provide about 100 scfm at 50 psig for emergency use.

6.4.5 Water Supply

6.4.5.1 Process Water Supply

An existing FEMP process water line (3-inch) is used to supply water to the cooling tower, recycle water tank, wastewater filters, scrubber, and flocculant make-up tank. Section 6 of the SSARR discusses the site's water supply. The process water supply system is shown on Drawing 94X-5900-N-00275 which is not part of this PSAR.

6.4.5.2 Potable Water Supply

A new potable water line (4-inch) is used to supply water to sinks, and drinking fountains.

6.4.6 Cooling Water System

The process cooling water systems consist of a cooling tower, heat exchanger, and cooling tower pump. The cooling water system is a closed loop. Cooling water passes through the recycle water heat exchanger and is capable of passing through the furnace and water jacket product-forming machine cooling water jackets if needed. Heated cooling water is then cooled in the cooling tower.

6.4.7 Building Sumps

The building sump system consists of two building sump pumps and associated controls and a building sump tank and spill containment. The building sump receives flow from the wastewater filters, cooling tower blowdown, spare storage tank containment sump, and desiccant condensate pump. The building sump discharges to the High Nitrate Tank. The building sump discharge line includes sample connections discussed in Subsection 6.4.8. Prior to discharge to the Great Miami River, the contents of the High Nitrate Tank are treated by the Biodenitrification Towers, the Biodenitrification Effluent Treatment System, and the Interim Advanced Wastewater Treatment (IAWWT) System.

6.4.8 Sampling and Analysis

Analytical sampling for radiological and hazardous constituents of unconditioned, conditioned, vitrified feed materials, and process wastewater will be completed routinely. Sample points are established at the locations listed in Table 6-6.

Table 6-6 - Sample Locations

Subsystem	Location
Silo 1 and 2 Feed Material	Upstream of Thickener
Thickener Overflow	Thickener/Recycle Water Tank Line
Dewatered Feed	Downstream of Thickener
Conditioned Feed	Downstream of Slurry Tank
Off-gas Condensate	Downstream of Desiccant Condensate Pump
Quench Tower Recycle Water Supply	Upstream and Downstream of Quench Tower
Wastewater Discharge to High Nitrate Tank	Downstream of Wastewater Transfer Pump
High Nitrate Tank to General Sump	Downstream of High Nitrate Tank

6.4.9 Monitoring

Section 6 of the SSARR discusses the site effluent monitoring system. Radiation monitoring, alarm, and warning systems that are required during a loss of normal power are provided with an uninterruptible power supply, unless they can: 1) tolerate a temporary loss of function without losing needed data and 2) are connected to standby or emergency power.

The estimated 1992 radon concentration at the site boundary has been reduced by about 30 percent to 0.57 ± 0.29 pCi/ℓ (Ref. 6.19) as a result of the Bentonite cap. This is now approximately 20 percent of the DOE guideline.

6.4.9.1 Existing Monitors

Radon is the primary radionuclide expected to be released from the silos. To determine radon concentrations, the FEMP monitors for radon at 21 locations along the site boundary. In addition, there are 16 monitoring stations on the K-65 Silos Area perimeter, eight monitoring stations located adjacent to the K-65 Silos, six monitoring locations on site at various distances from the silos, and seven off-site locations. These monitors are alpha track-etch monitors.

The seven off-site locations are: two at off-site air monitoring stations, three at nearby residences, and two control locations located more than 20 km from the FEMP in the two least prevailing wind directions. These last two locations are monitored to determine the background concentration of radon

in air. The program also includes four continuous radon monitors located at the K-65 exclusion fence. These monitors can be used for estimating doses to workers in the area outside of the K-65 Silos fence boundary.

6.4.9.2 Airborne Effluent

The vitrification furnace and ventilation system share a common exhaust stack with a radon monitor and isokinetic probe for particulates (Drawing 94X-5900-N-00315). The effluent monitors are designed in accordance with the criteria established in Subsection 3.7 of this PSAR. Section 9 "Analysis of Normal and Abnormal Operations and Accidents," of this report documents the magnitude of (1) the design basis effluent source term that could be potentially released during normal and postulated accident conditions, and (2) the associated impact to the workers and the public.

6.4.9.3 Liquid Effluent

The process wastewater generated during facility operations is monitored prior to and/or during transfers, as required, from the pilot plant to the high nitrate tank. The site liquid effluent system is adequate for the vitrification wastewater effluent composition (e.g., total solids, specific activity, etc.).

6.4.9.4 Area Radiation

Portable radon monitors are placed near the furnace and the RTS carbon filters. A remote reading radiation monitor is located near the carbon filters. In accordance with standard radiation practice, dosimetry badges are mounted throughout the process area.

6.4.10 Fire Protection

Section 6 of the SSARR discusses the site's fire protection system. The fire protection system within the vitrification process building will consist of a wet pipe sprinkler system which will supply sprinkler heads within the process area, electrical equipment room, control room, and battery room. The system and components will have fail-safe features and audible and visual alarms for operability and trouble indication which are monitored by the site alarm service.

Fire water supply of the system is provided through connections to the existing underground 12-inch fire water header. No new fire water booster pumps will be installed as the pressure in the supply header is adequate.

The hydrants will assist fire protection. Fire extinguishers are provided in the building and on all mobile heavy equipment for suppression of classes B, C, and equipment fires in compliance with NFPA 11, 11A, 12, 15, 16, and 16A.

A fire hazards analysis of the Pilot Plant Program will be completed prior to operation.

6.5 Safety-Significant Structures, Systems, and Components

Safety-Significant SSC are designed to keep radiological dose or toxicological dosage from exceeding on site within the limitation of Emergency Guidelines for an accident, or if necessary to reduce the consequence of a high risk accident. Safety-Significant SSC, unlike the more demanding requirements of Safety SSC, do not ordinarily require TSRs. Special design, procurement, installation, and operational controls are applied in a manner commensurate with their importance. Unless noted otherwise, no special design, preoperational, or operational inspections or tests are required.

6.5.1 Shielding

The shielding design criteria are addressed in Section 3.0. The results of this analysis, shielding material, location, and thickness, are discussed in Section 11.0. The adequacy of shielding is verified as part of the normal routine radiological surveys.

6.5.2 Fire Protection

The Vitrification Pilot Plant is protected by the Fire Protection System. Design features and the associated criteria are addressed in Sections 6.0 and 3.0 respectively. Section 6.0 of the SSARR discusses the special measures taken to ensure that this Safety Significant System is able to perform its required function when called upon to do so.

6.5.3 Effluent Monitoring

The Effluent Monitoring System ensures that the process systems are properly operating, and that dose to the on-site worker and the general public are acceptable and within specified limits. These Systems are discussed in section 6.4. The special requirements for the operation of these systems, i.e. calibration and maintenance, are addressed in Section 11.0 Radiation Protection, and Section 12.0 Hazardous Material Protection, of this PSAR and in the SSARR.

6.5.4 Building Ventilation

The flow of air from areas of less contamination to areas of more contamination is necessary to minimize the possibility of hazardous material inhalation or ingestion and is therefore considered a Safety Significant function. This part of the ventilation system consists of the furnace area supply fan, exhaust fan, and associated ductwork, instrumentation, filters, and stack. The operating procedure for the ventilation system shall ensure that this portion of the ventilation system is operable prior to beginning the process, and that the system should remain in operation so long as the furnace is operating. The capability of the heating air conditioning and ventilation system to maintain the temperature within optimal levels for man and equipment is not considered a Safety Significant function and is therefore not considered in this subsection.

6.5.5 Emergency Message System (EMS)

The Vitrification Pilot Plant contains an EMS speaker. Section 6.0 of the SSARR contains a description of this system and its criteria.

6.5.6 Building Evacuation System

The Vitrification Pilot Plant contains a Building Evacuation System speaker. Section 6.0 of the SSARR contains a description of this system and its criteria.

6.6 References

6.1) Westinghouse Hanford Company, February 1993. *Graded Approach to Safety Analysis Reports.* WHC-SP-0960, Rev. 1.

6.2) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

6.3) United States Department of Energy, February 1994. "Evaluation Guidelines for Accident Analysis and Safety Structures, Systems, and Components." Proposed DOE-STD-3005-YR.

6.4) Boback, M.W., 1986. *History of FMPC Radionuclide Discharges*, National Lead Co. of Ohio, NLCO-2039.

6.5) United States Department of Energy, October 1990. *Feasibility Study Report for Operable Unit 4, Task 15 Report, DRAFT, Feed Materials Production Center*. Oak Ridge: DOE.

6.6) Advanced Sciences, Inc./International Technology Corporation, 1990. *Feasibility Study Report for Operable Unit 4*, Draft.

6.7a) Camargo, 1986a. *K-65 Silos Study and Evaluation Report.*

6.7b) Camargo, 1986b. *Metal Oxide and Empty Silo Study and Evaluation Report.*

6.8) United States Department of Energy. DOE Order 5480.11, "Occupational Radiation Protection for Radiation Workers."

6.9) United States Department of Energy, September 23, 1986. DOE Order 5400.5, "Safety of Nuclear Facilities."

6.10) Code of Federal Regulations. 40 CFR 61, Subpart Q.

6.11) PARSONS, September 1993. *Structural Evaluation of Silos 1, 2, 3, and 4 with 6-Foot Diameter Opening at Center based on 1986 NDT Results.*

6.12) American Concrete Institute, 1989. *Building Requirements for Reinforced Concrete with Commentary*. ACI 318-89.

6.13a) Muenow & Associates, Inc., November 1985. *K-65 Silos Study and Evaluation for NLO, Inc.*

6.13b) Muenow & Associates, Inc., November 1985. *Non-Destructive Evaluation of K-65 Tanks Numbered Three and Four*. NLO Facility.

6.14) Fernald Environmental Management Project, April 6, 1992. WEMCO transmittal OU4:92-005, "Results of Surface Mapping for Silos 1 and 2."

6.15) PARSONS November 22, 1991. *Materials Handling Study for the ETPSF.*

6.16) Feed Materials Production Center, 1990. *Remedial Investigation Report (8/90) and Feasibility Study (9/90) for Operable Unit 4.*

6.17) PARSONS 1992. *Calculations for Remedial Action CDR, OU-4, PO-3.*

6.18) PARSONS, December, 1993. *Design Criteria for the CRU-4 Pilot Plant Program.*

6.19) United States Department of Energy, June 1993. *Site Environmental Report.*

6.20) United States Department of Energy, July 1993. *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components, DOE-STD-1021-93.*

6.21) PARSONS, February 1994. *Silos 1 through 4 Structural Integrity Determination.*

SECTION 7

CODES AND STANDARDS

Each of the following subsections summarizes the information for the OU-4 Pilot Plant Program that is required by Section 8.b.(u) of DOE Order 5480.23.

7.1 Existing Facilities

The following codes and standards were originally specified by Catalytic Construction Company for the design and construction of Silos 1 through 4:

1) Uniform Building Code (Ref. 7.1)
2) American Institute of Steel Construction Handbook (Ref. 7.2)
3) Building Code Requirements for Reinforced Concrete (ACI 318-51) (Ref. 7.3)

7.2 New Facilities

The Design Criteria Document (Reference 7.4) specifies the codes and standards of the new facilities. The following list summarizes the current major codes and standards:

1) American Concrete Institute (ACI) 318, Building Code Requirements for Reinforced Concrete

2) American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation

3) American Institute of Steel Construction 9th Edition

4) American National Standards Institute (ANSI) C2, National Electrical Safety Code

5) ANSI C84.1, Electrical Power Systems and Equipment - Voltage Ratings (60 Hz)

6) ANSI N13.1, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities

7) American Nuclear Society (ANS) 6.4, Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants

8) ANS 6.4.2, Specifications for Radiation Shielding Material

9) American Society of Chemical Engineers (ASCE) 7-88, Minimum Design Loads for Buildings and Other Structures

10) American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)-1989, Handbook of Fundamentals

11) American Society of Mechanical Engineers (ASME) - Boiler and Pressure Vessel Code

12) ASME B73.1 M-91, Specification for Horizontal End Suction Centrifugal Pumps

13) ASME N510-89, Testing of Nuclear Air-Cleaning Systems

14) American Water Works Association D100-84, Welded Steel Tanks for Water Storage

15) American Welding Society (AWS) D.1.1, Structural Welding Code - Steel

16) AWS D1.2-92, Structural Welding Code Steel

17) ERDA 76-21, Nuclear Air Cleaning Handbook

18) Instrument Society of America

19) Manufacturers Standardization Society (MSS) SP-58, Pipe Hangers and Supports - Material, Design, and Manufacture

20) MSS SP-69, Pipe Hangers and Supports Selection and Application

21) MSS SP-89, Pipe Hangers and Supports Fabrication and Installation Practices

22) National Electrical Manufacturer's Association 250-91 Enclosures for Industrial Equipment

23) National Fire Protection Association (NFPA) 70, National Electrical Code

24) NFPA 91, Installation of Exhaust Systems for Air Conveying Material

25) NFPA 101

26) Ohio Basic Building Code

27) Sheet Metal and Air Conditioning Contractors' National Association 75, Accepted Industrial Practice for Industrial Ducts

28) Tubular Exchanger Manufacturer's Association

29) Uniform Building Code

30) University of California Research Laboratory (UCRL)-15910, Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards

31) UCRL-53526, Rev. 1, Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites

32) UCRL 53852, Rev. 1, Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites

It is the function of the Design Criteria Document, not the PSAR, to detail the applicable codes and standards.

7.3 References

7.1) Uniform Building Code, 1949.

7.2) American Institute of Steel Construction Handbook, 1946.

7.3) Building Code Requirements for Reinforced Concrete (ACI 318-51).

SECTION 8

HAZARD ANALYSIS

This section describes the hazard analyses for Silos 1, 2, 3, and the Vitrification Pilot Plant in accordance with DOE Order 5480.23 and DOE-STD-1027-92 (Ref. 8.1). Hazard analysis is the initial step in the process of identifying and evaluating potential accidents. It is used to identify inventories and locations of hazardous chemical and radioactive materials in a facility, initiating events for potential release of these materials, energy sources involved, and the potential consequences. The primary purpose of hazard analysis is to focus the assessment effort on those hazards which have the potential to present significant, non-routine concerns to the worker, the co-worker, the public, and the environment. The objectives of a hazard analysis are to:

1) Identify the hazards contained in a facility

2) Perform hazard categorization, based on hazardous material quantity, energy sources, and initiating events (preventive and mitigative features are not to be considered in Hazard Categorization)

3) Characterize and analyze the remaining non-routine hazards that are unique and representative hazards to be analyzed in the SAR.

To accomplish these objectives, each facility, project, and activity must have a Hazard Analysis performed as a means of fulfilling the requirement of DOE Order 5480.23, Section 8.c. The end result of the Hazard Analysis is a final Hazard Categorization based on the consequences of potential accidents/events associated with the facility, project, or activity. DOE Order 5480.23 states that hazards may be separated into 3 categories:

Category 1: The hazard analysis shows the potential for significant off-site consequences, (per DOE-STD-1027-92 this category does not apply to the FEMP).
Category 2: The hazard analysis shows the potential for significant on-site consequences.
Category 3: The hazard analysis shows the potential for only significant localized consequences.

Because DOE Order 5480.23 does not define what is meant by "significant" consequences, additional guidance was developed in DOE-STD-1027-92. In this standard, a two step hazard categorization process is recommended. The first step is a preliminary hazard categorization in which the inventory of material at risk is compared to tables provided in the standard. This is to be used only for planning purposes.

The second step is the final hazard categorization in which consequences from the various accident scenarios are determined and compared to site-specific definitions.

The FEMP site has been divided into segments for safety analysis purposes. Table 8-1 shows the guidelines used to accomplish this. Table 8-2 identifies the site segments.

Table 8-1 - Segmentation Guidelines

1)	Fire (1) Fire lanes between buildings containing combustible materials must be at least 50 feet wide. (2) Buildings containing non-combustible, non-explosive materials are ignored for fire segmentation. (3) An administrative control is automatically generated by each fire lane used to segment between buildings. The control requires: a) The fire lane be marked b) That no combustible or explosive material be stored in the lane c) That the lane be checked for compliance (4) A fire conduit, such as a connecting combustible or explosive Out Side Over Head (OSOH) line, prevents segmentation of the buildings.
2)	Explosion (1) Segmentation is based on the ability of a building adjacent to a building containing explosive materials to withstand the explosion pressure wave. (2) The peak pressure wave is used to determine the ability to withstand the explosion. (3) The peak pressure wave is converted into an equivalent wind speed. (4) The wind speed is compared to the adjacent building's wind speed design criteria. (5) If the design criteria exceeds the resultant wind speed assigned for the explosion, then a segment may be formed. (6) An explosion conduit, such as a connecting flammable or explosive OSOH line, prevents segmentation of the buildings.

Table 8-2 - FEMP Segments

Segment	Building Numbers
A	Plant 1) 1A, 1B, 1C, 2E, 30B, 66, 67, 71, 72,
B	Plant 2/3) 2A, 2B, 2C, 2D, 2F, 2G, 3A, 3C, 3D, 3E, 3F, 3G, 3H, 3J, 3L, 18B, 18D, 39A, 39B, 39C
C	Plant 4) 4A, 4B, 4C, 7A
D	Plant 5) 5A, 5B, 5C, 5D, 5E, 5G, 55A, 55B
E	Plant 6) 6A, 6B, 6C, 6D, 6E, 6G
F	Plant 8) 8A, 8B, 8C, 8E, 8F
G	Plant 9) 9A, 9B, 9C, 9D, 9E, 9F
H	Pilot Plant) 13A, 13B, 13C, 13D, 20G, 37, 54A, 54B, 54C
I	64, 65, 81
M	Silos 1 and 2 (K-65 Silos) and the Radon Treatment System (RTS)
N	Silo 3
O	Vitrification Pilot Plant
Note-Segments J, K, and L were consolidated into other segments	

Silos 1 and 2 (also known as the K-65 Silos) and the existing Radon Treatment System (RTS) are considered to be treated together as labeled segment "M" of the FEMP site. Silo 3 is treated as an additional segment which is referred to as segment "N." The Vitrification Pilot Plant facility is treated as a third segment identified as segment "O." Segments "A" through "I" are the subjects of other safety analyses and are not discussed in this PSAR.

Silos 1 and 2 are one segment, "M," based on the similar function of the silos, similar hazards and material content, proximity, and the earthen berm which surrounds both silos. An internal event is one that is caused by something in the facility whereas an external event is the result of a natural phenomena event or an accident that is initiated by an activity or in another facility. There are no identified internal events from other segments which could affect Silos 1 and 2 nor could any internal event associated with Silos 1 and 2 impact another segment.

Silo 3 is considered one segment, "N," based on its material content and potential hazards being different from Silos 1 and 2. In addition, Silo 3 is not surrounded by the earthen berm which surrounds Silos 1 and 2. There are no internal events identified for Silo 3 which could cause a release of confined material in other segments nor are there any internal events originated in other segments which could cause a release of material from Silo 3.

Silo 4 is empty and was never used, and is therefore excluded from the hazard analysis.

The Vitrification Pilot Plant is considered another segment, "O," for hazard classification purposes. This is based on the facilities' structural independence, different functional purpose from the surrounding facilities, and the fact that no internal events could impact nearby facilities nor could internal events from nearby facilities impact the Vitrification Pilot Plant. The contents of the major pilot plant components are shown in Table 8-3.

The inventory of dispersible radioactive, organic, and inorganic material in each segment is shown in Tables 8-4, 8-5, 8-6, and 8-7. The inventory of Segment "O" is based on the worst case inventory of 10 tons of Silo 3 material stored in a bin near the Vitrification Pilot Plant process building and the thickener being full of K-65 residues at 50 percent residues and 50 percent water composition. The thickener being 100 percent full is not a normal occurrence and would represent an abnormal event for the Pilot Plant operations. This results in approximately 50 tons of K-65 residues being used as the basis for the hazard analysis (the current project is expected to process 20 tons of K-65 material). This is considered to be the bounding credible source term for the Pilot Plant. The volume and content of the major components of the Vitrification Pilot Plant are shown in Table 8-3. Drawings 94X-5900-F-00278, Sheet F002; 94X-5900-F-00279, Sheet F003; and the Design Criteria for the CRU-4 Pilot Plant Program, Rev. 1 identify the basis for these numbers. Material which has been vitrified or is in the furnace is considered non-respirable due to the properties of the material matrix.

Table 8-3 Maximum Contents of Vitrification Pilot Plant Components

	Surge Bin	Thickener	Melter	Slurry Tanks
Volume	N/A	19,700 gallons	27 ft^3	127 ft^3
Operating Mass of Residue (Maximum)	10 Tons	5.6E+7 g	1.3E+6 g	6.1E+6 g
% Solids (w)	100	50	80	80

The source term data for the material is based on results of the *Remedial Investigation Report* (Draft) (Ref. 8.2). The upper 95th percent confidence interval (UCL) on the mean is used as the contaminant concentration to ensure that subsequent risk assessment results are conservative. As indicated in the RI Report, the samples were taken from several manways for Silos 1 and 2 and from the center manway for Silo 3. The sample bores were taken from the top to near the bottom in each silo.

8.1 Hazard Analysis for Segment "M" (K-65 Silos)

8.1.1 Source Term Identification

Tables 8-4, 8-5, and 8-6 identify maximum credible radioactive, organic, and inorganic material inventory lists in the K-65 Silos.

8.1.2 Preliminary Hazard Categorization

Based on a comparison of the dispersible inventory of material in the K-65 Silos to threshold limits based on DOE-STD-1027-92, the preliminary hazard categorization is Hazard Category 2 (Moderate). This categorization is based on both dispersible and nondispersible material within the K-65 Silos. However, in the baseline facility SAR for OU-4 (Ref. 8.3), these silos were previously determined to be Hazard Category 3 (Low). This was based on the modeled consequences of a hazard analysis which was performed prior to the placement of bentonite over the residues. The Final Hazard Categorization is presented in Subsection 8.4 and confirms this categorization.

8.1.3 Hazard Analysis

Table 8-8 presents the results of the hazard analysis on the worksheet. The worksheet identifies the location of the hazards, hazard type, initiating events, energy sources, and consequences and was developed using the Risk Assessment Report for the OU-4 Pilot Plant Program (see Appendix C).

Table 8-4 - Inventory of Radionuclides for Segments M, N, and O (Curies)

Nuclides	Segment M	Segment N	Segment O Silo 3 Material Surge Bin	Segment O K-65 Material Thickener
Ac-227	8.47E+01	2.78E+00	7.20E-03	3.74E-01
Pa-231	5.07E+01	3.27E+00	8.45E-03	2.24E-01
Pb-210	2.28E+03	1.66E+01	4.29E-02	1.01E+01
Po-210	2.96E+03	0.00E+00	0.00E+00	1.31E+01
Ra-224	0.00E+00	1.29E+00	3.33E-03	0.00E+00
Ra-226	5.98E+03	1.36E+01	3.51E-02	2.65E+01
Ra-228	0.00E+00	1.43E+00	3.69E-03	0.00E+00
Th-228	8.04E+00	3.07E+00	7.95E-03	3.55E-02
Th-230	8.00E+02	2.11E+02	5.47E-01	3.54E+00
Th-232	6.30E+00	3.06E+00	7.91E-03	2.78E-02
U-234	1.21E+01	6.81E+00	1.76E-02	5.34E-02
U-235/6	8.72E-01	4.18E-01	1.08E-03	3.85E-03
U-238	1.22E+01	6.25E+00	1.62E-02	5.38E-02

Inventories in Curies calculated from silo concentrations identified from boring samples presented in the Remedial Investigation Report for Operable Unit 4 (Ref. 8.2) (Tables 4-2, 4-23, 4-19, D.2-3, and D.2-4).

Table 8-5 - Inventory of Organic Material for Segments M, N, and O

Organics	Segment M	Segment N	Segment O	
			Surge Bin	Thickener
	mg	mg	mg	mg
2-Butanone	1.18E+05	5.48E+07	1.42E+05	5.22E+02
2-Hexanone	1.73E+05	0.00E+00	0.00E+00	7.65E+02
2-Nitrophenol	0.00E+00	1.83E+05	4.72E+02	0.00E+00
4,4-DDE	1.51E+06	0.00E+00	0.00E+00	6.65E+03
4,4-DDT	8.53E+05	0.00E+00	0.00E+00	3.77E+03
4-Methyl-2-pentanone	3.76E+04	0.00E+00	0.00E+00	1.66E+02
4-Nitrophenol	0.00E+00	1.58E+05	4.09E+02	0.00E+00
Acetone	9.26E+05	2.94E+07	7.62E+04	4.09E+03
Aldrin	7.03E+05	0.00E+00	0.00E+00	3.11E+03
Aroclor-1248	1.99E+07	0.00E+00	0.00E+00	8.82E+04
Aroclor-1254	1.13E+08	0.00E+00	0.00E+00	4.98E+05
Aroclor-1260	3.27E+07	0.00E+00	0.00E+00	1.45E+05
Benzoic acid	4.89E+06	0.00E+00	0.00E+00	2.16E+04
bis (2-Ethylhexyl) phthalate	1.20E+07	1.40E+05	3.63E+02	5.32E+04
Carbon Tetrachloride	7.92E+04	0.00E+00	0.00E+00	3.50E+02
Chloroform	0.00E+00	2.74E+06	7.10E+03	0.00E+00
Chloromethane	0.00E+00	4.91E+05	1.27E+03	0.00E+00
Di-n-butylphthalate	7.15E+05	0.00E+00	0.00E+00	3.16E+03
Di-n-octylphthalate	3.53E+06	0.00E+00	0.00E+00	1.56E+04
Dieldrin	1.17E+06	0.00E+00	0.00E+00	5.16E+03
Diethyl phthalate	3.61E+06	0.00E+00	0.00E+00	1.60E+04
Dimethyl phthalate	2.01E+06	0.00E+00	0.00E+00	8.87E+03
Endosulfan-I	1.15E+06	0.00E+00	0.00E+00	5.10E+03
Endosulfan-II	3.26E+06	0.00E+00	0.00E+00	1.44E+04
Endrin	1.12E+06	0.00E+00	0.00E+00	4.94E+03
Flouranthene	8.03E+05	0.00E+00	0.00E+00	3.55E+03
Heptaclor epoxide	2.12E+06	0.00E+00	0.00E+00	9.37E+03
Methylene chloride	3.46E+05	8.24E+06	2.13E+04	1.53E+03
N-nitroso-di-n-propylamine	3.26E+06	0.00E+00	0.00E+00	1.44E+04
Phenol	3.51E+06	0.00E+00	0.00E+00	1.55E+04
Pyrene	5.90E+05	0.00E+00	0.00E+00	2.61E+03
Tetrachloroethene	7.70E+04	0.00E+00	0.00E+00	3.40E+02
Total xylenes	3.76E+04	0.00E+00	0.00E+00	1.66E+02
Toluene	1.74E+05	2.27E+07	5.86E+04	7.71E+02
Tributyl phosphate	9.16E+08	0.00E+00	0.00E+00	4.05E+06

Inventories in milligrams calculated from silo concentrations identified from boring samples presented in the Remedial Investigation Report for Operable Unit 4 (Ref. 8.2) (Tables 4-2, D.2-3, and D.2-4).

Table 8-6 - Inventory of Inorganics for Segments M, N, and O

Inorganics	Segment M	Segment N	Segment O	
			Filter Receiver	Thickener
	mg	mg	mg	mg
Aluminum	1.68E+10	6.77E+10	1.75E+08	7.43E+07
Antimony	3.81E+08	1.93E+07	4.99E+04	1.69E+06
Arsenic	8.42E+09	1.11E+10	2.88E+07	3.72E+07
Barium	1.46E+11	9.06E+08	2.34E+06	6.43E+08
Beryllium	2.15E+07	1.02E+08	2.64E+05	9.48E+04
Boron	6.65E+08	0.00E+00	0.00E+00	2.94E+06
Cadmium	1.02E+08	3.30E+08	8.54E+05	4.52E+05
Calcium	3.26E+11	1.17E+11	3.03E+08	1.44E+09
Chromium	1.11E+09	1.39E+09	3.59E+06	4.92E+06
Cobalt	2.33E+10	1.01E+10	2.61E+07	1.03E+08
Copper	5.78E+09	1.17E+10	3.03E+07	2.56E+07
Cyanide	4.25E+07	0.00E+00	0.00E+00	1.88E+05
Iron	2.52E+11	1.83E+11	4.74E+08	1.11E+09
Lead	2.45E+12	8.35E+09	2.16E+07	1.08E+10
Magnesium	4.97E+10	2.42E+11	6.26E+08	2.20E+08
Manganese	1.82E+09	1.81E+10	4.69E+07	8.04E+06
Mercury	1.33E+07	2.42E+06	6.27E+03	5.88E+04
Molybdenum	1.08E+11	0.00E+00	0.00E+00	4.77E+08
Nickel	2.33E+10	1.51E+10	3.90E+07	1.03E+08
Potassium	4.94E+09	4.91E+10	1.27E+08	2.18E+07
Selenium	2.72E+09	8.04E+08	2.08E+06	1.20E+07
Silicon	1.14E+10	0.00E+00	0.00E+00	5.02E+07
Silver	1.94E+08	6.47E+07	1.67E+05	8.59E+05
Sodium	1.56E+11	1.47E+11	3.81E+08	6.88E+08
Thallium	1.09E+07	1.97E+08	5.09E+05	4.83E+04
Vanadium	2.86E+09	1.22E+10	3.17E+07	1.26E+07
Zinc	6.56E+08	1.88E+09	4.85E+06	2.90E+06

Inventories in milligrams calculated from silo concentrations identified from boring samples presented in the Remedial Investigation Report for Operable Unit 4 (Ref. 8.2) (Tables 4-2, D.2-3, and D.2-4).

Table 8-7 - Additive Process Chemicals for Pilot Plant (Segment O)

Function	Chemical	Amount
Flocculant	Polymer (type to be determined)	0.2 lb/ton of material 450 lb in drum
Additive of feed	Na_2CO_3	200 lb/day 1,000 lb stored and available
Additive of Feed	PbO	200 lb/day 1,000 lb stored and available
Additive of Feed	$CaCO_3$	330 lb/day 1,000 lb stored and available
Additive of Feed	$CaSO_4$ Fe_2O_3 Al_2O_3 $BaCO_3$ MgO K_2CO_3	Minor additives < 100 lb each stored and available
Caustic (scrubber)	NaOH (liquid)	One 55-gallon drum, minimal makeup (intermittent use)
Off-gas desiccant	$CaCl_2$	5 gpm intermittent 60 ft^3 (full volume of tank)

Table 8-8- Segment "M" Hazards Analysis Worksheet

Date: 10/20/93
Facility: Segment "M" K-65 Silos

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard? Y or N	Comments and/or Justification for Standard Industrial Hazard
1a	K-65 Silos and RTS (internal)	Radioactive Material	Work on/around domes leads to excessive exposure to ionizing radiation.	Potential to exceed dose limits and controls.	N	None.
1b	K-65 Silos and RTS (internal)	Radioactive Material	Loss of containment due to dome collapse from earthquake, tornado, load drop (crane failure), structural failure etc. Berm remains intact due to inherent physical properties.	Release of radon and radon daughter products leading to internal exposure to workers and public.	N	Bentonite layer has reduced the total quantity of material which could be released to about 3.2 Ci of radon.
1c	K-65 Silos	Radioactive Material	Normal radon release from Silos	Based on radon monitoring at site boundary the average concentration is within the limits of DOE Order 5400.5	N	Hazard is covered as a normal operational occurrence. Radon concentrations do not exceed DOE Order 5400.5.

000112

Table 8-8 - Segment "M" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Segment "M" K-65 Silos

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard? Y or N	Comments and/or Justification for Standard Industrial Hazard
2	K-65 Silos (internal)	Hazardous Material	None identified due to bentonite layer emplacement.	None Identified.	Y	The bentonite 2-foot thickness effectively controls the release of hazardous material in the K-65 Silos while the berm remains intact.
3	K-65 Silos	Explosion	Buildup of H_2 gas as a result of water decomposition and ignition by lightning or ungrounded equipment.	Not a credible event.	N/A	The hydrogen content of the silo gas has been measured at less than 0.1 percent which is less than the Lower Explosive Limit of H_2 of 4 percent (Ref. 8.2).
4	K-65 Silos	Potential Energy from fall from a height	Person walks up embankment to silo domes and falls, due to various potential causes (i.e. trip, heat stress due to PPE interference).	Fall from silo causes physical harm.	Y	Administrative controls in place to control the access to the silo domes.

000113

89

Table 8-8 - Segment "M" Hazards Analysis Worksheet (Continued)

Date: 10/20/93

Facility: Segment "M" K-65 Silos

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard? Y or N	Comments and/or Justification for Standard Industrial Hazard
5	K-65 Silos	Special Nuclear Material (Fissile or Fissionable Material)	None Identified.	No initiating event identified. Uranium concentration (0.9 lb/ft^3)is below the safe density and concentration limits - Group IV for all enrichments listed in FEMP-2304, Table IV (Ref. 8.3). Concentration of fissile material is too low.	N/A	None.

000114

Table 8-8 - Segment "M" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Segment "M" K-65 Silos

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard? Y or N	Comments and/or Justification for Standard Industrial Hazard
6a	K-65 Silos	External Event	Aircraft crash.	Not credible.	N	Nearest airport is 4.7 miles away and considered not a reasonable concern. As described in Section 3.1.4 of the SSARR the probability of an airplane crash at the FEMP is less than 10^{-6}
6b	K-65 Silos	External Event	Large Dams.	Not credible.	N	None immediately upstream of facility.
6c	K-65 Silos	External Event	Rail car accident/explosion.	Not credible.	N	No railroad tracks in the vicinity of the silos.
6d	K-65 Silos	External Event	Barge accident/explosion.	Not credible.	N	None in vicinity of silos.
6e	K-65 Silos	External Event	Sabotage.	Not credible.	N	Excluded due to site security procedures per 5480.23.

000115

68

8.1.4 Scenario Development

The bounding consequences for each non-standard hazard type with a credible initiating event is the Loss of Silo Containment. The loss of silo containment under stable atmospheric conditions could occur due to an earthquake, silo dome collapse due to degradation of concrete, or overloading the weight limit on the dome. The silo dome collapse under the tornadic/high wind conditions is not the worst case scenario because the bentonite layer is expected to be reduced in effectiveness for the mitigation of radon release but will maintain the residues in place following a tornado. Thus, all scenarios of a silo dome collapse result solely in a release of radon from the silo dome headspace.

The consequences of this silo collapse are equal to the consequences of a failure associated with the RTS while it is fully loaded with radon from the headspace of the silos. Thus this scenario bounds all accident scenarios associated with the RTS.

8.1.5 Consequence Determination

The consequences of the postulated credible scenarios are estimated through the following means:

1) Identification of Exposed Individuals
2) Fate and Transport of Released Materials
3) Calculation of Impacts

At distances far from the release (greater than about 100 meters), transport and dispersion are controlled primarily by the wind and the atmospheric stability. At these distances, the concentrations and concentration-time integrals are estimated with dispersion models based on expressions given in United States Nuclear Regulatory Commission Regulatory Guide 1.145 (Ref 8.4).

For radionuclides released to the air, inhalation is the principal pathway for entering the body. An expression for calculating the internal radiation dose due to inhalation is:

$$D=BD_F I \qquad (1)$$

Where

D = the 50-year committed effective dose equivalent (CEDE), mrem
B = inhalation rate, m^3/s
D_F = radiation dose factor, mrem/pCi
I = time integral of the air concentration, pCi sec/m^3

The CEDE is a measure of the equivalent radiation dose to the whole body that is incurred over a 50-year period following inhalation of the radionuclide. The dose factors are tabulated in *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (Ref. 8.5). Unless there is specific information to indicate the solubility class of the radionuclide (Class D, W, or Y), the highest dose factor was used. In addition, the dose conversion factors used include short-lived decay products. The inhalation rate usually assumed is 1.2 m^3/h (0.000333 m^3/s) which may be typical for light activity.

The consequence to the maximally exposed individual at the site boundary (330 meters) is based on the release of 3.2 Ci of Rn-222 from the K-65 Silos headspace (or RTS).

8.1.5.1 Low-Energy Event

The release conditions and meteorology are assumed to be as follows:

1) Ground level point source release
2) Stability Class F
3) Windspeed of 2 meters per second
4) Distance to off-site receptor is 330 meters, on-site is 100 meters
5) Release duration 60 seconds - (arbitrary; the time integral of the air concentration would be the same if a larger duration was used, since the release rate is 3.2 Ci/duration)

8.1.5.2 High-Energy Event (Tornado)

The release conditions and meteorology are assumed to be as follows:

1) Ground level point source release
2) Stability Class A
3) Windspeed of 31 meters per second
4) Distance to the receptor is 330 meters off site and 100 meters on site
5) Release duration is 60 seconds.

Table 8-9 presents the results of the dispersion analysis and consequences.

Table 8-9 - Dispersion Analysis and Consequences for Segment M

Variable	Constants/Dose Calculated Values	
	Low-Energy Event	High-Energy Event
Airborne Respirable Fraction (ARF)	1.00E+00	1.00E+00
Release Rate (pCi/s)	5.33E+10	5.33E+10
Dilution factor (off-site 330 m) (s/m^3)	2.11E-03	3.76E-7
Dilution factor (on-site 100 m) (s/m^3)	1.75E-02	8.22E-6
Concentration (off-site) (pCi/m^3)	1.13E+08	2.01E+4
Concentration (on-site) (pCi/m^3)	9.33E+08	4.38E+5
Dose Conversion Factor (DCF) Inhalation Dose (mrem/pCi)	4.50E-05	4.50E-5
Dose (off-site) - 330 meters (mrem)	1.01E+02	1.80E-2
Dose (on-site) - 100 meters (mrem)	8.4E+02	3.95E-1
Note: Breathing rate is 1.2 m^3/hr and release duration is equal to exposure duration (60 seconds)		

8.2 Hazard Analysis for Segment "N" (Silo 3)

8.2.1 Source Term Identification

This section identifies the radioactive, organic, and inorganic material inventory that has been obtained from Silo 3, Segment "N" (see Tables 8-4, 8-5, and 8-6).

8.2.2 Preliminary Hazard Categorization

Based on the inventory of material in Silo 3, the preliminary hazard category for Segment "N" is Category 2 per Categorization criteria based on DOE-STD-1027-92. The final hazard category is determined using a quantitative consequence determination of the bounding accidents postulated in the hazard analysis. The final hazard category is identified in Subsection 8.4. The final hazard category is determined by quantitatively considering only those chemicals which are present in equal to or greater than Category 3 quantities. Chemicals which are present, but are less than the Category 3 threshold, are screened from further analysis. This is valid since the consequences due to multiple chemicals are

considered to not be cumulative for final hazard categorization. All radionuclides are included in the analysis since the effects from radionuclides are cumulative.

8.2.3 Hazard Analysis

Table 8-10 presents the results of the hazard analysis on the worksheet. The worksheet identifies the location of the hazards, hazard type, initiating events, and consequences and was developed using the Risk Assessment Report for the OU-4 Pilot Plant Program (see Appendix C).

8.2.4 Scenario Development

The only non-standard hazard with a credible initiating event is the Loss of Silo Containment. The loss of silo containment under stable atmospheric conditions due to an earthquake, silo dome collapse due to degradation of concrete, or overloading the weight limit on the dome is to be developed. This is a low-energy event.

Consequences of a loss of silo containment due to tornado or high wind conditions are also quantified. This is a high-energy event. Due to the greater release but also greater dispersion under high wind conditions, the bounding scenario for loss of containment accident was not obvious.

8.2.4.1 Low-Energy Event

The airborne fraction for a simple powder spill of 0.001 per DOE-STD-1027 is used with a respirable fraction of 0.488 based on RI data (Ref. 8.1) and 137.8 tons (1.25E8 g) (one percent of the Silo contents) of the silo contents released. One percent of the Silo contents are assumed to be susceptible to the energy associated with the release of material. Upon loss of containment, some material will slide and fall while the bulk of the material will remain in a location beneath the outer surface of material and thus not susceptible to suspension in the air.

Table 8-10 - Segment "N" Hazards Analysis Worksheet

Date: 10/20/93

Facility: Segment "N" Silo 3

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
1a	Silo 3 (internal)	Radioactive Material	Work on or around the silo leads to exposure to ionizing radiation.	Minimal due to low dose rate from material.	N	Dose rate generally less than 0.5 mrem/hr.
1b	Silo 3 (internal)	Radioactive Material	Loss of containment due to silo collapse from earthquake, tornado, load drop (crane failure), etc.	Release of uranium ore residues resulting in exposure to workers and the public.	N	Earthquake resulting in release and dispersion seen as the worst case accident scenario.
2	Silo 3 (internal)	Hazardous Material	Loss of containment due to silo collapse from earthquake, tornado, load drop (crane failure), structural failure, etc.	Release of uranium ore residues resulting in exposure to workers and the public.	N	Earthquake resulting in release and dispersion seen as the worst case accident scenario.

000120

Table 8-10 - Segment "N" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Segment "N" Silo 3

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
3	Silo 3	Explosion	Buildup of H_2 gas as a result of water decomposition and ignition by lightning or ungrounded equipment.	None.	N	Not a credible scenario due to low ionizing radiation levels and minimal quantities of water resulting in minimal H_2 generation.
4	Silo 3	Potential Energy from fall from a height	Person climbs on silo dome and falls.	Fall from silo causes physical harm.	Y	Administrative controls in place to control the access to the silo domes.

000121

89

Table 8-10 - Segment "N" Hazards Analysis Worksheet (Continued)

Date: 10/20/93

Facility: Segment "N" Silo 3

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
5	Silo 3	Special Nuclear Material	None identified.	No initiating event identified. Estimated Uranium concentration of 0.16 lb U/ft^3 based on RI/FS results of 2,956 mg/kg U. This is below the safe density and concentration limits - Group IV for all enrichments listed in FMPC-2304, Table IV (Ref. 8.3).Concentration of fissile material is too low.	N/A	N/A

000122

Table 8-10 - Segment "N" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Segment "N" Silo 3

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
6a	Silo 3	External Event	Aircraft crash.	None.	N	Nearest local airport is 4.7 miles away and is considered not a reasonable concern. An airplane crash within Segment "N" is an incredible event.
6b	Silo 3	External Event	Large dams.	None.	N	None upstream of facility.
6c	Silo 3	External Event	Rail car accident/explosion.	None.	N	No railroad tracks in the vicinity of the silo.
6d	Silo 3	External Event	Barge accident/explosion.	None.	N	None in vicinity of silo.
6e	Silo 3	External Event	Sabotage.	None.	N	Excluded from assessment due to site security procedures.

000123

89

8.2.4.2 High-Energy Event

Due to the high energy and greater potential for release, the airborne release fraction is assumed to be 0.01 (DOE-STD-1027-92) of the entire Silo 3 contents and a respirable fraction of 0.488. This release fraction is applicable to a pressurized powder release which is not exactly applicable to the release from Silo 3 but should be bounding due to the energy imparted from the tornado adding sufficient energy to the Silo 3 powder.

8.2.5 Consequence Determination

The consequence to the maximally exposed individual at the site boundary (330 meters) and on site (100 m) is determined by using the methodology of Subsection 8.1.5. Those chemicals present in quantities below the Category 3 threshold were screened from the consequence determination.

The release conditions and meteorology for an earthquake/natural degradation (low-energy event) are as follows:

1) Ground level point source release
2) Stability Class F
3) Windspeed 2 meters per second
4) Distance to receptor is 330 meters off site and 100 meters on site
5) Release duration occurs over a period of 2 hours

Table 8-11 presents the results of the dispersion analysis and consequences for the loss of containment low-energy event.

The release conditions and meteorology for a tornado (high-energy event) are as follows:

1) Ground level point source release
2) Stability Class A
3) Windspeed of 31 meters per second
4) Distance to receptor is 330 meters off site and 100 meters on site
5) Release duration is 2 hours

Table 8-12 presents the results of the dispersion analysis and consequences for the loss of containment (high-energy event).

Table 8-11 - Segment "N" Consequences of Loss of Containment (Low-Energy Event)

		Silo 3	Tornado/High Wind	Dilution Factor		Release Rate	Concentration			Dose	
Nuclides	Silo 3 (pCi/g)	Total Content mg	Release Fration ARF	Off-Site 330m (s/m³)	On-Site 100m (s/m³)	(pCi/s)	Off-Site (pCi/m³)	On-Site (pCi/m³)	Inhalation DCF (mrem/pCi)	Off-Site mrem	On-Site mrem
Ac-227	7.93E+02	2.78E+12	4.88E-05	3.76E-07	8.22E-06	1.89E+04	7.09E-03	1.55E-01	6.70E+00	1.14E-01	2.49E+00
Pb-210	4.73E+03	1.66E+13	4.88E-05	3.76E-07	8.22E-06	1.13E+05	4.23E-02	9.25E-01	2.10E-02	2.13E-03	4.66E-02
Ra-226	3.87E+03	1.36E+13	4.88E-05	3.76E-07	8.22E-06	9.21E+04	3.46E-02	7.57E-01	7.90E-03	6.56E-04	1.43E-02
Ra-228	4.06E+02	1.43E+12	4.88E-05	3.76E-07	8.22E-06	9.66E+03	3.63E-03	7.94E-02	4.50E-03	3.92E-05	8.57E-04
Th-228	8.75E+02	3.07E+12	4.88E-05	3.76E-07	8.22E-06	2.08E+04	7.83E-03	1.71E-01	3.10E-01	5.82E-03	1.27E-01
Th-230	6.02E+04	2.11E+14	4.88E-05	3.76E-07	8.22E-06	1.43E+06	5.38E-01	1.18E+01	3.20E-01	4.14E-01	9.04E+00
Th-232	8.71E+02	3.06E+12	4.88E-05	3.76E-07	8.22E-06	2.07E+04	7.79E-03	1.70E-01	1.60E+00	2.99E-02	6.54E-01
U-234	1.94E+03	6.81E+12	4.88E-05	3.76E-07	8.22E-06	4.62E+04	1.74E-02	3.79E-01	1.30E-01	5.41E-03	1.18E-01
U-235/6	1.19E+02	4.18E+11	4.88E-05	3.76E-07	8.22E-06	2.83E+03	1.06E-03	2.33E-02	1.20E-01	3.07E-04	6.70E-03
U-238	1.78E+03	6.25E+12	4.88E-05	3.76E-07	8.22E-06	4.23E+04	1.59E-02	3.48E-01	1.20E-01	4.59E-03	1.00E-01
									Total	5.76E-01	1.26E+01
Inorganics	(mg/kg)	(mg)		(s/m³)	(s/m³)	(mg/s)	(mg/m³)	(mg/m³)		(mg)	(mg)
Aluminum	1.93E+04	6.77E+10	4.88E-05	3.76E-07	8.22E-06	4.59E+02	1.73E-04	3.77E-03		4.14E-04	9.06E-03
Arsenic	3.17E+03	1.11E+10	4.88E-05	3.76E-07	8.22E-06	7.54E+01	2.84E-05	6.20E-04		6.80E-05	1.49E-03
Barium	2.58E+02	9.06E+08	4.88E-05	3.76E-07	8.22E-06	6.14E+00	2.31E-06	5.05E-05		5.54E-06	1.21E-04
Beryllium	2.91E+01	1.02E+08	4.88E-05	3.76E-07	8.22E-06	6.92E-01	2.60E-07	5.69E-06		6.25E-07	1.37E-05
Cobalt	2.87E+03	1.01E+10	4.88E-05	3.76E-07	8.22E-06	6.83E+01	2.57E-05	5.61E-04		6.16E-05	1.35E-03
Copper	3.34E+03	1.17E+10	4.88E-05	3.76E-07	8.22E-06	7.95E+01	2.99E-05	6.53E-04		7.17E-05	1.57E-03
Iron	5.22E+04	1.83E+11	4.88E-05	3.76E-07	8.22E-06	1.24E+03	4.67E-04	1.02E-02		1.12E-03	2.45E-02
Lead	2.38E+03	8.35E+09	4.88E-05	3.76E-07	8.22E-06	5.66E+01	2.13E-05	4.65E-04		5.11E-05	1.12E-03
Magnesium	6.89E+04	2.42E+11	4.88E-05	3.76E-07	8.22E-06	1.64E+03	6.16E-04	1.35E-02		1.48E-03	3.23E-02
Nickel	4.29E+03	1.51E+10	4.88E-05	3.76E-07	8.22E-06	1.02E+02	3.84E-05	8.39E-04		9.21E-05	2.01E-03
Potassium	1.40E+04	4.91E+10	4.88E-05	3.76E-07	8.22E-06	3.33E+02	1.25E-04	2.74E-03		3.01E-04	6.57E-03
Vanadium	3.49E+03	1.22E+10	4.88E-05	3.76E-07	8.22E-06	8.30E+01	3.12E-05	6.82E-04		7.49E-05	1.64E-03

000125

68

000126

Table 8-12 - Segment N Consequences of Loss of Containment (High-Energy Event)

Nuclides	Silo 3 (pCi/g)	Total Inventory Segment N	Earthquake/ Natural Degradation ARF	Dilution Factor Off-Site 330m (s/m³)	Dilution Factor On-Site 100m (s/m³)	Release Rate (pCi/s)	Concentration Off-Site (pCi/m³)	Concentration On-Site (pCi/m³)	Inhalation DCF (mrem/pCi)	Dose Off-Site mrem	Dose On-Site mrem
Ac-227	7.93E+02	2.78E+12	4.88E-06	2.11E-03	1.75E-02	1.89E+03	3.98E+00	3.30E+01	6.70E+00	6.40E+01	5.31E+02
Pb-210	4.73E+03	1.66E+13	4.88E-06	2.11E-03	1.75E-02	1.13E+04	2.37E+01	1.97E+02	2.10E-02	1.20E+00	9.92E+00
Ra-226	3.87E+03	1.36E+13	4.88E-06	2.11E-03	1.75E-02	9.21E+03	1.94E+01	1.61E+02	7.90E-03	3.68E-01	3.05E+00
Ra-228	4.06E+02	1.43E+12	4.88E-06	2.11E-03	1.75E-02	9.66E+02	2.04E+00	1.69E+01	4.50E-03	2.20E-02	1.83E-01
Th-228	8.75E+02	3.07E+12	4.88E-06	2.11E-03	1.75E-02	2.08E+03	4.39E+00	3.64E+01	3.10E-01	3.27E+00	2.71E+01
Th-230	6.02E+04	2.11E+14	4.88E-06	2.11E-03	1.75E-02	1.43E+05	3.02E+02	2.51E+03	3.20E-01	2.32E+02	1.92E+03
Th-232	8.71E+02	3.06E+12	4.88E-06	2.11E-03	1.75E-02	2.07E+03	4.37E+00	3.63E+01	1.60E+00	1.68E+01	1.39E+02
U-234	1.94E+03	6.81E+12	4.88E-06	2.11E-03	1.75E-02	4.62E+03	9.74E+00	8.08E+01	1.30E-01	3.04E+00	2.52E+01
U-235/6	1.19E+02	4.18E+11	4.88E-06	2.11E-03	1.75E-02	2.83E+02	5.97E-01	4.95E+00	1.20E-01	1.72E-01	1.43E+00
U-238	1.78E+03	6.25E+12	4.88E-06	2.11E-03	1.75E-02	4.23E+03	8.94E+00	7.41E+01	1.20E-01	2.57E+00	2.13E+01
									Total	3.24E+02	2.68E+03
Inorganics	(mg/kg)	(mg)		(s/m³)	(s/m³)	(mg/s)	(mg/m³)	(mg/m³)		(mg)	(mg)
Aluminum	1.93E+04	6.77E+10	4.88E-06	2.11E-03	1.75E-02	4.59E+01	9.69E-02	8.04E-01		2.33E-01	1.93E+00
Arsenic	3.17E+03	1.11E+10	4.88E-06	2.11E-03	1.75E-02	7.54E+00	1.59E-02	1.32E-01		3.82E-02	3.17E-01
Barium	2.58E+02	9.06E+08	4.88E-06	2.11E-03	1.75E-02	6.14E-01	1.30E-03	1.07E-02		3.11E-03	2.58E-02
Beryllium	2.91E+01	1.02E+08	4.88E-06	2.11E-03	1.75E-02	6.92E-02	1.46E-04	1.21E-03		3.51E-04	2.91E-03
Cobalt	2.87E+03	1.01E+10	4.88E-06	2.11E-03	1.75E-02	6.83E+00	1.44E-02	1.19E-01		3.46E-02	2.87E-01
Copper	3.34E+03	1.17E+10	4.88E-06	2.11E-03	1.75E-02	7.95E+00	1.68E-02	1.39E-01		4.02E-02	3.34E-01
Iron	5.22E+04	1.83E+11	4.88E-06	2.11E-03	1.75E-02	1.24E+02	2.62E-01	2.17E+00		6.29E-01	5.22E+00
Lead	2.38E+03	8.35E+09	4.88E-06	2.11E-03	1.75E-02	5.66E+00	1.19E-02	9.91E-02		2.87E-02	2.38E-01
Magnesium	6.89E+04	2.42E+11	4.88E-06	2.11E-03	1.75E-02	1.64E+02	3.46E-01	2.87E+00		8.30E-01	6.88E+00
Nickel	4.29E+03	1.51E+10	4.88E-06	2.11E-03	1.75E-02	1.02E+01	2.15E-02	1.79E-01		5.17E-02	4.29E-01
Potassium	1.40E+04	4.91E+10	4.88E-06	2.11E-03	1.75E-02	3.33E+01	7.03E-02	5.83E-01		1.69E-01	1.40E+00
Vanadium	3.49E+03	1.22E+10	4.88E-06	2.11E-03	1.75E-02	8.30E+00	1.75E-02	1.45E-01		4.20E-02	3.49E-01

8.3 Hazard Analysis for Segment "O" (Vitrification Pilot Plant)

The radioactive, organic, and inorganic material inventory in the Vitrification Pilot Plant area is listed in Tables 8-4, 8-5, 8-6, and 8-7.

8.3.1 Preliminary Hazard Categorization

Based on a comparison of the inventory of material in the Vitrification Pilot Plant to values based on DOE-STD-1027-92, the preliminary hazard category is Hazard Category 3. The final hazard category is determined by the results of the hazard analysis for the final hazard category. Chemicals which are present, but are less than the Category 3 threshold are screened from further analysis. This is valid since the consequences due to multiple chemicals are not cumulative for final hazard categorization. The Final Hazard Categorization is presented in Subsection 8.4 and confirms this preliminary categorization.

8.3.2 Hazard Analysis

Table 8-13 presents the results of the hazard analysis worksheets. The worksheet identifies the hazard type, initiating events, energy sources, consequences, and locations of the hazards and was developed using the Risk Assessment Report for the OU-4 Pilot Plant Program (see Appendix C).

Table 8-13 - Segment "O" Hazards Analysis Worksheet

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
1a	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin, the furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Work in the vicinity of components containing K-65 residues leads to exposure to ionizing radiation.	Potential to exceed dose limits and controls.	N	Shielding to be used as necessary and administrative controls to limit access will be incorporated into design and operations.

000128

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
1b	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Loss of containment of material due to earthquake.	Exposure to airborne particulate radioactive material to the public and workers.	N	N/A
1c	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin, furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Loss of containment of material due to tornado strike.	Exposure to airborne particulate radioactive material to the public and workers.	N	N/A

000129

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
1d	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin, furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Loss of containment on slurry line due to material defect, weld seam, incompatibility of slurry and pipe material etc.	None	N	Double walled pipe with leak detection is used in all piping carrying liquid radioactive wastes.
1e	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin, furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Loss of containment on major process vessel due to material defect, weld failure, etc.	Exposure to airborne particulate radioactive material to the public and workers.	N	Use of secondary containment for process vessels to contain the release of liquids from spreading to other areas.

0001130

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
1f	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin, furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Loss of containment due to traffic accident impacting storage container.	Exposure to airborne particulate radioactive material to the public and workers.	N	N/A
1g	Internal to primary confinement system and surge bin for Silo 3 material. Bulk of inventory is in thickener, Silo 3 material surge bin, furnace and off-gas collection system.	Radioactive material from Silos 1, 2, and 3	Release of radon and daughter products attached to carbon due to charcoal filter failure.	Exposure to airborne particulate radioactive material to the public and workers.	N	N/A

0001131
89

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
2	Internal to Pilot Plant.	K-65 residues, Silo 3 material, vitrification feed additives, etc.	Loss of confinement of vitrification system components due to material defects, component failure, weld defects, tornado, earthquake, etc.	Internal exposure of personnel and workers to hazardous material.	N	N/A
3	Inside Vitrification Process storage area, vehicles fuel, carbon within off gas.	Flammable materials	Combustible materials catching fire due to initiating source such as an engine in operation, furnace, heaters, local refueling.	Fire leading to personnel injury, equipment damage, potential radioactive/ hazardous material release.	N	Source term much less than total inventory. Consequences bounded by earthquake scenario. System/facility design per NFPA guidance

0001132

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
4	Furnace in Pilot Plant.	Explosion	Overpressurization of furnace due to rapid expansion of gases within furnace with defective pressure relief.	Death/injury to workers, equipment damage, and structural damage to the process building. Airborne hazard minimal due to size of airborne particles.	Y	Common hazard to all furnaces. Other project considerations include (1) the feed rate and the associated gas generation rate are very slow, (2) the melter vents to atmosphere with little backpressure, (3) three layers of different materials separate cooling water from molten material, (4) a constant but slow gas generation rate sweeps away generated gas,

000133

89

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
4 (cont)						(5) the melter is cooled so that its exterior is not at a temperature high enough to burn, (6) the process can be easily and quickly terminated, and (7) there is no expected source of combustible or explosive gas.
5	Diesel backup power units.	Electrical energy hazard	Accidental contact of line circuit through erroneous connection, faulty connection, or inadequate insulation.	Shock, electrocution, or skin burns. Carbon monoxide generation.	Y	Standard hazard common to all diesel electric units.

000134

Table 8-13 - Segment "O" Hazards Analysis Worksheet (Continued)

Date: 10/20/93
Facility: Vitrification Pilot Plant

Item No.	Location of Hazard	Hazard Type	Initiating Event	Consequence	Standard Industrial Hazard Y or N	Comments and/or Justification for Standard Industrial Hazard
6	Furnace.	Thermal energy (high temperature)	Insulation failure, lack of adequate insulation, loss of cooling water.	Equipment and structure damage, burns, or death to workers. Ignition of combustible material nearby.	Y	Standard hazard for high temperature furnace
7	Vitrification Process Building.	Kinetic energy (linear)	Forklift accident.	Injury to personnel or equipment, potential release of hazardous/ radioactive material from process equipment.	N	Source term much less than total dispersible inventory.

8.3.4 Scenario Development

The bounding consequence for each non-standard hazard type with a credible initiating event is described in the following subsections.

8.3.4.1 Loss of Process Containment (Earthquake)

There are several potential accidents which involve the loss of containment. The bounding event would be the earthquake-induced failure of the Vitrification Pilot Plant process confinement and the loss of containment of the Silo 3 material storage bin adjacent to the Vitrification Pilot Plant. This is bounding because it releases the most material of all low-energy events under the same atmospheric conditions. The high-energy loss of containment has been shown to not be the bounding event due to the significant dispersion which would take place under the tornado/high wind conditions.

The airborne release of solid powder from the Silo 3 material storage would be 0.001 for nonconsolidated powder (DOE-STD-1027-92) with a respirable fraction of 0.488. The airborne release of K-65 material from the thickener would be 4.0×10^{-6} at 100 percent respirable (Ref. 8.6). This is a reasonably conservative estimate for the free fall spill of a liquid with a density of greater than one (Ref. 8.6).

In addition all of the radon in the off-gas system is released (4 Ci) based on pilot plant operation.

8.3.4.2 Loss of Containment on Thickener (Material Defect, Weld Failure, etc.) Low-Energy Event

This scenario involves the failure of the thickener for reasons other than natural phenomena under low-energy initiating conditions. The release of material from the thickener is the same as for the earthquake scenario 4×10^{-6} airborne respirable fraction (Ref. 8.6).

8.3.4.3 Loss of Containment Silo 3 Material Storage Bin (Material Defect, Weld Failure, Traffic Accident, etc.) Low-Energy Event

This scenario involves the failure of the Silo 3 material storage bin independent of other scenarios. The release fraction and respirable fraction are the same as the earthquake scenario (0.001 airborne fraction and 0.488 respirable fraction).

8.3.4.4 Loss of Containment on Off-gas

This scenario involves the loss of containment on the off-gas carbon canisters (due to a variety of potential reasons) and releases 100 percent of the radon contained in the canisters. It is assumed that the canisters are fully loaded and all radon is released in a 2-hour period.

8.3.5 Consequence Determination

The consequence to the maximally exposed individual at the site boundary, approximately 430 meters from the likely Vitrification Pilot Plant location, and the on-site individual (100 m) is determined for each accident scenario developed. The methodology of Subsection 8.1.5 is used. The Pilot Plant location is approximately 100 meters further from the fence line than the silos. The release conditions for all low-energy events for the Vitrification Pilot Plant are:

1) Ground level point source release
2) Stability Class F
3) Wind speed is 2 meters per second
4) Release duration is 2 hours

The consequences of chemicals present in less than Category 3 quantities are not included.

Tables 8-14 through 8-17 present the consequences of the unmitigated accidents for each of the scenarios developed for the Vitrification Pilot Plant.

Table 8-14 - Consequences of Loss of Pilot Plant Containment due to Earthquake

Nuclides	K-65 Material in Pilot Plant (Ci)	Silo 3 Material in Pilot Plant (Ci)	Earthquake Silo 3 Material ARF	Earthquake K-65 ARF	Dilution Factor Off-Site 430m (s/m³)	Dilution Factor On-Site 100m (s/m³)	Release Rate (pCi/s)	Concentration Off-Site (pCi/m³)	Concentration On-Site (pCi/m³)	Inhalation DCF (mrem/pCi)	Dose Off-Site mrem	Dose On-Site mrem
Ac-227	3.7E-01	7.2E-03	4.9E-04	4.0E-06	1.4E-03	1.8E-02	7.0E+02	9.4E-01	1.2E+01	6.7E+00	1.51E+01	1.96E+02
Pb-210	1.0E+01	4.3E-02	4.9E-04	4.0E-06	1.4E-03	1.8E-02	8.5E+03	1.2E+01	1.5E+02	2.1E-02	5.80E-01	7.51E+00
Ra-226	2.6E+01	3.5E-02	4.9E-04	4.0E-06	1.4E-03	1.8E-02	1.7E+04	2.3E+01	3.0E+02	7.9E-03	4.37E-01	5.67E+00
Ra-228	0.0E+00	3.7E-03	4.9E-04	4.0E-06	1.4E-03	1.8E-02	2.5E+02	3.4E-01	4.4E+00	4.5E-03	3.64E-03	4.72E-02
Th-228	3.6E-02	7.9E-03	4.9E-04	4.0E-06	1.4E-03	1.8E-02	5.6E+02	7.5E-01	9.8E+00	3.1E-01	5.61E-01	7.27E+00
Th-230	3.5E+00	5.5E-01	4.9E-04	4.0E-06	1.4E-03	1.8E-02	3.9E+04	5.3E+01	6.8E+02	3.2E-01	4.05E+01	5.24E+02
Th-232	2.8E-02	7.9E-03	4.9E-04	4.0E-06	1.4E-03	1.8E-02	5.5E+02	7.4E-01	9.7E+00	1.6E+00	2.86E+00	3.71E+01
U-234	5.3E-02	1.8E-02	4.9E-04	4.0E-06	1.4E-03	1.8E-02	1.2E+03	1.7E+00	2.1E+01	1.3E-01	5.15E-01	6.68E+00
U-235/6	3.9E-03	1.1E-03	4.9E-04	4.0E-06	1.4E-03	1.8E-02	7.5E+01	1.0E-01	1.3E+00	1.2E-01	2.93E-02	3.80E-01
U-238	5.4E-02	1.6E-02	4.9E-04	4.0E-06	1.4E-03	1.8E-02	1.1E+03	1.5E+00	2.0E+01	1.2E-01	4.38E-01	5.67E+00
Rn-222 (Off gas only)	4.0E+00		RN ARF	1.0E+00	1.4E+00	1.8E-02	5.6E+08	7.5E+05	9.7E+06	4.5E-05	8.10E+01	1.05E+03
										Total	1.42E+02	1.84E+03
Organics	(mg)	(mg)			(s/m³)	(s/m³)	(mg/s)	(mg/m³)	(mg/m³)		(mg)	(mg)
Tributyl phosphate	4.0E+06	0.0E+00	4.9E-04	4.0E-06	1.4E-03	1.8E-02	2.2E-03	3.0E-06	3.9E-05		7.29E-06	9.45E-05
Inorganics												
Aluminum	7.4E+07	1.8E+08	4.9E-04	4.0E-06	1.4E-03	1.8E-02	1.2E+01	1.6E-02	2.1E-01		3.86E-02	5.01E-01
Arsenic	3.7E+07	2.9E+07	4.9E-04	4.0E-06	1.4E-03	1.8E-02	2.0E+00	2.7E-03	3.5E-02		6.39E-03	8.28E-02
Barium	6.4E+08	2.3E+06	4.9E-04	4.0E-06	1.4E-03	1.8E-02	5.2E-01	7.0E-04	9.0E-03		1.67E-03	2.17E-02
Beryllium	9.5E+04	2.6E+05	4.9E-04	4.0E-06	1.4E-03	1.8E-02	1.8E-02	2.4E-05	3.1E-04		5.82E-05	7.54E-04
Cobalt	1.0E+08	2.6E+07	4.9E-04	4.0E-06	1.4E-03	1.8E-02	1.8E+00	2.5E-03	3.2E-02		5.91E-03	7.66E-02
Copper	2.6E+07	3.0E+07	4.9E-04	4.0E-06	1.4E-03	1.8E-02	2.1E+00	2.8E-03	3.6E-02		6.71E-03	8.69E-02
Iron	1.1E+09	4.7E+08	4.9E-04	4.0E-06	1.4E-03	1.8E-02	3.3E+01	4.4E-02	5.7E-01		1.06E-01	1.38E+00
Lead	1.1E+10	2.2E+07	4.9E-04	4.0E-06	1.4E-03	1.8E-02	7.5E+00	1.0E-02	1.3E-01		2.42E-02	3.14E-01
Magnesium	2.2E+08	6.3E+08	4.9E-04	4.0E-06	1.4E-03	1.8E-02	4.3E+01	5.7E-02	7.4E-01		1.38E-01	1.79E+00
Nickel	1.0E+08	3.9E+07	4.9E-04	4.0E-06	1.4E-03	1.8E-02	2.7E+00	3.6E-03	4.7E-02		8.74E-03	1.13E-01
Potassium	2.2E+07	1.3E+08	4.9E-04	4.0E-06	1.4E-03	1.8E-02	8.6E+00	1.2E-02	1.5E-01		2.80E-02	3.62E-01
Vanadium	1.3E+07	3.2E+07	4.9E-04	4.0E-06	1.4E-03	1.8E-02	2.2E+00	2.9E-03	3.8E-02		6.98E-03	9.05E-02

000138

Table 8-15 - Consequences of Loss of Containment in the Silo 3 Material Surge Bin (Low-Energy Event)

Nuclides	Silo 3 Material in Pilot Plant (Ci)	Silo 3 Material ARF Earthquake	Dilution Factor (Off- (s/m³)	Dilution Factor (On- (s/m³)	Release Rate (pCi/s)	Concentration (Off-Site) (pCi/m³)	Concentration (On-Site) (pCi/m³)	Inhalation DCF (mrem/pCi)	Dose (Off-Site) (mrem)	Dose (On-Site) (mrem)
Ac-227	7.2E-03	4.9E-04	1.4E-03	1.8E-02	4.9E+02	6.6E-01	8.5E+00	6.7E+00	1.1E+01	1.4E+02
Pb-210	4.3E-02	4.9E-04	1.4E-03	1.8E-02	2.9E+03	3.9E+00	5.1E+01	2.1E-02	2.0E-01	2.6E+00
Ra-226	3.5E-02	4.9E-04	1.4E-03	1.8E-02	2.4E+03	3.2E+00	4.2E+01	7.9E-03	6.1E-02	7.9E-01
Ra-228	3.7E-03	4.9E-04	1.4E-03	1.8E-02	2.5E+02	3.4E-01	4.4E+00	4.5E-03	3.6E-03	4.7E-02
Th-228	7.9E-03	4.9E-04	1.4E-03	1.8E-02	5.4E+02	7.3E-01	9.4E+00	3.1E-01	5.4E-01	7.0E+00
Th-230	5.5E-01	4.9E-04	1.4E-03	1.8E-02	3.7E+04	5.0E+01	6.5E+02	3.2E-01	3.8E+01	5.0E+02
Th-232	7.9E-03	4.9E-04	1.4E-03	1.8E-02	5.4E+02	7.2E-01	9.4E+00	1.6E+00	2.8E+00	3.6E+01
U-234	1.8E-02	4.9E-04	1.4E-03	1.8E-02	1.2E+03	1.6E+00	2.1E+01	1.3E-01	5.0E-01	6.5E+00
U-235/6	1.1E-03	4.9E-04	1.4E-03	1.8E-02	7.3E+01	9.9E-02	1.3E+00	1.2E-01	2.8E-02	3.7E-01
U-238	1.6E-02	4.9E-04	1.4E-03	1.8E-02	1.1E+03	1.5E+00	1.9E+01	1.2E-01	4.3E-01	5.5E+00
								Total	5.4E+01	6.9E+02
Inorganics	(mg)		(s/m³)	(s/m³)	(mg/s)	(mg/m³)	(mg/m³)		(mg)	(mg)
Aluminum	1.8E+08	4.9E-04	1.4E-03	1.8E-02	1.2E+01	1.6E-02	2.1E-01		3.8E-02	5.0E-01
Arsenic	2.9E+07	4.9E-04	1.4E-03	1.8E-02	2.0E+00	2.6E-03	3.4E-02		6.3E-03	8.2E-02
Barium	2.3E+06	4.9E-04	1.4E-03	1.8E-02	1.6E-01	2.1E-04	2.8E-03		5.1E-04	6.7E-03
Beryllium	2.6E+05	4.9E-04	1.4E-03	1.8E-02	1.8E-02	2.4E-05	3.1E-04		5.8E-05	7.5E-04
Cobalt	2.6E+07	4.9E-04	1.4E-03	1.8E-02	1.8E+00	2.4E-03	3.1E-02		5.7E-03	7.4E-02
Copper	3.0E+07	4.9E-04	1.4E-03	1.8E-02	2.1E+00	2.8E-03	3.6E-02		6.7E-03	8.6E-02
Iron	4.7E+08	4.9E-04	1.4E-03	1.8E-02	3.2E+01	4.3E-02	5.6E-01		1.0E-01	1.3E+00
Lead	2.2E+07	4.9E-04	1.4E-03	1.8E-02	1.5E+00	2.0E-03	2.6E-02		4.7E-03	6.2E-02
Magnesium	6.3E+08	4.9E-04	1.4E-03	1.8E-02	4.2E+01	5.7E-02	7.4E-01		1.4E-01	1.8E+00
Nickel	3.9E+07	4.9E-04	1.4E-03	1.8E-02	2.6E+00	3.6E-03	4.6E-02		8.6E-03	1.1E-01
Potassium	1.3E+08	4.9E-04	1.4E-03	1.8E-02	8.6E+00	1.2E-02	1.5E-01		2.8E-02	3.6E-01
Vanadium	3.2E+07	4.9E-04	1.4E-03	1.8E-02	2.1E+00	2.9E-03	3.8E-02		7.0E-03	9.0E-02

0001139

89

000140

Table 8-16 - Loss of Containment of Thickener in the Pilot Plant (Low-Energy Event)

Nuclides	K-65 Material in Pilot Plant (Ci)	K-65 ARF Earthquake	Dilution Factor (Off- (s/m³)	Dilution Factor (On- (s/m³)	Release Rate (pCi/s)	Concentration (Off-Site) (pCi/m³)	Concentration (On-Site) (pCi/m³)	Inhalation DCF (mrem/pCi)	Dose (Off-Site) mrem	Dose (On-Site) mrem
Ac-227	3.74E-01	4.00E-06	1.35E-03	1.75E-02	2.08E+02	2.81E-01	3.64E+00	6.70E+00	4.52E+00	5.85E+01
Pb-210	1.01E+01	4.00E-06	1.35E-03	1.75E-02	5.61E+03	7.57E+00	9.81E+01	2.10E-02	3.82E-01	4.95E+00
Ra-226	2.65E+01	4.00E-06	1.35E-03	1.75E-02	1.47E+04	1.98E+01	2.57E+02	7.90E-03	3.76E-01	4.88E+00
Ra-228	0.00E+00	4.00E-06	1.35E-03	1.75E-02	0.00E+00	0.00E+00	0.00E+00	4.50E-03	0.00E+00	0.00E+00
Th-228	3.56E-02	4.00E-06	1.35E-03	1.75E-02	1.98E+01	2.67E-02	3.46E-01	3.10E-01	1.98E-02	2.57E-01
Th-230	3.54E+00	4.00E-06	1.35E-03	1.75E-02	1.97E+03	2.65E+00	3.44E+01	3.20E-01	2.04E+00	2.64E+01
Th-232	2.78E-02	4.00E-06	1.35E-03	1.75E-02	1.55E+01	2.09E-02	2.71E-01	1.60E+00	8.02E-02	1.04E+00
U-234	5.34E-02	4.00E-06	1.35E-03	1.75E-02	2.97E+01	4.01E-02	5.19E-01	1.30E-01	1.25E-02	1.62E-01
U-235/6	3.85E-03	4.00E-06	1.35E-03	1.75E-02	2.14E+00	2.89E-03	3.75E-02	1.20E-01	8.33E-04	1.08E-02
U-238	5.38E-02	4.00E-06	1.35E-03	1.75E-02	2.99E+01	4.04E-02	5.23E-01	1.20E-01	1.16E-02	1.51E-01
								Total	7.44E+00	9.64E+01
Organics	(mg)		(s/m³)	(s/m³)	(mg/s)	(mg/m³)	(mg/m³)		(mg)	(mg)
Tributyl phosphate	4.05E+06	4.00E-06	1.35E-03	1.75E-02	2.25E-03	3.04E-06	3.94E-05		7.29E-06	9.45E-05
Inorganics										
Aluminum	7.43E+07	4.00E-06	1.35E-03	1.75E-02	4.13E-02	5.57E-05	7.23E-04		1.34E-04	1.73E-03
Arsenic	3.72E+07	4.00E-06	1.35E-03	1.75E-02	2.07E-02	2.79E-05	3.62E-04		6.70E-05	8.68E-04
Barium	6.43E+08	4.00E-06	1.35E-03	1.75E-02	3.57E-01	4.83E-04	6.26E-03		1.16E-03	1.50E-02
Beryllium	9.48E+04	4.00E-06	1.35E-03	1.75E-02	5.27E-05	7.11E-08	9.22E-07		1.71E-07	2.21E-06
Cobalt	1.03E+08	4.00E-06	1.35E-03	1.75E-02	5.73E-02	7.74E-05	1.00E-03		1.86E-04	2.41E-03
Copper	2.56E+07	4.00E-06	1.35E-03	1.75E-02	1.42E-02	1.92E-05	2.49E-04		4.60E-05	5.97E-04
Iron	1.11E+09	4.00E-06	1.35E-03	1.75E-02	6.19E-01	8.36E-04	1.08E-02		2.01E-03	2.60E-02
Lead	1.08E+10	4.00E-06	1.35E-03	1.75E-02	6.01E+00	8.11E-03	1.05E-01		1.95E-02	2.52E-01
Magnesium	2.20E+08	4.00E-06	1.35E-03	1.75E-02	1.22E-01	1.65E-04	2.14E-03		3.95E-04	5.12E-03
Nickel	1.03E+08	4.00E-06	1.35E-03	1.75E-02	5.73E-02	7.74E-05	1.00E-03		1.86E-04	2.41E-03
Potassium	2.19E+07	4.00E-06	1.35E-03	1.75E-02	1.21E-02	1.64E-05	2.12E-04		3.93E-05	5.10E-04
Vanadium	1.26E+07	4.00E-06	1.35E-03	1.75E-02	7.03E-03	9.48E-06	1.23E-04		2.28E-05	2.95E-04

Table 8-17 - Segment "O" Consequences of Loss of Containment on RTS Canisters (Low-Energy Event)

Variable	Constant/Dose Calculated Value
Maximum carbon filter inventory (Ci)	4.1
ARF	1.0
Release Rate (pCi/s)	5.7E+08
Dilution factor (off-site 430 m) (s/m^3)	1.4E-03
Dilution factor (on-site 100 m) (s/m^3)	1.8E-02
Concentration (off-site) (pCi/m^3)	7.5E+05
Concentration (off-site) (pCi/m^3)	1.0E+07
DCF Inhalation Dose (mrem/pCi)	4.5E-05
Dose (off-site) (mrem)	81
Dose (on-site) (mrem)	1.1E+03
Note: Breathing Rate is 1.2 m^3/hr and exposure duration is equal to release duration (2 hours)	

8.4 Final Hazard Categorization of Segments M, N, and O

The definition of the Category 3 threshold at the FEMP is designed to exclude those facilities which cannot have a significant radiological or chemical impact outside the facility.

The estimated consequences for determining the hazard category of a facility, project, activity, or segment thereof should be determined based on the consequences of the worst case credible scenario developed as a part of the hazard analysis. Table 8-18 lists the criteria to determine the hazard category based on unmitigated accident consequences.

The final hazard category is based on the accident scenario which results in the most conservative hazard classification, either chemical or radiological. If chemical-specific ERPG-3 values are not available, Table 8-19 presents the hierarchy of alternative parameters which were used.

The unmitigated consequences of the bounding event for each segment are compared to the criteria for final hazard categorization. The bounding radiological consequences for each segment are summarized in Table 8-20. Based on the results, the final hazard categories for each segment are shown.

Table 8-18 - FEMP Final Hazard Categorization

Hazard Category[1]	Radiation Exposure		Chemical Exposure[2]	
	On-site (rem)	Off-site (mrem)	On-Site	Off-Site
2	> 25	> 500	≥ ERPG-3 or 2 times ICR	≥ ERPG-2 or 0.02 times ICR
3	5 ≤ x ≤ 25	100 ≤ x ≤ 500	≥ ERPG-2 or 0.02 times the ICR	≥ ERPG-1 or 2×10^{-4} times the ICR

1 Category 1 does not apply to the FEMP, per DOE-STD-1027-92.
2 From Table 1, Ref. 8.7, ERPG-Emergency Response Planning Guide, ICR-Incremental Cancer Risk

Table 8-19 - Recommended Hierarchy of Alternative Concentration-Limit Parameters

Primary Guideline	Hierarchy Group (Hazard Category)	Hierarchy of Alternative Guidelines	Source of Concentration Parameter
ERPG-3	1	EEGL (30 min) IDLH	AIHA 1991 NAS 1985 NIOSH 1990
ERPG-2	2	EEGL (60 min) LOC PEL-C TLV-C TLV-TWA x 5	AIHA 1991 NAS 1985 EPA 1987 29 CFR 1910.1000 ACGIH 1992 ACGIH 1992
ERPG-1	3	PEL-STEL TLV-STEL TLV-TWA x 3	AIHA 29 CFR 1910.1000 ACGIH 1992 ACGIH 1992

Table 8-20 - Summary of Bounding Radiological Consequences for Segments M, N, and O

	Silos 1 and 2 Segment M		Silo 3 Segment N		Pilot Plant Segment O	
	Off-Site (mrem)	On-Site (rem)	Off-Site (mrem)	On-Site (rem)	Off-Site (mrem)	On-Site (rem)
	101	0.84	324	2.68	142	1.84
Final Hazard Categorization	3		3		3	
Bounding Hazard	Loss of containment (low-energy)		Loss of containment (earthquake)		Loss of containment (earthquake)	

8.5 References

8.1) United States Department of Energy, December 1992. *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. DOE-STD-1027-92.

8.2) United States Department of Energy, 1993. *Remedial Investigation Report for Operable Unit 4*, Volumes 1 through 3. Fernald, Ohio: Fernald Field Office.

8.3) PARSONS, 1991. *Silos 1 and 2 Facility Safety Analysis Report*, Rev. 2. Fairfield, OH.

8.4) United States Nuclear Regulatory Commission Regulatory Guide 1.145, February, 1983. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*.

8.5) United States Environmental Protection Agency, 1988. "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion." Federal Guidance Report No.11. EPA-5201/1-88-020.

8.6) Sutter, S.L., J.W. Johnston, and J. Mishima, December 1981. "Aerosols Generated by Free Fall Spill of Powders and Solutions in Static Air." NUREG/CR-2139 (PNL-3786). Richland, WA: Pacific Northwest Laboratory.

8.7) Craig, D.K., J.S. Davis, L.G. Lee, P.J. Lein, and P. Hoffman, April 1993. *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines For Use in DOE Facilities*, Rev. 1. WSRC-MS-92-206.

Table 8-19 - Recommended Hierarchy of Alternative Concentration-Limit Parameters

Primary Guideline	Hierarchy Group (Hazard Category)	Hierarchy of Alternative Guidelines	Source of Concentration Parameter
ERPG-3	1	EEGL (30 min) IDLH	AIHA 1991 NAS 1985 NIOSH 1990
ERPG-2	2	EEGL (60 min) LOC PEL-C TLV-C TLV-TWA x 5	AIHA 1991 NAS 1985 EPA 1987 29 CFR 1910.1000 ACGIH 1992 ACGIH 1992
ERPG-1	3	PEL-STEL TLV-STEL TLV-TWA x 3	AIHA 29 CFR 1910.1000 ACGIH 1992 ACGIH 1992

Table 8-20 - Summary of Bounding Radiological Consequences for Segments M, N, and O

	Silos 1 and 2 Segment M		Silo 3 Segment N		Pilot Plant Segment O	
	Off-Site (mrem)	On-Site (rem)	Off-Site (mrem)	On-Site (rem)	Off-Site (mrem)	On-Site (rem)
	101	0.84	324	2.68	142	1.84
Final Hazard Categorization	3		3		3	
Bounding Hazard	Loss of containment (low-energy)		Loss of containment (earthquake)		Loss of containment (earthquake)	

8.5 References

8.1) United States Department of Energy, December 1992. *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. DOE-STD-1027-92.

8.2) United States Department of Energy, 1993. *Remedial Investigation Report for Operable Unit 4*, Volumes 1 through 3. Fernald, Ohio: Fernald Field Office.

8.3) PARSONS, 1991. *Silos 1 and 2 Facility Safety Analysis Report*, Rev. 2. Fairfield, OH.

8.4) United States Nuclear Regulatory Commission Regulatory Guide 1.145, February, 1983. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*.

8.5) United States Environmental Protection Agency, 1988. "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion." Federal Guidance Report No.11. EPA-5201/1-88-020.

8.6) Sutter, S.L., J.W. Johnston, and J. Mishima, December 1981. "Aerosols Generated by Free Fall Spill of Powders and Solutions in Static Air." NUREG/CR-2139 (PNL-3786). Richland, WA: Pacific Northwest Laboratory.

8.7) Craig, D.K., J.S. Davis, L.G. Lee, P.J. Lein, and P. Hoffman, April 1993. *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines For Use in DOE Facilities*, Rev. 1. WSRC-MS-92-206.

SECTION 9

ANALYSIS OF NORMAL, ABNORMAL, AND ACCIDENT OPERATIONS

This section analyzes normal, abnormal, and accident conditions to assess the risk associated with activities which (1) construct the vitrification building, (2) transfer material from the silos to the melter, (3) operate the vitrification facility, and (4) provide for continued storage of material in Silos 1, 2, and 3.

Risks due to accidents, abnormal, and normal operations have been assessed for on-site and off-site receptors. The analysis is presented in Subsections 9.4 through 9.6. The results of this analysis are presented in Subsection 9.7. This section fulfills the requirements in DOE Order 5480.23 Attachment 1, Item 11. This analysis will be updated during the preparation of the FSAR to focus more specifically on the accident sequences associated with the installed equipment and the operating procedures.

9.1 Methodology

The methodology subsection is organized to mirror the analysis itself. For example, accident scenario methodology is presented in Subsection 9.1.4, while the actual accident scenario analysis is presented in Subsection 9.4.

9.1.1 Safety Analysis Process

The methodology provided in this subsection describes the process used to perform the accident analysis and assess risk. In general, the planned duration of the vitrification pilot plant is less than 1 year; however, this analysis attempts to provide some operational flexibility by calculating all accident frequencies based on events/year as though the operation were continued for 50 weeks per year. The exception to this rule is the worker dose rates for direct radiation exposure. Subsection 9.6 describes this case. The safety analysis flow chart, Figure 9-1, presents the process for performing the analysis.

Accidents and abnormal operations are evaluated in four steps: classification, scenario development, consequence determination, and frequency determination.

9.1.2 Grading

The graded approach provided in WHC-SP-0960, Revision 1, Table 4.10-1 has been used in this accident analysis (Ref 9.1). The grading is performed by evaluation of the hazard class, life cycle, complexity, and mission time. The final grade for each subtopic is determined by taking the highest numbered grade applicable in each row, and consequently the least rigorous requirement.

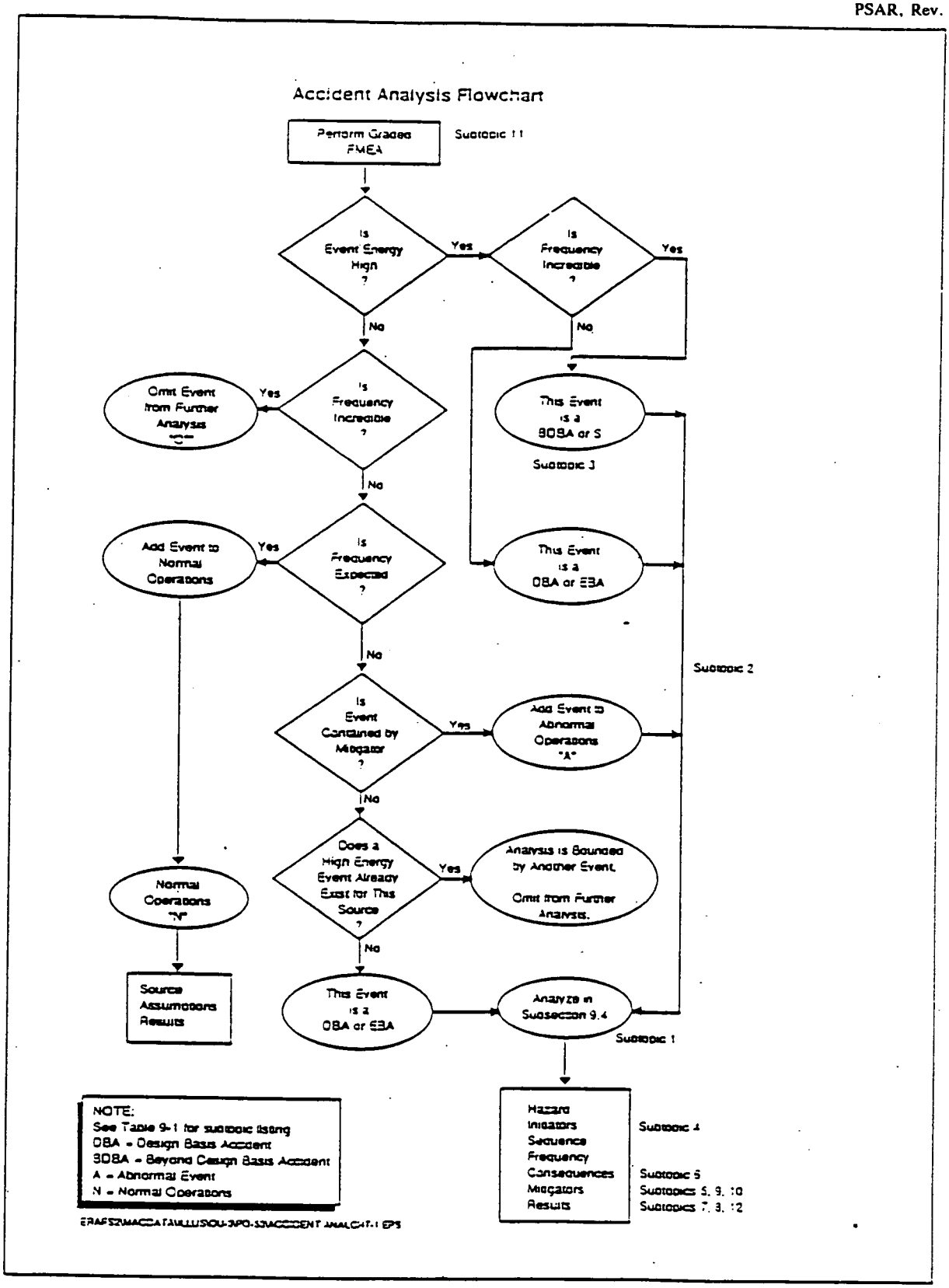


Figure 9-1 - Safety Analysis Flow Chart

9.1.3 Classification of Analysis for Each Event

The hazards for Silos 1, 2, 3, and the vitrification pilot plant activity were identified in Section 8, Hazard Analysis. The hazards are further classified in the accident analysis by identifying the type of analysis involved. To accomplish this, the Block Diagram of Pilot Plant Activities (see Figure 1-4) and the Process Flow Diagrams were used to identify each step in the vitrification process sequence. At each step, event scenarios were generated by selecting all possible energy sources and considering potential events. The events are classified as evaluation basis events, abnormal events, and normal operations, based on their energy and frequency of occurrence.

9.1.4 Accident Scenario Development

Events and sequences were systematically analyzed using the Block Diagram of Pilot Plant Activities. Sequences were developed by considering each possible energy source in combination with each hazardous material. Each combination represented a possible accident event. Accident events were eliminated from further consideration if the potential for a release was shown to be incredible based on the building configuration or characteristics of the operation under evaluation (e.g., the energy source is not located near the hazardous material or the operation itself is innocuous). For each credible event associated with the activity, the results were used to define the accident scenario in terms of the initiating event and methods for accident prevention, detection, mitigation, and recovery.

The consequences to the project worker are not explicitly calculated. The consequences for the receptor at 100 m adequately bound the project worker consequences. This is due to the conservative approach to calculating the dispersion of material from the point of release and the fact that the consequences at 100 m are based on the worker spending 100 percent of the time in the plume for the duration of the accident. A project worker would be exposed to a high concentration of unconfined material for a short period of time but would quickly egress the accident area and not be exposed further. No credit is taken in any part of this analysis for the confinement systems to contain any airborne material. Project workers spend only a small fraction of their time in the vicinity of the pilot plant process components.

Consequences for each scenario are quantified by performing the following steps

1) Determine an Airborne Respirable Fraction (ARF) for the accident scenario under consideration. The ARF combines the expected amount of material likely to become airborne with the percentage of that material which is respirable.

2) The consequences are calculated for three receptor locations
   (1) The on-site individual at 100 meters from the source
   (2) The off-site individual at 330 meters or more from the silos and RTS
   (3) The off-site individual at 430 meters or more from the source in the vitrification facility

   The radiological dose consists of the 50-year Committed Effective Dose Equivalent (CEDE) from inhalation. The submersion dose from direct radiation of the dust cloud is not considered since it is expected to be much less than the CEDE. Only the respirable material is considered to contribute to the chemical uptake.

   A dispersion factor based on a wind speed of 2 m/s and stability class F is used for accident receptors. The dispersion factor is calculated to maximize the dose to both receptor groups and is used to determine an airborne concentration of contaminants at the receptor location. This is the reason for the variation in distance to the receptor. The accident scenarios assume that the off-site receptor is exposed to the airborne release for the entire period.

   The activity inhaled by the receptor is based on the concentration of the contaminant in air, the respiration rate, and exposure duration. In cases where the material is released into a confined area (such as the sealed area of the vitrification pilot plant building) no credit is taken for the dilution and delay which would occur in the release of the material to the environment.

3) The exposure of the receptor to the radioisotopes is converted to a radiological dose in rem using a Dose Conversion Factor (DCF) specific to the isotopes involved. The DCFs used in this analysis are based on Federal Guide No. 11 (Ref. 9.2) and A Manual for Implementing Residual Radioactive Material Guidelines (Ref. 9.3).

4) Breathing rates for the receptors were based on DOE Order 5400.5 and use 1.2 m^3/hr (Ref. 9.4).

5) Exposure durations for on- and off-site personnel are for the duration of the release up to a maximum of 2 hours (per LA-10294 [Ref.9.5]).

The frequencies of events in this analysis involve simple structures and component failures. A single failure rate of the initiating event is estimated and assumed to then result in a release of material. No multiple failure accident scenarios are involved.

The level of analysis required for all accident scenarios is consistent with the grading criteria of Subsection 9.2. Generally, unmitigated conservative assumptions in the accident consequence analysis

are used and produce acceptable results based on qualitative estimations of failure frequencies and simple release/exposure models for consequence evaluation.

9.1.5 Method of Accident Analyses for Severe Natural Phenomena

Section 8 provides an analysis of the unmitigated consequences of severe natural phenomena. Since the hazard analysis is performed in a way that lends itself to an analysis of severe natural phenomena, their evaluation is repeated here.

The probabilities associated with the failure of Silo 1, 2, or 3 are based on the data presented in the SSARR for exceedance probabilities for existing structures. The pilot plant exceedance probabilities for low hazard facilities are used per UCRL-15910.

9.1.6 Methods to Analyze Normal Operations

Normal operations for this PSAR were evaluated based on the design criteria for the pilot plant vitrification facility. The actual performance of the system is not known at this stage due to the pilot stage of the vitrification process. Compliance with the requirements will be demonstrated through models as the design progresses. Compliance will be confirmed in the field through the existing environmental monitoring program and specific monitoring of effluent streams from the vitrification pilot plant.

External exposure to project workers is based on calculated dose rates from shielding for activities associated with the vitrified material storage and transport.

9.1.7 Methods of Analyzing Risk

Risk is the combination of two components in an accident analysis. The first component is the frequency of an event occurring expressed in events per year. The second component is the consequence of the event. This is expressed in 50-year lifetime CEDE (mrem) for radiological hazards and as mg or mg/m^3 of a substance inhaled for chemical hazards. In the analysis, both components are plotted on a risk acceptance curve to determine the acceptability of the risk.

9.2 Grading

The graded approach is illustrated in WHC-SP-0960, Revision 1 (Ref. 9.1), Table 4.10-1, which provides a graded approach for the 12 subtopics which relate to the accident analysis. In this analysis a new column, "Final Grade," has been added to the table. The final grade is determined by taking the largest number across a row and applying it as the final grade, thus the least conservative. This final grade is

used to determine the level of detail provided. When the description of a subtopic is required in the text, the level of detail is based on the results shown in Tables 9-1 through 9-4. Each level of detail, except accident analysis, is defined in Subsection 1.4, "Grading Factors" of this PSAR. The accident analysis level of detail is described in Section 9.2.2.

Table 9-1 - Results of the Grading Evaluation

Description	Segment	Hazard Class	Complexity	Life Cycle	Mission Time
Silos 1 and 2	"M"	3	Simple	Operation	Long
Silo 3	"N"	3	Simple	Operation	Long
Pilot Plant	"O"	3	Simple	Construction	Short

9.2.1 Grading Factors

The four grading factors, as specified in DOE Order 5480.23, Paragraph 8a, are evaluated below. These factors are the major headings in Tables 9-2 to 9-4.

9.2.1.1 Grading Factor - Hazard Category

As demonstrated in Section 8, Segments "M," "N," and "O" are Category 3, "low hazard" facilities.

9.2.1.2 Grading Factor - Complexity

The complexity of Segment O is simple due to the lack of need for backup systems in the design. No complicated chemical reactions take place as part of the process, and safety systems and components are minimized due to the pilot stage of the facility.

The complexity of both Segments M and N is simple due to the lack of activities, lack of process operations, and their use as passive concrete storage facilities.

Table 9-2 - Graded Subtopics for Segment "M," Silos 1 and 2

Subtopic	Hazard Categories			Complexity		Life Cycle		Mission Tine		FINAL GRADE
	1	2	3	Complex	Simple	Const.	Operation	Short	Long	
Accident Analysis Methods	1/2	2/3	3/4	1	2	3/4	1	1	1	3/4
Set of Bounding Conditions	I	I	I							I
Beyond Evaluation Basis	III	V	V	III	V	V	III	V	III	V
Initiating Events	I	II	III	I	II	II	I	II	I	III
Barrier Analysis	I	II	III	I	II	II	I	II	I	III
Nearby Facility Impacts	III	III	IV			IV	III			IV
Risk Acceptance Criteria	I	I	I							I
Alternatives Evaluation	II	III	IV	II	III			III	II	IV
Validating Training & Procedures	II	III	IV	I	III			III	I	IV
Derivation of Safety Provisions	II	III	IV	I	III			III	I	IV
Failure Modes and Effects Analysis	I	II	III	I	II	II	I	II	I	III
Derivation of Principal Safety Criteria	II	III	IV	II	III	II	II	III	II	IV

000153

89

Table 9-3 - Graded Subtopics for Segment "N," Silo 3

Subtopic	Hazard Categories			Complexity		Life Cycle		Mission Tine		FINAL GRADE
	1	2	3	Complex	Simple	Const.	Operation	Short	Long	
Accident Analysis Methods	1/2	2/3	3/4	1	2	3/4	1	1	1	3/4
Set of Bounding Conditions	I	I	I							I
Beyond Evaluation Basis	III	V	V	III	V	V	III	V	III	V
Initiating Events	I	II	III	I	II	II	I	II	I	III
Barrier Analysis	I	II	III	I	II	II	I	II	I	III
Nearby Facility Impacts	III	III	IV			IV	III			IV
Risk Acceptance Criteria	I	I	I							I
Alternatives Evaluation	II	III	IV	II	III			III	II	IV
Validating Training & Procedures	II	III	IV	I	III			III	I	IV
Derivation of Safety Provisions	II	III	IV	I	III			III	I	IV
Failure Modes and Effects Analysis	I	II	III	I	II	II	I	II	I	III
Derivation of Principal Safety Criteria	II	III	IV	II	III	II	II	III	II	IV

000154

Table 9-4 - Graded Subtopics for Segments "O," Vitrification Facility

Subtopic	Hazard Categories			Complexity		Life Cycle		Mission Tine		FINAL GRADE
	1	2	3	Complex	Simple	Const.	Operation	Short	Long	
Accident Analysis Methods	1/2	2/3	3/4	1	2	3/4	1	1	1	3/4
Set of Bounding Conditions	I	I	I							I
Beyond Evaluation Basis	III	V	V	III	V	V	III	V	III	V
Initiating Events	I	II	III	I	II	II	I	II	I	III
Barrier Analysis	I	II	III	I	II	II	I	II	I	III
Nearby Facility Impacts	III	III	IV			IV	III			IV
Risk Acceptance Criteria	I	I	I							I
Alternatives Evaluation	II	III	IV	II	III			III	II	IV
Validating Training & Procedures	II	III	IV	I	III			III	I	IV
Derivation of Safety Provisions	II	III	IV	I	III			III	I	IV
Failure Modes and Effects Analysis	I	II	III	I	II	II	I	II	I	III
Derivation of Principal Safety Criteria	II	III	IV	II	III	II	II	III	II	IV

0001155

- 89

9.2.1.3 Grading Factor - Life Cycle of the Facility

This analysis considers both the construction and operation life cycles of the various segments. Segments M and N are operational and undergoing remediation. Segment O is currently in the design phase and to be constructed.

9.2.1.4 Grading Factor - Mission Time of the Facility

The mission times of Segments M and N are not known. These segments are awaiting remediation per the Record of Decision under CERCLA for OU-4. The life expectancy is greater than 1 year and is therefore graded as "**Long.**" Segment O is a short duration project expected to last less than 1 year and is therefore graded as "**Short.**"

9.2.2 Analysis Grades for Accident Conditions

The required level of analysis as determined from Tables 9-2 through 9-4, is described below, as extracted from WHC-SP-0960 (Ref. 9.1)

Analysis Level 1: Well defined mitigating but conservative assumptions in the accident analysis result in acceptable consequences based on detailed probabilistic analysis demonstrating low failure frequencies for the accident control/mitigation features (e.g., probabilistic risk assessment using detailed release/exposure models for consequence evaluation or a detailed accident simulation model).

Analysis Level 2: Well-defined mitigating but conservative assumptions in the accident consequence analysis produce acceptable results based on detailed quantitative analysis demonstrating low failure frequencies for the accident control/mitigation features (e.g., fault tree or event tree analysis for hazards evaluation, detailed release/exposure model for consequence evaluation).

Analysis Level 3: Mitigating but conservative assumptions in the accident consequence analysis produce acceptable results based on qualitative estimations of low failure frequencies for the accident control/mitigation features (e.g., barrier analysis, Failure Modes and Effects Analysis or hazardous operation analysis for hazards evaluation, or simple release/exposure model for consequence evaluation).

Analysis Level 4: Conservative unmitigated bounding assumptions in the accident consequence analysis produce acceptable results regardless of the accident frequency (e.g., materials and energy inventory/checklist or preliminary hazards analysis evaluation, simple release/exposure model for consequence evaluation).

Most of the analyses require a Level 3 or Level 4 detail. Level 3 detail is used extensively in place of Level 4 detail to determine the acceptability of risks on the risk acceptance curve. A conservative estimate of all consequences are made and an associated probability is estimated for comparison to the Evaluation Guidelines from DOE-STD-3005-YR (Ref. 9.6).

9.3 Classification of Analysis for Each Event

The hazards and initiating events were identified in Section 8. Table 9-5 presents the analysis classification for the events. Events that occur with a frequency greater than 0.1 are classified as "normal operations (N)." Events that can interrupt or aggravate the operation are classified as "abnormal operations (A)." Events that are a result of natural phenomena that exceed the evaluation criteria are classified as "severe NPH events (S)." All other events within the evaluation criteria are classified as "Evaluation Basis Accidents" (EBA).

The Hazard Source identifies the location of the non-standard hazard.. Event Description provides a brief description of the event sequence. The Energy descriptor is a qualitative description of the energy available to disperse radioactive or toxic material contained within the Segments. The Frequency descriptor provides a designator for whether the hazard presents an accident scenario or an expected operational occurrence. The Analysis indicator describes the classification of analysis required.

9.4 Accident Scenarios

This subsection presents the analysis of abnormal and accident conditions for Segments M, N, and O. The analysis includes a systematic evaluation of the impacts on on-site personnel, and the off-site public by hazards associated with construction, operation, and continued storage of material in Silos 1, 2, and 3. It does not discuss safety considerations covered under OSHA. Considerations for OSHA will be addressed in the Project-Specific Health and Safety Plan. The purpose of the accident analysis is to

1) Systematically classify and analyze the hazards associated with the vitrification pilot plant project construction, operation, and continued storage in Silos 1, 2, and 3.

2) Develop the bounding envelope of frequency and consequences through the analysis and evaluation of potential accidents, then determine the acceptability of the associated risks.

3) Develop methods to control, mitigate, or eliminate unacceptable hazards.

4) Identify needed safety systems.

Table 9-5 - Safety Analysis Classification

Hazard Source	Accident/Natural Phenomena Event Description	Energy	Frequency	Possible Mitigators	Analysis[a]
All Segments	BDBA Earthquake	low	possible	None	EBA/ NPH
Furnace Segment O	Fires/Extreme temperature	high	possible	Sprinkler, Operator	DBA
Silo 3 Material Surge Bin	Forklift Impact/Traffic Accident	low	possible	Operator	DBA
1 Storage Container of Vitrified Product	Forklift Drop	low	possible	Operator, material form	DBA
Silo Dome Failure	Hoist/Crane Drop, Physical Degradation	low	possible	Operator	EBA
Silo 3 Material (Powder)	Dust explosion	high	incredible	Oxidized materials	EBA
Propane (Forklift)	Propane gas explosion	high	possible	Shield walls, ventilation system	DBA
Silo Dome Failure	Snow load causes dome failure	low	possible	None	EBA/ NPH
Radon in Existing RTS	RTS failure, fire	low	possible	Building	EBA
Slurry from Pilot Plant process vessels	Loss of containment on thickener	low	possible	Walls, liquid spill containment	DBA
All Segments	EBA/DBA Earthquake	low	possible	Seismic design of Pilot Plant	EBA/ DBA
All Segments	EBA High Velocity Straight Winds	high	possible	None	EBA/ DBA
All Segments	Tornado	high	possible	None	S/NPH
Direct Radiation	Direct Radiation Exposure	n/a	n/a	Training, Procedures	N
Radon inhalation from ambient air[a]	Inhalation of radon	n/a	n/a	Bentonite cover, Radon Treatment System	N
see section 9.6	Normal Radon releases from stack	n/a	n/a	Charcoal filter unit	N

[a] Note N = normal operations, A = abnormal operations, S=severe NPH events, DBA=Design Basis Accidents, EBA=Evaluation Basis Accident, NPH=Natural Phenomena Event, BDBA=Beyond Design Basis Accident

5) Develop TSRs through analysis of the variables that determine the consequences and frequency of the accidents.

The accident analysis develops frequency and consequence models for accident scenarios associated with identified hazards. These models are used to estimate risks posed by the project given the proposed configuration during the operation.

Each hazard is thoroughly investigated and the consequences of the accident scenarios analyzed to their conclusions. The scenarios documented in the accident analysis define the envelope of bounding accidents. In general, an abnormal event is any occurrence during normal operation that temporarily places the facility in an unsafe condition or causes operations to stop due to adverse conditions. Abnormal events include scenarios such as

1) Extreme weather
2) Utility failures
3) Safety class items or engineered safety features failing under non-accident conditions
4) Failure of any feature designed to mitigate health or environmental effects during normal operations
5) Human errors that bypass safety systems or safety features
6) Events that cause shutdown of the operation

For the operations considered in the analysis, the failures described above do not result in a release of the radioactive or hazardous material from confinement.

Accident scenarios are analyzed in three major groupings: internal events in Subsections 9.4.1, 9.4.2, and 9.4.3; natural phenomena in Subsections 9.4.4, 9.4.5, and 9.4.6; and externally induced events in Subsections 9.4.7, 9.4.8, and 9.4.9. Segments "M," "N," and "O" are analyzed sequentially under each grouping.

9.4.1 Internal Events in Silos 1 and 2 (Segment "M")

This section quantifies the consequences of the internal events postulated in Segment "M." For hazard classification, the bounding consequences for each type of accident initiator were quantified in Section 8. The analysis of Section 8 is used in consequence determination for this section.

The K-65 Silos and the radon treatment system (Segment M) have no normal operational activities and as such there are few internal events which could release material confined within this segment. The primary accident scenarios involve the release of material due to a loss of confinement caused by a material defect or natural degradation.

9.4.1.1 RTS Failure/Radon Release

Hazard: Dispersion of radon/daughters from RTS carbon filters.

Energy Source: Low-energy event with loss of containment due to various potential initiators, such as material defect, weld defect, etc.

Sequence: A loss of containment of the radon within the carbon filters occurs due to a material defect, weld seam failure, or fire.

Assumptions

1) The carbon filter is fully loaded with radon at the time of the loss of containment (3.2 Ci). All radon is released and respirable and one half of the daughter products are released based on the DCF being applicable under these conditions. This assumption is conservative since the ARF for similar materials is less than 0.5 as reported in literature by Mishima.

2) Action is taken to recover control of the silos within 2 hours following the release (Ref 9.5). Thus, the continued evolution of radon gas from the residues is insignificant in comparison to the initial release of the headspace contents. A continued release for 2 hours from the residues is approximately 1 percent of the initial release of radon from the canisters.

2) No project worker exposure since the area in the vicinity of the carbon canisters will not be occupied when loaded with radon due to high dose rates.

3) The failure rate is 2.66E-8/hr (based on Seabrook Component Failure Distributions) for a rupture of a storage tank during operation. This value was compared for reasonableness to values used in DP-1633 (Ref. 9.7).

Consequences: Exposure of on-site workers and the off-site resident to radon gas.

Frequency: The frequency is based on 2.66E-8 failures/hr and 8,760 hr/yr of operation, or an annual failure frequency of 2.33E-4/yr. This is conservative since the vitrification pilot plant will operate for 1 month and the frequency is based on 12 months of operation.

Mitigators Credited in the Analysis: None.

Other Mitigators: The carbon canisters are located within a building which will delay the escape of some radon to the atmosphere so that a small portion of the radon will decay and not be released to the

atmosphere. Following the accident, measures, such as de-energizing the fans and isolation of the failed equipment, will take place to isolate the silos to minimize further radon release.

Results: This accident results in a radiological dose of approximately 840 mrem on-site and 101 mrem off site and has an estimated frequency of 2.33E-4 per year.

9.4.1.2 Natural Degradation (Dome Collapse)

Hazard: Dispersion of radioactive materials (Rn-222 gas).

Energy Source: Diffusion and dispersion of radon from silo dome headspace (No external energy capable of releasing residues since residues are protected by an average of 2 feet bentonite (which when maintained provides a covering) and an earthen berm with a vegetative cover.)

Sequence: This accident scenario entails a collapse of the silo dome as a result of natural degradation followed by the release of all of the contents of the silo headspace.

Assumptions

1) All of the contents of the headspace from Silos 1 and 2 are released to the atmosphere as a point source (based on a headspace volume of 44,800 ft^3 and an average radon concentration of 2.4E6 pCi/l maximum credible source term for Silo 2 and 27,900 ft^2 and an average radon concentration of 0.23E6 pCi/l for Silo 1).

2) No additional degradation of the silo dome has occurred since the K-65 Silos Probabilistic Risk Assessment (Ref. 9.8).

Consequences: The consequence is the inhalation of radon by site workers (100m) or off-site individuals (330m). Since project workers do not normally access the silo domes no project worker exposure or injury is associated with the silo dome collapse due to natural degradation.

Frequency: From the Silos 1 and 2 FSAR (Ref. 9.9), the frequency of a silo dome collapse is 0.0389/yr.

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: The natural degradation failure of the silo dome results in a 840 mrem dose on-site and a 101 mrem dose off site with an expected frequency of 0.0389/yr.

9.4.2 Internal Event in Silo 3 (Segment "N")

This section quantifies the consequences of the internal events postulated in Segment "N."

Silo 3 (Segment N) has no normal operational activities, and as such there are few internal events which could release material confined within this segment. The primary accident scenario involves the release of material due to a loss of confinement caused by a material defect or natural degradation.

9.4.2.1 Natural Degradation

Hazard: Dispersion of radioactive materials.

Energy Source: Diffusion and dispersion of Silo 3 material due to silo dome collapse.

Sequence: This accident scenario has a collapse of the silo dome as a result of natural degradation followed by the release of 38.7 tons (3.5E7 g) (1 percent of the silo contents) of the silo contents released.

Assumptions

1) One percent (38.7 tons, 3.5E7 g) of the Silo 3 material is released with an airborne fraction of 0.001 (non-consolidated powder per DOE-STD-1027) and a respirable fraction of 0.488 based on particle size (Ref. 9.9). Table 8-4 identifies the curie inventory for Silo 3. One percent of the Silo contents are assumed to be susceptible to the energy associated with the release of material. Upon loss of containment, some material will slide and fall while the bulk of the material will remain in a location beneath the outer surface of material and thus would not be susceptible to suspension in the air.

2) The frequency of a silo dome collapse due to natural degradation is less than that of the natural degradation of either Silo 1 or 2.

Consequences: The consequence is the inhalation of radioactive and hazardous material by site workers (100m) or off site (330m). Because project workers do not normally access the silo domes no project worker exposure or injury is associated with the silo dome collapse due to natural degradation.

Frequency: Qualitatively evaluated to be an extremely unlikely event (Frequency in the range of 10^{-4} to 10^{-6}). This is bounded by the snow load event.

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: The natural degradation failure of the silo dome results in an on-site dose of 2680 mrem and 324 mrem dose off site with an assumed frequency of extremely unlikely. Toxicological doses are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.3 Internal Events in Pilot Plant (Segment "O")

This section quantifies the consequences of the internal events postulated in Segment "O." For hazard classification, only the bounding consequences for each type of accident initiator are quantified. Propane cylinders located outside on portable carts and inside on forklifts present explosion hazards. These cylinders are in use in the vicinity of the stored inventory. Some flammable materials are possible initiators for the "fire" hazard category. If ignited, these materials could impact nearby storage drums and result in an airborne release.

9.4.3.1 Propane Gas Explosion

Because the forklift is propane powered, an accident scenario was developed that considers three sequences that could result in a release of propane from the cylinder in a quantity and at a rate that could achieve the Lower Explosive Limit (LEL) for propane in the confined area of the pilot plant. The following discussion describes a generic model for the frequency analysis of propane gas explosions.

Hazard: Dispersion of radioactive/hazardous material due to the explosion.

Energy Source: Explosion of propane gas.

Sequence: Three sequences that could result in a release of propane in significant concentrations into the confined pilot plant area are (1) the fitting for the propane cylinder is damaged during operations due to mechanical or human failure resulting in a loss of control of the propane driven vehicle; (2) the propane cylinder leaks due to a mechanical failure (rupture) of the vehicle's propane distribution system; or (3) human error during propane cylinder installation results in an improper seal between the cylinder and the fitting.

All release mechanisms lead to the following sequence: (1) the propane leaks from the cylinder; (2) a concurrent ignition source (e.g., electrical spark) ignites the released gas causing an explosion; (3) the propane gas tank heats up and explodes and; (4) the energy generated by the explosion impacts the shield walls, causing damage to the pilot plant process building and the vitrified product stored inventory.

Assumptions

1) The energy involved in the blast is insufficient to totally destroy the shield wall (6 inches of reinforced concrete), which will protect the process vessels which store and contain the furnace feed material.

2) The forklifts are not operated in the vicinity of the filter receiver, which is located outdoors. This makes the possibility of an explosion and release from the filter receiver unlikely.

Consequences: Capital equipment loss, serious injury and /or fatality.

Frequency: Not applicable.

Mitigators Credited in the Analysis: None.

Other Mitigators: Vitrified material form. Inherent properties of concrete used for shielding major process vessels.

Results: The blast may damage the vitrified product but will not cause a significant release of respirable material due to the solid consolidated form of the vitrified material. The blast may cause the release of large glass shards which present a hazard to workers common to all vitrification processes.

9.4.3.2 Dust Explosions

Because ignition of finely divided combustible powders and dusts may result in an explosion, the potential for a dust explosion during pilot plant activities was evaluated. In addition to the dust composition (e.g., combustibility), explosive limits are dependent on numerous properties including particle size, moisture content, volatile content, and oxygen concentration. The concern with this activity results from the suspension of powders in the air in the immediate vicinity of the dust collector/surge bin process line operation. Review of the process history of the materials in Silo 3 indicates the metals were processed through a calciner prior to transfer to Silo 3 to convert the metals to metal oxides. Therefore, these powders are oxidized materials, consequently they are non-combustible and do not present an explosion hazard. No other dust explosion hazards were identified.

9.4.3.3 Fires

In the presence of large quantities of combustible materials, fires involving stored inventory are a significant concern. However, the vitrified material that may be stored in the process building is a solid, nondispersible material encapsulated at the molecular level, effectively controlling any release of respirable or soluble material. No hazard is identified for the process area, except potential equipment damage.

Hazard: Equipment damage.

Energy Source: Fire.

Sequence: Two types of fires have been considered: (1) building fires and (2) equipment fires.

Building Fires: During the 35 years of full production activities, which were discontinued in July 1989, no facility fires occurred at the FEMP. This is, in part, attributable to the presence of operators who could prevent the growth of small fires into facility fires; however, a facility fire which occurred at the site after production ceased involved the boiler plant which was in operation at the time and produces steam for plant usage. Although this was a significant site event, it should be noted that the boiler plant contained significantly greater quantities of combustible material than the vitrification pilot plant program. The combustible material (i.e., coal) in the boiler plant was also in a form which is highly susceptible to combustion.

One potential source of a building fire would be the loss of insulation on the furnace leading to temperatures which exceed the ignition temperature of the building materials.

Frequency: The frequency for an insulation failure is not known, but is assumed to be low.

Assumptions No consequences likely.

Mitigators Credited in the Analysis: None.

Other Mitigators: Building sprinkler systems, operator action to extinguish small fires. The furnace insulation is subject to vendor and acceptance inspections decreasing the probability of a failure.

Results: Not a significant accident scenario.

9.4.3.4 Forklift Drop

Since a forklift may be used to transport containers of vitrified material to storage, it is possible to have a container drop and lose its integrity. However, the solid consolidated form of the vitrified material would not result in an airborne hazard. This scenario does not need further development.

9.4.3.5 Loss of Confinement (Thickener Rupture)

It is possible for any part of the vitrification process system to lose confinement of the material it is carrying and release material to the environment. Because the slurry line carrying material from Silos 1 and 2 to the vitrification pilot plant is double walled, the probability of a simultaneous loss of both primary and secondary confinement is very unlikely. The loss of containment accident will be evaluated based on the thickener, which also contains the greatest amount of material. The risk from the slurry line spill is bounded by the thickener rupture.

Hazard: Release of radioactive and hazardous material.

Energy Source: Gravity drain of thickener tank.

Sequence: Thickener develops leak due to material defect or weld failure. Material is leaked into the diked area of the process area. The spill is contained by the diked area.

Assumptions

1) The unmitigated consequences will be determined.

2) Airborne release fraction of 4E-06 is assumed for free fall spill of liquid with a density greater than one.

4) K-65 material is used for the source term, thickener 50 percent full of solid material and 50 percent water at the time of the accident. See Table 8-1 for the thickener inventory.

5) The failure rate is 2.66E-8/hr (Seabrook Component Failure Distributions) for a rupture of a storage tank during operation.

Consequences: Exposure to airborne radionuclides and chemicals.

Frequency: The frequency is based on 2.66E-8/hr and 8,760 hr/yr of operation, or an annual frequency of 2.33E-4/yr.

Mitigators Credited in the Analysis: None.

Other Mitigators: The liquid spill is contained within the process area secondary containment. The short duration of the project (30 days) reduces the expected frequency.

Results: The unmitigated consequences result in a dose of 96.4 mrem on-site and 7.4 mrem to an off-site individual. Toxicological consequences are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.3.6 Loss of Confinement (Surge Bin)

It is possible for any part of the vitrification process system to lose confinement of the material it is carrying and release material to the environment. This accident evaluates the loss of dry Silo 3 material from the filter receiver storage area due to a tank rupture.

Hazard: Release of radioactive and hazardous material.

Energy Source: Gravity drain of surge bin.

Sequence: Surge bin develops leak due to material defect, weld failure, etc.

Assumptions

1) The unmitigated consequences will be determined.

2) Airborne release fraction of 0.001 for nonconsolidated powder and a respirable fraction of 0.488. See Table 8-1 for the Loss of Confinement on the Surge Bin.

3) Surge bin full of 10 tons of material.

4) The failure rate is 2.66E-8/hr (Seabrook Component Failure Distributions) for a rupture of a storage tank during operation.

Consequences: Exposure to airborne radionuclides and chemicals.

Frequency: The frequency is based on 2.66E-8/hr and 8,760 hr/yr of operation, or an annual frequency of 2.33E-4/yr.

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: The unmitigated consequences result in a dose of 690 mrem on-site and 54 mrem to an off-site individual. Toxicological consequences are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.3.7 Off-Gas Failure/Radon Release

Hazard: Dispersion of radon from carbon filters.

Energy Source: Low-energy event with loss of containment due to various potential initiators.

Sequence: A loss of containment of the radon/daughter products within the carbon filters occurs due to a material defect, weld seam failure, or fire.

Assumptions

1) The carbon filter is fully loaded with radon and radon decay products from pilot plant operations at the time of the loss of containment (4 Ci).

2) No project worker exposure since the area in the vicinity of the carbon canisters will not be occupied when loaded with radon due to high dose rates.

3) The failure rate is 2.66E-8/hr (based on Seabrook Component Failure Distributions) for a rupture of a storage tank during operation.

Consequences: Exposure of on-site workers and the off-site receptor to radon gas.

Frequency: The frequency is based on 2.66E-8 failures/hr and 8,760 hr/yr of operation, or an annual failure frequency of 2.33E-4/yr. This is conservative since the vitrification pilot plant will operate for 1 month and the frequency is based on 12 months of operation.

Mitigators Credited in the Analysis: None.

Other Mitigators: The carbon canisters are located within the building which will contain/delay the escape of radon to the atmosphere so that a portion of the radon will decay and not be released to the atmosphere. Following the accident, measures will take place to recover the silos to minimize further radon release.

Results: This accident results in a radiological dose of 1080 mrem on-site and 81 mrem off site and has an estimated frequency of 2.33E-4 per year. The consequences of this event are less than those of Subsection 9.4.1.1 due to the off-gas system proposed location being approximately 100 meters farther (430 m) from the site boundary than the existing RTS.

9.4.4 Natural Phenomena in Segment "M"

Extremes in natural phenomena can adversely affect the K-65 Silos by causing damage or by aggravating the deteriorated condition of the domes. Natural phenomena are summarized herein as they have affected or can directly affect the segment. Snow, lightning, rain and flooding, earthquakes, high velocity straight winds, and tornados were considered. Volcanism, glaciation, and meteorites were qualitatively screened from the analysis.

9.4.4.1 Snow

Hazard: Release of radon/decay products from silo headspace due to dome collapse.

Energy Source: Radon diffuses/disperses from headspace.

Sequence: Mass of snow causes failure of the silo dome.

Assumptions

1) All of the contents of both silo headspaces are released to the atmosphere as a point source (based on a headspace volume of 44,800 ft^3 and an average radon concentration of 2.4E6 pCi/l maximum credible source term for Silo 2 and 27,900 ft^3 and an average radon concentration of 0.23E6 pCi/l for Silo 1).

2) No additional degradation of the silo dome has occurred since the K-65 Silos Probabilistic Risk Assessment (Ref. 9.7).

Consequences: The consequence is the inhalation of radon by site workers (100m) or off site (330m). Because project workers do not normally access the silo domes, no project worker exposure or injury is associated with the silo dome collapse due to natural degradation.

Frequency: The possibility of snow causing a dome failure is not known, but is assumed qualitatively to be less than 2E-2 based on past operational history of the silos.

Mitigators Credited in the Analysis: None.

Other Mitigators: Snow falls on bentonite adding a layer to partially reduce radon emanation.

Results: The failure of the silo dome results in a 840 mrem dose on-site and 101 mrem dose off site. Toxicological doses for on-site workers and the off-site public are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.4.2 EBA Earthquake

Hazard: Dispersion of radioactive/hazardous materials.

Energy Source: Horizontal and vertical ground accelerations.

Sequence: An earthquake occurs causing the failure of the silo dome.

Assumptions

1) All of the contents of both silo headspaces are released to the atmosphere as a point source (based on a headspace volume of 44,800 ft^3 and an average radon concentration of 2.4E6 pCi/l maximum credible source term for Silo 2 and 27,900 ft^3 and an average radon concentration of 0.23E6 pCi/l for Silo 1).

2) No additional degradation of the silo dome has occurred since the K-65 Silos Probabilistic Risk Assessment (Ref.9.8).

Consequences: The consequence is the inhalation of radon by site workers (100m) or off site (330m). Because project workers do not normally access the silo domes, no project worker exposure or injury is associated with the silo dome collapse.

Frequency: 8E-4/yr (see Section 3) estimated frequency.

Mitigators Credited in the Analysis None.

Other Mitigators: None.

Results: The earthquake induced failure of the silo dome results in a on-site dose of 840 mrem and 101 mrem dose off site with an estimated frequency of 8E-4/yr.

9.4.4.3 EBA High Velocity Straight Winds

Hazard: Additional degradation to the silo domes.

Energy Source: High Velocity Straight Winds (HVSWs).

Sequence: HVSWs cause damage to or collapse of the silo domes.

Assumptions:

1) The low end defining HVSWs is 50 miles per hour.

2) The silos have been constructed to at least the evaluation criteria limits as discussed in Section 3.

Consequences: HVSWs could cause minor damage to the silo domes or protective coverings with no expected release if within the evaluation limits. HVSWs could contribute to physical degradation (as described in Subsection 9.4.1.7).

Frequency: The frequency for a 50 mph HVSW is 0.1 (Ref. 9.10). The upper limit of the evaluation criteria is for winds of 80 mph, which have a frequency of 2.5E-02. Therefore, in 1 year the frequency of occurrence for an HVSW within the design criteria is 0.1 - 0.025 = 7.5E-02.

Mitigators Credited in the Analysis: Survival of the silo.

Other Mitigators: None.

Results: Abnormal operations.

9.4.4.4 Severe Tornado

Hazard: Dispersion of radioactive/hazardous materials.

Energy Source: Tornado winds, low pressure differential, and missiles.

Sequence: A tornado causes the silo dome to collapse and results in a release of radioactive materials.

Assumptions

1) All of the contents of both silo headspaces are released to the atmosphere as a point source (based on a headspace volume of 44,800 ft^3 and an average radon concentration of 2.4E6 pCi/l maximum credible source term for Silo 2 and 27,900 ft^3 and an average radon concentration of 0.23E6 pCi/l for Silo 1).

2) No additional degradation of the silo dome has occurred since the K-65 Silos Probabilistic Risk Assessment (Ref.9.8).

Consequences: Since the slowest tornado winds only occur above the design wind speed of the segment, an Evaluation Basis Event cannot occur. All tornado events at the segment would be classified as severe NPH events.

Frequency: The frequency for a tornado at the FEMP is 6.6E-4/year (Ref. 9.8).

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: This accident results in a radiological dose of 1.8E-2 mrem off site and 0.4 mrem on site and has an estimated frequency of 6.6E-4 per year.

9.4.4.5 Severe Earthquake

Results are the same as described in Subsection 9.4.4.2.

9.4.5 Natural Phenomena in Segment "N"

Natural phenomena are summarized herein as they may directly affect the segment. Snow, earthquakes, HVSWs, and tornados were considered.

9.4.5.1 Snow

Hazard: Loss of containment on silo dome.

Energy Source: Release of material into air due to collapse of dome.

Sequence: Mass of snow causes failure of the silo dome.

Assumptions: One percent of the Silo 3 material is released with an airborne fraction of 0.001 and a respirable fraction of 0.488 based on particle size.

Consequences: The consequence is the inhalation of radiological and toxicological material by site workers (100m) or off site (330m). Since project workers do not normally access the silo domes no project worker exposure or injury is associated with the silo dome collapse due to natural degradation.

Frequency: The possibility of snow causing a dome failure is not known but is assumed qualitatively to be significantly less than that of the Silos 1 and 2 snow loading failure.

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: The failure of the silo dome results in an on-site dose of 2680 mrem and 324 mrem off site. Toxicological doses for on-site workers and the off-site public are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.5.2 EBA Earthquake

Hazard: Dispersion of radioactive/hazardous materials.

Energy Source: Horizontal and vertical ground accelerations.

Sequence: This accident scenario has a collapse of the silo dome as a result of an EBA earthquake followed by the release of 38.7 tons (3.5E7 g) (1 percent of the Silo contents) of the silo contents released.

Assumptions

1) One percent (38.7 tons, 3.5E7 g) of the Silo 3 material is released with an airborne fraction of 0.001 (non-consolidated powder per DOE-STD-1027) and a respirable fraction of 0.488 based on particle size (Ref. 9.9). Table 8-4 identifies the curie inventory for Silo 3. One percent of the Silo contents are assumed to be susceptible to the energy associated with the release of material. Upon loss of containment, some material will slide and fall while the bulk of the material will remain in a location beneath the outer surface of material and thus not susceptible to suspension in the air.

Assumptions: One percent of the Silo 3 material is released with an airborne fraction of 0.001 (non-consolidated powder per DOE-STD-1027) and a respirable fraction of 0.488 based on particle size (Ref. 9.9). See Table 8-1 for Silo 3 inventory. 97.4 tons (8.84E+7 grams) (one percent of the Silo contents) of the silo contents released.

Consequences: The consequence is the inhalation of radioactive and hazardous material by site workers (100m) or off site (330m). Since project workers do not normally access the silo domes, no project worker exposure or injury is associated with the silo dome collapse due to natural degradation.

Frequency: 8E-4/yr (See Section 3) estimated frequency.

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: The natural degradation failure of the silo dome results in a dose of 2680 mrem on-site and 324 mrem dose off site with an expected frequency of 8E-4/yr. Toxicological doses for on-site workers and the off-site public are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.5.3 EBA High-Velocity Straight Winds

Hazard: Additional degradation to the silo domes.

Energy Source: High-Velocity Straight Winds (HVSWs).

Sequence: HVSWs cause damage to or collapse of the silo domes.

Assumptions

1) The low end defining HVSWs is 50 mph.

2) The silos have been constructed to at least the evaluation criteria limits as discussed in Section 3.

Consequences: HVSWs could cause minor damage to the silo domes or protective coverings with no expected release if within the evaluation limits. HVSWs could contribute to physical degradation (as described in Subsection 9.4.1.7).

Frequency: The frequency for a 50 mph HVSWs is 0.1 (Ref. 9.8). The upper limit of the evaluation criteria is for winds of 80 mph, which have a frequency of 2.5E-02. Therefore, in 1 year the frequency of occurrence for an HVSWs within the design criteria is 0.1 - 0.025 = 7.5E-02.

Mitigators Credited in the Analysis: Survival of the silo.

Other Mitigators: None.

Results: Abnormal operations.

9.4.5.4 Severe Tornado

Hazard: Dispersion of radioactive/hazardous materials.

Energy Source: Tornado winds, low pressure differential, and missiles.

Sequence: A tornado causes the silo dome to collapse and results in a release of radioactive materials.

Assumptions: See Section 8, Segment N tornado scenario for details.

Consequences: Since the slowest tornado winds only occur above the design wind speed of the segment, an Evaluation Basis Event cannot occur. All tornado events at the segment would be classified as severe NPH events.

Frequency: The frequency for a tornado at the FEMP is 6.6E-4/year (Ref. 9.8).

Mitigators Credited in the Analysis: None.

Other Mitigators: None.

Results: This accident results in a radiological dose of 12.6 mrem on-site and 0.6 mrem off site and has an estimated frequency of 6.6E-4 per year. Toxicological doses for on-site workers and the off-site public are presented at the end of this section (see Tables 9-8 and 9-9).

9.4.6 Natural Phenomena in Segment "O"

Natural phenomena do not need to be considered in detail in the accident analysis for a short duration project such as the operation of the pilot plant per WHC-SP-0960 (Ref. 9.1). This is due to the

occurrence of a natural phenomena event during the intermittent use for less than 1 year is extremely unlikely.

The bounding consequences caused by natural phenomena are presented in Section 8. The bounding natural phenomena event would be an earthquake with an on-site dose of 1,840 mrem and an off-site dose of 142 mrem. This is the equivalent of a simultaneous loss of confinement on the thickener (off-site - 7.43E+0, on-site 9.64E+1), surge bin (off-site - 5.4E+1, on-site 6.9E+2), and off-gas collection (off-site 8.1E+1, on-site 1.1E+3) system. Since natural phenomena is bounded by this event and the occurrence is extremely unlikely no other scenarios will be evaluated.

9.4.7 Externally Induced Events in Segment "M"

Most safety-related occurrences are the result of failure within the system or of some action intentionally directed toward the system. It is possible, however, for the damage to be inflicted on a system as a result of some occurrence in an apparently separate system. No credible external events were identified in the hazard analysis Section 8.

9.4.8 Externally Induced Events in Segment "N"

Most safety-related occurrences are the result of failure within the system or of some action intentionally directed toward the system. It is possible, however, for the damage to be inflicted on a system as a result of some occurrence in an apparently separate system. No credible external events were identified in the hazard analysis in Section 8.

9.4.9 Externally Induced Events in Segment "O"

Most safety-related occurrences are the result of failure within the system or of some action intentionally directed toward the system. It is possible, however, for the damage to be inflicted on a system as a result of some occurrence in an apparently separate system. No credible external events were identified in the hazard analysis in Section 8.

9.5 EBA/DBA Conditions and Performance Criteria

The purpose of this section is to document the specific set of conditions used to determine the performance criteria for safety class systems and features.

There are no DBAs/EBAs which require an SSC to mitigate the effects to the public or on-site workers based on proposed DOE-STD-3005-YR.

9.6 Normal Operations

This section presents the normal operational requirements and allowed impacts of the proposed facility. The normal operational impacts from Segments M and N are based on data collected and presented in previous Annual Site Environmental Reports. Segment O is currently under title design and no operational history is available, nor is there any similar facility with which to compare the impact.

Normal operations for Segment O are presented as requirements which the design must meet to operate in accordance with the health and safety criteria, and ARARs.

9.6.1 Normal Operations for Segment M

Segment M has no normal operations other than the continued storage of K-65 residues within the silos. The hazards associated with this normal activity are monitored through the environmental monitoring program and reported in the FEMP Annual Site Environmental Report.

The results of the environmental monitoring program are summarized below (from DOE RI Report, Ref. 9.11).

9.6.1.1 Air

Air data consists of FEMP Environmental Monitoring Program quarterly radon monitoring results obtained during the period 1989 through 1992. Monitoring results were obtained from 24 sampling stations along the FEMP fenceline perimeter, four sampling stations within the FEMP, 13 sampling stations along the fence surrounding Silos 1 and 2, and eight sampling stations located along the perimeters of the Silo 1 and 2 domes.

Fenceline monitoring for radon shows small variations from year to year. For example, FEMP boundary fenceline monitoring stations recorded annual average concentrations for 1990 ranging from 0.4 to 1.5 pCi/l as compared to 0.5 to 1.0 pCi/l in 1989. These concentrations are, however, in the range of background.

In 1991, FEMP personnel completed the K-65 Silos Removal Action. This removal action consisted of placing the bentonite clay layer over the residues stored in Silos 1 and 2. Changes in radon at the fenceline were not discernable from background variations. In the vicinity of OU-4, however, radon concentrations were reduced by a factor of as much as 20.

9.6.1.2 Direct Radiation

Direct radiation data consists of quarterly exposure data measured at 12 points along the FEMP perimeter and at two points within the FEMP perimeter, northeast of the former production area. Natural background measurements for areas surrounding the FEMP site ranged from 6.1 to 6.9 μrem/hr during 1990. During 1990, the FEMP perimeter monitoring stations which exhibited the highest average radiation exposure rate (12.6 μrem/hr) was located 1,100 feet directly west of OU-4. The 1992 monitoring data for this location yielded a dose rate of 5.2 μrem/hr. Thus, along the FEMP perimeter, direct radiation from OU-4 is no longer discernable from background.

9.6.2 Normal Operation for Segment N

Segment N has no normal operations other than the continued storage of residues. The hazards associated with this normal activity is monitored through the environmental monitoring program and reported in the FEMP Site Annual Environmental Report.

The results of the environmental monitoring program for OU-4 are summarized in Subsection 9.6.1.

There is no appreciable external dose rate from the material within Silo 3.

9.6.3 Normal Operations for Segment O

The pilot plant vitrification facility has not been constructed. There are no operational data available on which to base the analysis of normal operations. The operational safety-related requirements for the pilot plant are summarized here. An assessment of expected releases has been made using available information. The confirmation of the assessment of the design will be finalized following further tests of the charcoal effectiveness to adsorb radon on a large, active flow-through system. In addition, the pilot plant is intended to assist in collecting data to determine the potential source terms and hazards associated with vitrification of the wastes within OU-4. These data will be used in the design of the full scale remediation facility in compliance with all rules, regulations, and standards.

The uncertainty associated with the system meeting the requirements for normal operations is acceptable because appropriate controls will be in place to monitor releases from the vitrification process and the existing environmental monitoring will account for radon at the site boundary as a requirement for the FEMP site and not just the vitrification pilot plant.

9.6.3.1 Air Discharges

The exhaust air from the upgraded RTS and the off-gas from the proposed vitrification facility represent the only two contaminated airborne effluent discharges that will be generated during normal vitrification pilot plant operations. The RTS exhaust air will consist predominantly of Rn-222, whereas the vitrification facility melter off-gas will contain Rn-222 and other uranium and thorium decay chain radioisotopes as well as other off-gases. Section 2 and 3 of this PSAR identify the requirements that will be incorporated into the design bases of the OU-4 pilot plant.

The radon emissions from the pilot plant shall be controlled such that:

1) The average Rn-222 concentration for ambient air in an unrestricted area does not exceed 3 pCi/l above background (DOE Order 5400.5.IV.6.b.[2]).

2) The annual average Rn-222 concentration for ambient air in a restricted area does not exceed 30 pCi/l above background (DOE Order 5400.5.IV.6.b.[2]).

3) The maximum Rn-222 concentration for ambient air in a restricted area does not exceed 100 pCi/l above background (DOE Order 5400.5.IV.6.b.[2]).

4) The average Rn-222 release rate does not exceed 20 pCi/m^2/sec (applicable to fugitive releases only; see DOE Order 5400.5.IV.6.b.[2]).

Air dispersion modeling was conducted to establish radionuclide discharge limitations at each point source of normal operations. A summary of this modeling is below

<u>Radon Release from Off-Gas Treatment System</u>

The release of radon from Segment O normal operations are assessed. There is no worker exposure to radon gas in the pilot plant under expected conditions except for background and any nominal releases from the vitrified product. This will be confirmed as the project is operated through radon monitoring. Any vitrified product which is off-spec as a result of excessive radon release will be removed from the pilot plant.

The assessment of radon releases through the stack in Segment O was made with the following assumptions:

1) Stack height will be 12 feet above any building within 500 feet. Since the silos are likely to be within 500 feet of the vitrification pilot plant process building the assumed stack height for

modeling will be 36 feet (silos' height) and an additional 12 feet (minimum). Therefore, a mean stack height of 15 meters is used in the PSAR and will be revised in the FSAR.

2) The distance to the fence line depends on the sector. The concentration will be calculated in concentric rings at various distances to estimate the concentration in all 16 sectors.

3) Emissions estimates from the Off-gas Treatment system are based on processing 10 tons of Silo 3 material and 20 tons of Silo 2 material. The annual average concentration will be calculated since the acceptance criteria are based solely on the annual average concentration.

4) The sluicing operation at Silo 2 will be done using "bag-in, bag-out" methods which will maintain the silo in a sealed condition.

5) The annual average radon concentration at the site boundary is limited to 3 pCi/l above background per the Pilot Plant Program ARARs. All pilot plant operations will be limited to an annual average impact on the radon concentration of 2.0 pCi/l to account for other sources of radon.

6) For ease of calculational purposes and summing the impacts from the various sources of radon associated with the Pilot Plant Program, all sources will be treated as a point source from the same location at a distance of 330 meters from the nearest site boundary. This is reasonably conservative since the Pilot Plant will be located further from the boundary than the 330 meters.

7) Emissions from Silo 1, 2, and 3 may increase during the material removal process due to breaching the bentonite cap. Overall annual emission from the silos will be less than previous years emissions prior to bentonite addition. Bentonite cover in Silos 1 and 2 will be repaired as necessary, following the material removal.

8) The radon concentration off-site will be evaluated as the highest concentration which is at a distance greater than the nearest site boundary. This is without regard to the sector in which the maximum occurs. This is reasonable and conservative given the uncertainties associated with long term dispersion modeling.

The US EPA computer program Industrial Source Complex Dispersion Model Version 2 (ISC2) was used in the long term mode (ISCLT2). The meteorological data from the 4 year STability ARray (STAR) format which has been used in the annual NESHAPs compliance reports was used. Other data required by ISCLT2, were selected as regulatory default values in the code.

The emission estimates are as follows: off-gas emissions of 10 tons of Silo 3 material (surge bin limit) at 3.87E3 pCi/g of Rn-222 assumed equilibrium with Ra-226, 23 tons of Silo 2 material (based on furnace capacity of 1 metric ton per day, 10 tons Silo 3 material and no additive feed) at 4.77E5 pCi/g Rn-222 assumed equilibrium with Ra-226, and additional radon emissions from Silo 2. The total radon emissions are then 7.0E6 pCi/s on an annual average basis or approximately 8.4E6 pCi/s for the 30 days of the pilot plant program duration.

Based on the modeling results of the ISCLT2 computer program, the maximum radon concentration off-site is expected to be 48 pCi/m^3 or 0.048 pCi/l. Based on this assessment, the radon removal portion of off-gas treatment are not essential to satisfy the ARARs. Thus, there is no specification for the effectiveness of the radon removal systems. It will be designed using Best Available Technology (BAT) for ALARA purposes and used to collect data for the design of the large scale remediation facility.

Radioactive Particulate Release

Radionuclide emissions from the OU-4 pilot plant, excluding radon and decay progeny, shall be controlled to ensure that the maximally exposed individual (MEI) member of the public does not receive a total effective dose equivalent in excess of 10 mrem/yr for the airborne pathway in accordance with 40 CFR 61, Subpart H requirements (radionuclide NESHAP for DOE facilities). In addition, the exposure to MEI members of the public, as a consequence of the OU-4 pilot plant activities, shall not exceed 100 mrem/yr for all exposure pathways (DOE Order 5400.5.II.1a).

The only activities which may release particulates to the environment under normal operating conditions are the transfer of Silo 3 material from Silo 3 to the surge bin and its subsequent transfer to the slurry tanks. Since 48.8 percent of Silo 3 material is less than 1 micron in size, the material is transferred pneumatically through a filter/receiver. The filter/receiver exhaust air is filtered through a HEPA filter and exits through a stack.

The carryover fraction and the HEPA filter efficiency for the fine particles in Silo 3 are not well known. This assessment determines the maximum release of particulate material allowed to maintain normal operations off-site doses to acceptable levels. In order to assure that the actual release is less than calculated allowed release, pre-operational tests must be performed to verify the filter/receiver and HEPA filter performance.

There is no worker exposure to Silo 3 material due to the elevated release

The assessment in developing the maximum release of Silo 3 material allowed and the performance requirements for the HEPA filter and filter/receiver are as follows

Assumptions

1) Stack height will be 12 feet above any building within 500 feet. Since the silos are likely to be within 500 feet of the vitrification pilot plant process building the assumed stack height for modeling will be 36 feet (silos' height) and an additional 12 feet (minimum). Therefore, a mean stack height of 15 meters is used in the PSAR and will be revised in the FSAR.

2) The distance to the fence line depends on the sector. The concentration will be calculated in concentric rings at various distances to estimate the concentration in all 16 sectors.

3) Emissions estimates are based on processing 10 tons of Silo 3 material through the 2 transfer operations. The annual average concentration and CEDE will be calculated since the acceptance criteria are based solely on the annual average concentration.

4) The sources is treated as a point source at a distance of 330 meters from the nearest site boundary. This is reasonably conservative since the Pilot Plant will be located further from the boundary than the 330 meters.

5) The concentration off-site will be evaluated as the highest concentration which is at a greater distance than the nearest site boundary. This is without regard to the sector in which the maximum occurs. This is reasonable and conservative given the uncertainties associated with long term dispersion modeling.

6) The conservative assumptions used to calculate the release rate allowed from the Pilot Plant accounts for the uncertainty associated with applying the long term dispersion model to a one month release.

The modeling was done using the same code and parameters as for radon except for the source term. ISCLT2 was run based on the STAR data file to develop the long term dispersion factors. The minimum long term dispersion factor for any sector at a distance of 330 meters was used to back calculate the allowed Silo 3 material release based on an acceptable annual dose of 0.1 mrem/yr through the inhalation pathway. This is based on one percent of the allowable air pathway exposure to the pilot plant project. The calculation was performed in this manner to develop performance criteria for the filter/receiver and HEPA filter.

Based on the modeling results of the ISCLT2 computer program, the minimum dilution factor is 7E-6 off-site. This dilution factor is more than twice the dilution factor in the direction of the nearest site boundary (3E-6 at 330 meters). Based on the minimum dilution factor, the 0.1 mrem dose limit, and the concentration of radionuclides in Silo 3 material as listed in Table 8-1 the removal efficiency required

of the HEPA and filter/receiver combined must be 99.98 percent for the Silo 3 material. This is to be confirmed by benchscale or pre-operational testing prior to use of those systems to transfer Silo 3 materials and release to the atmosphere.

The allowed emissions in the effluent from the Silo 3 material transfer system to the stack is listed in Table 9-6.

Table 9-6 Effluent Release Limits for Silo 3 Material

Radionuclides	Project Release Limit, pCi
Ac-227	1.2E6
Pb-210	7.5E6
Ra-226	6.1E6
Ra-228	6.4E5
Th-228	1.4E6
Th-230	9.6E7
Th-232	1.3E6
U-234	3.1E6
U-235/6	1.9E5
U-238	2.8E6

9.6.3.2 Process Wastewater Discharges

Excess process wastewater generated during the treatability study of OU-4 will be transferred to on-site treatment facilities prior to discharge to the Great Miami River. This wastewater discharge is regulated under the Federal Clean Water Act and the State of Ohio Water Pollution Control Act. The process effluent wastewater from the OU-4 pilot plant will be sampled, monitored, and treated if required, to meet any influent wastewater limits imposed by the Advanced Wastewater Treatment (AWWT) Facility. All process wastewater will then be treated by the AWWT to ensure that the discharge is within the pre-established limits imposed by the National Pollutant Discharge Elimination System permit, 40 CFR 125, 40 CFR 136, 10 CFR 20.1302(b), OAC 3745-01, OAC 3745-33-04, and DOE Order 5400.5.

9.6.3.3 Stormwater Discharges

Appropriate controls will be implemented during construction of the OU-4 pilot plant to minimize contamination of stormwater runoff in accordance with 40 CFR 122 and OAC 3745.38. The stormwater runoff which has the potential to become contaminated with hazardous substances will be segregated, retained, and transferred to the sitewide contaminated stormwater control system for treatment. All stormwater discharges will comply with the requirements established in 40 CFR 122, OAC 3745-01-07, and OAC 3745-33-04. The stormwater runoff which does not have the potential to become contaminated with hazardous substances will be segregated and discharged directly to the Bio-Surge Lagoon. Soil erosion controls will be provided as required.

The drainage systems will be sized to handle the peak flows and runoff volumes from a 25-year storm event. Drainage and erosion controls shall be in place during the construction period.

9.6.3.4 Occupational Radiation Exposure

Areas that are normally occupied are designed to have dose rates of less than 0.25 mrem/hr by shielding the sources of gamma emitting radionuclides. Activities in these areas are assumed to be free from restrictions. The two normal activities leading to significant exposures to workers are vitrified drummed material movement (K-65 material) and sampling activities.

The external dose from these two activities are summarized below:

Vitrified Material Movement to Temporary Storage

The dose rate from the Silo 3 material is not a concern. The dose rate from the K-65 material is a real exposure hazard.

The analysis is based on the following:

1) Nine drums in casks with 1-inch lead shielding in the furnace area

2) Six full drums removed every other day

3) Five minutes per drum for swiping and capping

4) The cask covers will not be placed on the lid

5) The forklift operator is 9 feet, 4 inches from the source when loading empty containers and 3 feet, 6 inches from the source when loading full containers

6) A total of 90 drums (1 per shift, 3 shifts per day)

7) Six drums loaded by forklift operator every other day

8) Five minutes per empty drum to load onto the roller conveyor

9) Ten minutes to load a full drum onto a truck

10) Fifteen minutes to deliver six drums to storage

The following man-rem doses were calculated:

1) Worker swiping cask and capping drum: 0.150 man-rem
2) Forklift operator loading empty casks: 0.025 man-rem
3) Forklift operator loading full casks: 0.039 man-rem
4) Truck driver (based on two casks at the front of the truck): 0.020 man-rem

The dose to the maximally exposed individual will be controlled through a radiation work permit, personal monitoring and administrative controls such as ALARA analysis to maintain exposures less than the requirements specified in Section 3. Section 11 identifies the shielding requirements if the furnace area is changed to a continuous occupancy area.

There has been experience in the handling of drums of non-vitrified K-65 residues during past operations. Although these operations are not directly applicable to this current operation they are similar enough to be included for a comparison of the potential actual exposure to workers as a result of drum handling of K-65 material. The activities associated with the vitrified drum handling have similar activities except for the drum sealing activities prior to actual drum movement.

The following summarizes a National Lead Company of Ohio internal correspondence concerning the K-65 Shipment from LOSA (Ref. 9.12).

Truckload 1

The following data was obtained during the unloading and handling of a carload of LOSA K-65 on Thursday, September 11, 1952. The individual radiation exposures are based on the handling of one half carload (48 drums) by truck.

Radiation Data

mr/hr - contact with drumtops: High, 460; Low, 340; Ave, 405
mr/hr - contact with drumsides: High, 480; Low, 330; Ave, 436.7

Exposure Data (48 drums)

Fork Operator, unloading car (time 60 min.)

a) Dosimeter #1 - after 16 drums: 10 mr
32 drums: 24 mr
48 drums: 58 mr

b) Dosimeter #2 - after 16 drums: 10 mr
32 drums: 24 mr
48 drums: 58 mr

Total exposure for 48 drums: 58 mr

Fork Operator, Unloading truck (time 15 min.)

a) Dosimeter #1 - 5 mr
b) Dosimeter #2 - 6 mr

Radiation Reading in cab of truck, 48 drum load

High 44.5 mr/hr; low, 41.5 mr/hr; ave., 43.0 mr/hr

The following summarizes a National Lead Company of Ohio document concerning the K-65 Shipment from LOSA (Ref. 9.13).

Truckload 2

The following data was obtained during the unloading and handling of a carload of LOSA K-65 on Monday, September 15, 1952. The individual radiation exposures are based on the handling of one half carload (48 drums) by truck.

Radiation Data

mr/hr - contact with drumtops: High, 580; Low, 450; Ave, 506.7
mr/hr - contact with drumsides: High, 470; Low, 380; Ave, 428.4

Exposure Data (48 drums)

Fork Operator, unloading car (time 60 min.)

a) Dosimeter #1 - after 16 drums: 9 mr
32 drums: 26 mr
48 drums: 40 mr

b) Dosimeter #2 - after 16 drums: 7 mr
32 drums: 26 mr
48 drums: 38 mr

Total exposure for 48 drums: 58 mr

Checker

a) Dosimeter #1 - after 16 drums: 10 mr
32 drums: 32 mr
48 drums: 46 mr

b) Dosimeter #2 - after 16 drums: 14 mr
32 drums: 38 mr
48 drums: 48 mr

Fork Operator, Unloading truck (time 30 min.)

a) Dosimeter #1 - 10 mr

b) Dosimeter #2 - 10 mr

Radiation Reading in cab of truck, 47 mr/hr

The comparison of the predicted dose from vitrified material to the recorded doses in handling a shipment of drummed K-65 residues, would indicate that the PSAR estimate is likely to be conservative.

Sampling

The sample of material from the slurry tanks is taken behind a shield wall. The sample is drawn in an area with dose rate of 1.6 mrem/hr. It will take approximately 20 minutes to draw one sample and one sample per shift must be drawn. Two people are required to take the sample assuming the "buddy system" is in place. Sampling activities result in a total exposure of 0.08 man-rem.

Due to the short duration of the project (1 month) there is no assessment of doses due to maintenance or repairs. These activities are not considered to be likely during the 1 month of operations. However, if repairs and maintenance are required, provisions are in the design to allow the transfer of material from

the process vessels to allow access to the components with the radioactive source term removed. This will greatly reduce any external radiation present during maintenance and repair activities.

9.6.3.5 Occupational Chemical Exposure

The chemicals that are in the residues will be contained in the process equipment thereby preventing worker exposure. Worker protection from the feed chemicals will be provided as discussed in Section 12.

9.7 Summary and Conclusions

Risk is the combination of two components in an accident analysis. The first component is the frequency of an event occurring, expressed in events per year. The second component is the consequence of the event. This is expressed in 50-year lifetime CEDE (mrem) for radiological hazards, and as mg/m^3 of a substance or chemical hazards. Risk involves the relationship (sometimes as a product of the two) between frequency and consequence. In this analysis, both components are plotted separately on a risk acceptance curve to determine the acceptability of the risk. Figures 9-2 and 9-3 present a comparison of the radiological risks associated with Segments M, N, and O to the Evaluation Guidelines specified by proposed DOE-STD-3005-YR .

Table 9-7 summarizes the radiological consequences for both on-site and off-site recipients. Tables 9-8 and 9-9 show the toxicological consequences of accidents associated with Segments N and O. There are no toxicological consequences identified for Segment M due to the bentonite layer emplacement. The only consequences from Segment M are radiological due to the radon release.

Proposed DOE-STD-3005-YR states that off-site toxicological consequences should be compared to the ERPG-2 concentrations and the on-site concentrations should be compared to ERPG-3 levels. However, if these values have not been determined then the IDLH levels should be used or other appropriate values. For the purposes of this SAR, Evaluation Guidelines (EGs) were taken from the "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for DOE Facilities " by Westinghouse Savannah River Company (WSRC) (Ref. 9.14) and the NIOSH "Pocket Guide to Chemical Hazards." The following rationale was used to determine the EGs shown in Tables 9-8 and 9-9:

1) The chemicals that are included in the analysis were first compared to Table 6 of the WSRC report.

2) If an ERPG-2 value was shown it was used as the EG for off-site and if an ERPG-3 value was shown it was used as the EG for on-site.

3) If no values were found in the WSRC report the NIOSH Pocket Guide was used to determine the IDLH for an on-site EG or 10% of the IDLH for the off-site EG

4) If an IDLH level was not included in the NIOSH Pocket Guide, then the Time Weighted Average (TWA) was used as the EG. It is not necessarily appropriate to compare the acute concentrations from an accident to the TWA, however, it is conservative and for the accident sequences evaluated in this SAR the chemical concentrations are below this very conservative EG. Therefore, it was not necessary to develop a more appropriate, i.e., higher concentration, as an EG for those chemicals that do not have an ERPG or IDLH.

The risks are acceptable when compared to criteria for risk acceptance from proposed DOE-STD-3005-YR and WSRC-MS-92-206, Rev. 1.

1 RTS Failure
2 Seg. M (Silos 1 and 2) Natural Degradation
3 Seg. N (Silo 3) Natural Degradation
4 Loss of Containment (Surge Bin)
5 Loss of Containment (Thickener)
6 Seg. M (Silos 1 and 2) Snow
7 Seg. M (Silos 1 and 2) EBA Earthquake
8 Seg. M (Silos 1 and 2) Tornado (Severe)
9 Seg. M (Silos 1 and 2) Earthquake (Severe)
10 Seg. N (Silo 3) Snow
11 Seg. N (Silo 3) EBA Earthquake
12 Seg. N (Silo 3) Tornado (Severe)
13 Seg. O (Pilot Plant) Earthquake
14 Seg. O (Pilot Plant) Off-Gas System Failure

Figure 9-2 - Risk Acceptance Curve for Off-Site Consequences

1 RTS Failure
2 Seg. M (Silos 1 and 2) Natural Degradation
3 Seg. N (Silo 3) Natural Degradation
4 Loss of Containment (Surge Bin)
5 Loss of Containment (Thickener)
6 Seg. M (Silos 1 and 2) Snow
7 Seg. M (Silos 1 and 2) EBA Earthquake
8 Seg. M (Silos 1 and 2) Tornado (Severe)
9 Seg. M (Silos 1 and 2) Earthquake (Severe)
10 Seg. N (Silo 3) Snow
11 Seg. N (Silo 3) EBA Earthquake
12 Seg. N (Silo 3) Tornado (Severe)
13 Seg. O (Pilot Plant) Earthquake
14 Seg. O (Pilot Plant) Off-Gas System Failure

Figure 9-3 - Risk Acceptance Curve for On-Site Consequences

Table 9-7 Radiological Accident Consequences

		Radiological Dose (mrem)	
Accident	**Frequency/yr**	**On-site**	**Off-site**
Silos 1 and 2 - RTS Failure	2.3E-04	8.4E+02	1.0E+02
Silo 1 and 2 - Natural Degradation	3.9E-02	8.4E+02	1.0E+02
Silo 3 - Natural Degradation	5.0E-05	2.7E+03	3.2E+02
Pilot Plant - Loss of Containment (Surge bin)	2.3E-04	6.9E+02	5.4E+01
Pilot Plant - Loss of Containment (Thickener)	2.3E-04	9.6E+01	7.4E+00
Silo 1 and 2 - Snow	2.0E-02	8.4E+02	1.0E+02
Silo 1 and 2 - EBA Earthquake	8.0E-04	8.4E+02	1.0E+02
Silo 1 and 2 - Tornado (Severe)	6.6E-04	4.0E-1	1.8E-2
Silo 1 and 2 - Earthquake (Severe)	8.0E-04	8.4E+02	1.0E+02
Silo 3 - Snow	5.7E-03	2.7E+03	3.2E+02
Silo 3 - EBA Earthquake	8.0E-04	2.7E+03	3.2E+02
Silo 3 - Tornado (Severe)	6.6E-04	1.3E+01	5.8E-1
Pilot Plant - Earthquake	8.0E-04	1.8E+03	1.4E+02
Pilot Plant - Off-gas System Failure	2.3E-04	1.1E+03	8.1E+01

Table 9-8 Toxicological Consequences of Silo 3 (Segment "N") Accidents (mg/m^3)

Chemical	Receptor Location	Natural Degradation	Snow	EBA Earthquake	Tornado (Severe)	Evaluation Guidelines (mg/m^3)	EG Source
		Frequency/yr					
		5E-05	5.71E-03	8E-04	6.6E-04		
Aluminum	On-site	0.80	0.80	0.80	3.8E-3	25	WSRC
	Off-site	9.7E-2	9.7E-2	9.7E-2	1.7E-4	15	WSRC
Arsenic	On-site	0.13	0.13	0.13	6.2E-4	100	IDLH
	Off-site	1.6E-2	1.6E-2	1.6E-2	2.8E-5	10	0.1 IDLH
Barium	On-site	1.1E-2	1.1E-2	1.1E-2	5.5E-5	1100	IDLH
	Off-site	1.3E-3	1.3E-3	1.3E-3	2.3E-6	110	0.1 IDLH
Beryllium	On-site	1.2E-3	1.2E-3	1.2E-3	5.6E-6	100	WSRC
	Off-site	1.5E-4	1.5E-4	1.5E-4	2.6E-7	25	WSRC
Cobalt	On-site	0.12	0.12	0.12	5.6E-4	20	IDLH
	Off-site	1.4E-2	1.4E-2	1.4E-2	2.6E-5	2	0.1 IDLH
Copper	On-site	0.14	0.14	0.14	6.5E-4	1	TWA
	Off-site	1.7E-2	1.7E-2	1.7E-2	3.0E-5	1	TWA
Iron	On-site	2.2	2.2	2.2	1.0E-2	5	TWA
	Off-site	0.26	0.26	0.26	4.7E-4	5	TWA
Lead	On-site	9.9E-2	9.9E-2	9.9E-2	4.7E-4	700	IDLH
	Off-site	1.2E-2	1.2E-2	1.2E-2	2.1E-5	70	0.1 IDLH
Magnesium	On-site	2.9	2.9	2.9	1.4E-2	10	TWA
	Off-site	0.35	0.35	0.35	6.2E-4	10	TWA
Nickel	On-site	0.18	0.18	0.18	8.4E-4	1	TWA
	Off-site	2.2E-2	2.2E-2	2.2E-2	3.8E-5	1	TWA
Vanadium	On-site	0.15	0.15	0.15	6.8E-4	70	IDLH
	Off-site	1.8E-2	1.8E-2	1.8E-2	3.1E-5	7	0.1 IDLH

WSRC-Table 6 of Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities. WSRC-MS-92-206, Rev. 1
IDLH-Immediately Dangerous to Life and Health from "NIOSH Pocket Guide to Chemical Hazards"
TWA-Time Weighted Average from "NIOSH Pocket Guide to Chemical Hazards"

Table 9-9 Toxicological Consequences of Pilot Plant (Segment "O") Accidents (mg/m³)

Chemical	Receptor Location	Loss of Containment (surge bin)	Loss of Containment (thickener)	Earthquake (Severe)	Evaluation Guideline (EG)	EG Source
		Frequency/yr				
		2.3E-04	**2.3E-04**	**8.0E-04**		
Tributyl Phosphate	On-site	N/A	3.9E-05	3.9E-05	2.5	TWA
	Off-site	N/A	3.0E-06	3.0E-06	2.5	TWA
Aluminum	On-site	0.21	7.2E-04	0.21	25	WSRC
	Off-site	1.6E-02	5.6E-05	1.6E-2	15	WSRC
Arsenic	On-site	3.4E-02	3.6E-04	3.5E-2	100	IDLH
	Off-site	2.6E-03	2.8E-05	2.7E-3	10	0.1 IDLH
Barium	On-site	2.8E-03	6.3E-03	9.0E-3	1100	IDLH
	Off-site	2.1E-04	4.8E-04	7.0E-4	110	0.1 IDLH
Beryllium	On-site	3.1E-04	9.2E-07	3.1E-4	100	WSRC
	Off-site	2.4E-05	7.1E-08	2.4E-5	25	WSRC
Cobalt	On-site	3.1E-02	1.0E-03	3.2E-2	20	IDLH
	Off-site	2.4E-03	7.7E-05	2.5E-3	2	0.1 IDLH
Copper	On-site	3.6E-02	2.5E-04	3.6E-2	1	TWA
	Off-site	2.8E-03	1.9E-05	2.8E-3	1	TWA
Iron	On-site	0.56	1.1E-02	0.57	5	TWA
	Off-site	4.3E-02	8.4E-04	4.4E-2	5	TWA
Lead	On-site	2.6E-02	1.1E-01	0.14	700	IDLH
	Off-site	2.0E-03	8.1E-03	1.0E-2	70	0.1 IDLH
Magnesium	On-site	0.74	2.1E-03	0.74	10	TWA
	Off-site	5.7E-02	1.7E-04	5.7E-2	10	TWA
Nickel	On-site	4.6E-02	1.0E-03	4.7E-2	1	TWA
	Off-site	3.6E-03	7.7E-05	3.6E-3	1	TWA
Vanadium	On-site	3.8E-02	1.2E-04	3.8E-2	70	IDLH
	Off-site	2.9E-03	9.5E-06	2.9E-3	7	0.1 IDLH

WSRC-Table 6 of Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities. WSRC-MS-92-206, Rev. 1
IDLH-Immediately Dangerous to Life and Health from "NIOSH Pocket Guide to Chemical Hazards"
TWA-Time Weighted Average from "NIOSH Pocket Guide to Chemical Hazards"

9.8 References

9.1) Westinghouse Hanford Company, Feb. 1993. *Graded Approach to Safety Analysis Reports.* WHC-SP-0960, Rev. 1.

9.2) United States Environmental Protection Agency, 1933. "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion." EPA-520/1-88-020. Federal Guide No. 11.

9.3) United States Department of Energy, 1989. "A Manual for Implementing Residual Radioactive Material Guidelines." ANL/ES-160.

9.4) United States Department of Energy, February 1990. DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

9.5) Los Alamos National Laboratory, 1986. "A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities." LA-10294-MS.

9.6) United States Department of Energy, 1994. DOE-STD-3005-YR (Draft). "Evaluation Guidelines for Accident Analysis and Safety Structures, Systems and Components."

9.7) Dexter, Arthur H., and William C. Perkins, July 1982. *Component Failure-Rate Data with Potential Applicability to a Nuclear Fuel Reprocessing Plant.* DP-1633. E.I du Pont de Nemours and Company. Aiken, S. Carolina: Savannah River Laboratory.

9.8) University of Cincinnati, 1990. "A Probabilistic Risk Assessment for the K-65 Silos at the FMPC." FMPC/SUB-02A. UC-702.

9.9) PARSONS, 1991. *Silos 1 and 2 Facility Safety Analysis Report*, Rev. 2. Fairfield, OH.

9.10) University of California Research Laboratory, June, 1990. *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards.* R.P. Kennedy, Lawrence Livermore National Laboratory UCRL-15910.

9.11) United States Department of Energy, 1993. *Remedial Investigation Report for Operable Unit 4*, Volumes 1 through 3. Fernald Field Office.

9.12) National Lead Company of Ohio, September 1952. "K-65 Shipment from LOSA," Internal Memorandum. C.E. Schumann to R.C. Heatherton.

9.13) National Lead Company of Ohio, September 15, 1952. "K-65 Shipment from LOSA - GTW 595262," Internal Memorandum. C.E. Schumann to R.C. Heatherton.

9.14) Craig, D.K., J.S. Davis, L.G. Lee, P.J. Lein, and P. Hoffman, April 1993. *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines For Use in DOE Facilities.* WSRC-MS-92-206, Rev. 1.

SECTION 10

INADVERTENT CRITICALITY PROTECTION

The contents of the silos are residues from processing uranium ores and ore concentrates. These ores and concentrates are natural uranium 0.711 percent fissile material (U-235). The uranium concentration (0.9 lbs/ft^3 for K-65, 0.16 lb/ft^3 for Silo 3) is below the concentration of uranium (approximately 158 lb/ft^3) in ore. The silo concentration of uranium is less than that required to achieve criticality since it is below the safe density and concentration limits for all Group IV (homogeneous uranium solutions) enrichments (Ref. 10.1).

The uranium concentration in the K-65 Silo material goes through various changes during the vitrification process. Water is added (20 weight percent solids) during slurry transport and removed to 50 weight percent solids in the thickener. Additives are added in the slurry feed tanks and the material is slurried (80 weight percent solids) to the furnace. The furnace essentially removes all the water. The addition of water increases the volume, thereby, reducing the uranium concentration below 0.9 lb/ft^3. The vitrified glass has a density of 2.6 g/cm^3. Considering the original density of K-65 material to be 2.2 g/cm^3, the final uranium concentration in the melter and in the glass would be 1.06 lb/ft^3 (0.9 x 2.6/ 2.2). The concentration of uranium in all steps of the vitrification process is below the safe concentration limits for all Group IV enrichments.

10.1 References

10.1) Fernald Environmental Restoration Management Corporation, 1993. *FEMP Nuclear Criticality Safety Guide*. FEMP-2304.

SECTION 11

RADIATION PROTECTION

This section addresses the project-specific requirements delineated in Attachment 1, Item 9 of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 11.1). Section 11 of the SSARR (Ref. 11.2) addresses site-specific requirements. All subsections of Section 11 of the SSARR apply to the OU-4 Pilot Plant Program except those concerned with nuclear criticality control.

11.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the Standards/ Requirements Identification Document (S/RID) for radiological protection. This S/RID identifies the occupational radiological protection requirements for the FEMP per the FERMCO contract with the DOE; applicable Federal, state, and local laws; DOE Orders; and DOE guidance documents. The principal requirements are identified in the DOE *Radiological Control Manual* which provides the basis for the FEMP radiological protection program and DOE Order 5480.11, "Radiation Protection for Occupational Workers." The FERMCO *Comprehensive Environmental Occupational Safety and Health Program (CEOSHP) Manual* describes the radiological protection program at the FEMP and includes the site Radiological Control Manual as Section 3.

11.2 Policy and Program

ALARA and radiological protection considerations are incorporated into the Vitrification Pilot Plant design, RTS upgrade, and existing facilities at OU-4. Table 8-3 of this document lists the sources of external and internal exposure in OU-4. The hazards associated with the radiological sources are identified in Tables 8-6, 8-8, and 8-11. The accident sequences and their associated consequences can be found in Section 9 of this document. Section 6 of this document describes the engineered features used to control internal and external doses. Section 6 of this document, "Facility Description and Operation," describes the engineered features used to control internal and external dose. The radiation protection features are summarized in Table 11-1. Permanent shielding requirements are identified in Table 11-2. The need for temporary shielding is based on personnel access requirements and the radiation source.

11.3 References

11.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

11.2) PARSONS, November 1993. *Site Safety Analysis Reference Report*, Rev. B.

Table 11-1 - Radiation Protection Features

Feature	Location	Result
Automatic Material Handling	Silo Material Removal and Transfer All Vitrification Subsystems Product Forming	Minimize Exposure Time Maximize Source Distance
Radon Treatment Systems	Silos Vitrification Storage and Transfer Tanks Vitrification Furnace Product Forming	Minimize Exposure Levels Control Contamination
Shielding	See Table 11-2	Minimize Exposure Levels
Secondary (to process) Containments	Double-Walled Slurry Transfer Piping Pre-Fabricated Vitrification Building Containment Dikes for Storage Tanks**	Control Contamination
Admin. Controls: Radiation Work Permits* Bag In/Bag Out Procedure Radiation Surveys Decontamination Monitoring Project-Specific Health and Safety Plan	Silos Vitrification Subsystems Product Forming Product Handling	Minimize Exposure Time Maximize Source Distance Maximize Shielding Control Contamination

* Protective clothing and respirator requirements are identified in Radiation Work Permits.

** The dikes are sized to hold 100 percent of the largest tank. In addition, tanks external to the process building will hold 100 percent of the largest tank plus precipitation resulting from the 25-year, 24-hour storm event.

Table 11-2 - Shielding Requirements

Component/Location	Type	Amount
Off-Gas Carbon Beds	Concrete	12" - North wall 12" - West wall 12" - South wall 12" - East wall
Thickener	Concrete	12" - North wall 12" - West wall (with the exception of the southern part of the west wall to be 18") 12" - South wall 12" - East wall
Slurry Tanks	Concrete	18" - North wall 18" - West wall 18" - South wall 18" - East wall
Furnace Area	Concrete	None - North wall 18" - West wall None - South wall 12" - East wall
Spare Storage Tank	Temporary	As required by calculations
Silo 3 Surge Bin	None	
Recycle Tank	None	

Notes:

1) Tanks are shielded to at least the height of the top of the tank. Shielding around the thickener is high enough to protect workers from direct radiation from surrounding sources.

2) Figure 11-1 identifies radiation occupancy zones.

fullplan.m(5591.ws499) po85@ws499. Fri Apr 8 15:43:02 EDT 1994

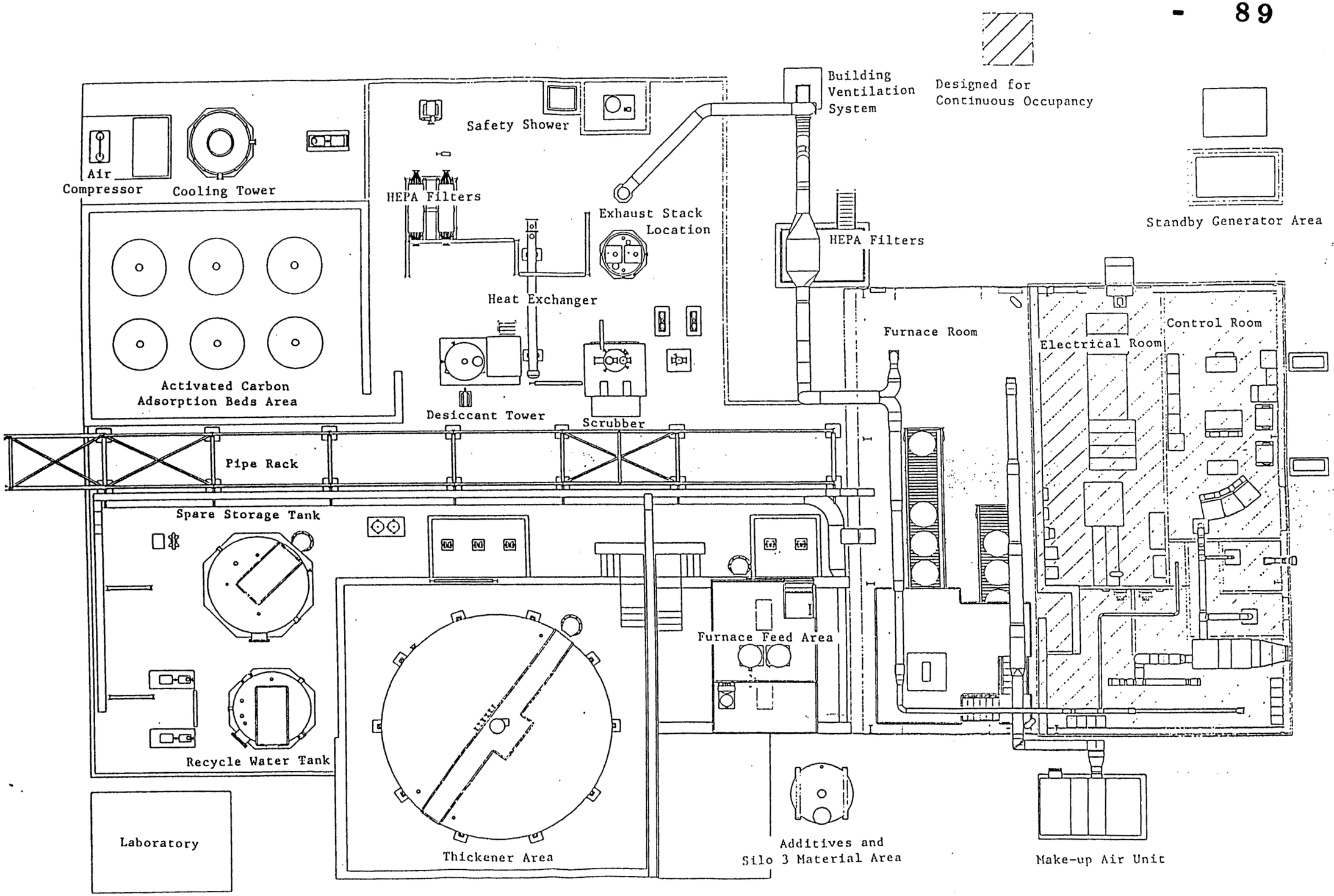


Figure 11-1 - Radiation Occupancy Zones

SECTION 12

HAZARDOUS MATERIAL PROTECTION

This section addresses the project-specific requirements delineated in Attachment 1, Item 10 of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 12.1). Section 12 of the SSARR (Ref. 12.2) addresses site-specific requirements. All subsections of Section 12 of the SSARR apply to the OU-4 Pilot Plant Program. The ARARs in the project DCP have identified the hazardous materials of the silos to be RCRA-like. The hazardous material protection program identified below is adequate for RCRA-like materials.

12.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RID for Occupational Safety and Health. This S/RID identifies the protection requirements for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents. The *Comprehensive Environmental Occupational Safety and Health Program* (CEOSHP) provides the basis for FERMCO's hazardous material protection program.

The criteria for hazardous material protection are specified in 29 Code of Federal Regulations (CFR) 1910.120 and 29 CFR 1910.1200. DOE Order 3790.1B, "Federal Employee Occupational Safety and Health Program," mandates that facilities comply with criteria for protection from standard industrial hazards as specified in 29 CFR 1910 and 29 CFR 1926. Compliance with these requirements is addressed in the FERMCO *CEOSHP Manual*. The glossary of the SSARR defines standard industrial hazards.

12.2 Chemical ALARA Policy and Program

Chemical ALARA and hazardous material protection considerations are incorporated into the OU-4 Pilot Plant Program. The chemical contents of the silos are shown in Tables 8-2 and 8-3 of this document. The hazards associated with the chemical sources are identified in Tables 8-6, 8-8, and 8-11 of this document. The accident sequences and their associated consequences can be found in Section 9 of this document. Section 6 of this document describes the engineered features used to control internal and external dosages. The hazardous material protection features are summarized in Table 12-1.

Table 12-1 - Hazardous Material Protection Features

Feature	Location	Result
Automatic Material Handling	Silo Material Removal and Transfer All Vitrification Subsystems	Minimize Exposure Time
Secondary (to process) Containments	Product Forming Double-Walled Slurry Transfer Piping Pre-Fabricated Vitrification Building Containment Dikes for Storage Tanks**	Control Contamination
Admin. Controls: Hazardous Material Work Permits Bag In/Bag Out Procedure Decontamination Project-Specific Health and Safety Plan	Silos Vitrification Subsystems Product Forming Product Handling	Minimize Exposure Time Control Contamination

* Protective clothing and respirator requirements are identified in Hazardous Material Work Permits.

** Tanks are shielded to at least the height of the top of the tank. Shielding around the thickener is high enough to protect workers from direct radiation from surrounding sources.

12.3 References

12.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

12.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

SECTION 13

RADIOACTIVE AND HAZARDOUS MATERIAL WASTE MANAGEMENT

This section addresses the Pilot Plant Program requirements of Attachment 1, Item 7, of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 13.1).

13.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RIDs for Packaging and Transportation and for Environmental Restoration and Waste Management. The Packaging and Transportation S/RID (No.12) identifies the packaging and the administration and monitoring requirements of on-site/off-site transportation of hazardous and radioactive materials and waste for the FEMP per the FERMCO contract with the DOE; applicable Federal, State, and local laws; DOE Orders; and DOE guidance documents. The Environmental Restoration and Waste Management S/RID (No.17) identifies the requirements for the elements and programmatic controls necessary to manage hazardous, radioactive, and solid waste compliance at the FEMP.

13.2 Waste Forms and Quantities

The following three major waste forms will be generated as the result of the Pilot Plant Program:

1) Vitrified waste (approximately 30 metric tons)
2) Gaseous and particulate effluent (Drawing No. 94X-5900-F-00280)
3) Liquid effluent (Drawing No. 94X-5900-F-00280)

The drawings identified above identify the waste quantities expected during operations. The hazards associated with the major waste forms generated as a result of the Pilot Plant Program are discussed in Section 8 of this PSAR. Section 6 identifies the project-specific engineered features used to manage the wastes from the Pilot Plant Program. Section 13 of the SSARR (Ref. 13.2) addresses the sitewide common and generic systems, operation of waste management, and routinely used protective equipment. Sections 11 and 12 of this PSAR discuss the radiation and chemical hazard protective measures for the Pilot Plant Program. Section 18 of this PSAR identifies specific training requirements for waste management. Section 19 of this PSAR addresses inspection and maintenance requirements for waste.

13.2.1 Vitrified Waste

All vitrified waste will be stored on site until final disposition is made. The leading final remedial alternative for OU-4 waste is currently off-site burial. The vitrified waste will be sampled to ensure

compliance with the waste acceptance criteria of the DOE's Nevada Test Site (NTS). Waste not in compliance will be stored appropriately or reprocessed..

13.2.2 Gaseous and Particulate Effluent

The air discharge consists of a source from the Vitrification Pilot Plant Off-Gas Treatment System (Drawing No. 94X-5900-F-00280). This point source is primarily regulated under the Federal Clean Air Act and the State of Ohio Air Pollution Control Act. The Federal Clean Air Act was amended in 1990 and requires the US EPA to develop and propose new toxic air pollution standards in addition to those regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP). The flow and contents of exhaust air are discussed in Section 9, "Analysis of Normal and Abnormal Operations and Accidents" of this PSAR.

13.2.3 Liquid Effluent

The liquid effluent of this facility is discharged to the High Nitrate Tank via the building sump (Drawing No. 94X-5900-F-00280). The Advanced Wastewater Treatment (AWWT) System, which will treat water from the High Nitrate Tank forms a part of the overall site discharge and is therefore not addressed in this PSAR. Figure 6-6 of the SSARR illustrates the current configuration of the site liquid effluent handling system. The AWWT is expected to be operational prior the Pilot Plant operations. The amount and characteristics of the project liquid discharge are discussed in Section 9, "Analysis of Normal and Abnormal Operations and Accidents."

13.3 Waste Management Process

The philosophy, objectives, and associated controls for waste management at the FEMP are addressed in Section 13 of the SSARR. Section 17 of this PSAR identifies the CRU-4 management responsibilities and interfaces with the site waste management program.

13.4 References

13.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

13.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

SECTION 14

QUALITY ASSURANCE

This section addresses the Pilot Plant Program-specific information that is required by Attachment 1, Item 18, of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 14.1). Section 14 of the SSARR (Ref. 14.2) addresses sitewide quality assurance (QA) requirements. In addition, Section 14 of the SSARR identifies those sections of the SSARR which address specific measures to ensure quality at the FEMP.

14.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RIDs for QA. This S/RID (No. 13) identifies the requirements for identifying the integral elements of the QA Program and ensuring corrective action and tracking of non-compliance for the FEMP per the FERMCO contract with the DOE; applicable Federal, State, and local laws; DOE Orders; and DOE guidance documents.

The basic requirements of RM-0012, the QA Program Description (Ref. 14.3) apply to all activities and phases of this project. The program provides for compliance to DOE Orders 5700.6C (Ref. 14.4) and 5480.23, and establishes a graded approach to quality assurance based on importance to safety, reliability, and quality requirements.

14.2 Assessment

The *Risk Assessment Report* (see Appendix C) prepared for this project has identified 86 possible event sequences (Quality Level 1, 2, 3) associated with the OU-4 Pilot Plant Program. Two event sequences involving heat-related events are considered Quality Level 1. Sixty event sequences involving waste removal, transport, and vitrification operations are considered Quality Level 2. Twenty-four event sequences involving internal/external exposure, natural phenomena, industrial-type accidents, and excessive cold are considered Quality Level 3.

The *Risk Assessment Report* states that, with proper mitigation, all quality levels are reduced to Quality Level 3 or 4. The *Risk Management Plan* (Ref. 14.5) describes the general and job-specific controls, mitigators, training, and requirements necessary to reduce all event sequences to a Quality Level of 3 or 4.

FERMCO QA and RSO/QC procedures will be used to perform and document assessment and verification activities applied to the OU-4 Pilot Plant Program. Special quality elements applied to the OU-4 Pilot

Plant Program provide for the identification and control of safety design features (if any), the control of operational processes, and the documentation required for controls.

14.3 Procedure

Training will be developed to outline requirements for special operational procedures developed for the OU-4 Pilot Plant Program. Documented evidence of personnel who must attend this training will be provided and will be used as an administrative control for personnel entry into the work area. All personnel requiring entry into the operation area will be trained.

Site QA and Project Procedures, as applicable, will be used to provide surveillance, inspection, testing, Measuring and Test Equipment (M&TE) control, corrective action reports, document control, construction component testing, start-up and operability testing, and waste verification required for this project. Other procedures may be developed as necessary for future requirements.

14.4 References

14.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

14.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

14.3) FERMCO, April 1993. "Quality Assurance Program Description", RM-0012.

14.4) US DOE, August 1991. DOE Order 5700.6C, Quality Assurance.

14.5) FERMCO, December 1993. *Risk Management Plan for Operable Unit 4 Vitrification Project.*

SECTION 15

CONDUCT OF OPERATIONS

This section addresses the Pilot Plant Program-specific conduct of operations requirements of Attachment 1, Item 17, of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 15.1). Section 15 of the SSARR (Ref. 15.2) addresses the common and generic aspects of the conduct of operations for the site.

15.1 Policies and Procedures

Company policy documents and facility implementation procedures will be developed and implemented, as appropriate, to the Pilot Plant Program. Compliance with these requirements is provided in Table 15-1, "Conduct of Operations Guidelines" of the SSARR (Ref. 15.2). Project-specific aspects of conduct of operations are summarized in Table 15-1.

15.2 References

15.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

15.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

Table 15-1 - Project-Specific Operations

Subsection	Project-Specific Operation
6.1.1.2	Decant Sump Tank Level Check
6.3.1	Pneumatic Waste Removal System
6.3.2	Vitrification Pilot Plant
6.3.3	Radon Treatment System
6.4	Vitrification Support Systems
6.5	Safety-Significant SSCs
11.2	Radiation Shielding
12.2	Hazardous Material Administrative Controls
17.1	Contractor Organization
18.1	Procedures and Training
19.3	Surveillance Testing
19.4	Maintenance

SECTION 16

EMERGENCY PREPAREDNESS

This section addresses the Pilot Plant emergency preparedness requirements of Attachment 1, Item 19, of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 16.1). Section 16 of the SSARR (Ref. 16.2) addresses the sitewide emergency preparedness requirements.

16.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RIDs for Emergency Preparedness and Management. This S/RID (No. 3) identifies the requirements for emergency preparedness planning and hazards identification; emergency response; and emergency reporting for the FEMP per the FERMCO contract with the DOE; applicable Federal, State, and local laws; DOE Orders; and DOE guidance documents.

16.2 Objectives

The FEMP maintains the necessary emergency plans and procedures to adequately define the emergency management program, provide guidance for all emergency responders (including employees), ensure adequate performance for critical systems, and to meet regulatory requirements. Subsection 16.1 of the SSARR addresses the site objectives for emergency preparedness.

The hazards associated with the Pilot Plant program are identified in Section 8 of this document. Section 9 of this document identifies the accident sequences and their consequences. Section 6 of this document discusses safety significant systems in place to protect workers during pilot plant operation. Sections 11 and 12 discuss the radiological and hazardous material protection programs in place to protect workers.

16.3 Functional Responsibilities

16.3.1 Sitewide Organizations

Subsection 16.2.1 of the SSARR summarizes the responsibilities of key on-site emergency management personnel.

16.3.2 Off-Site Organizations

Subsection 16.2.2 of the SSARR summarizes the responsibilities of key off-site emergency organizations.

16.3.3 CRU-4 Pilot Plant Program

16.3.3.1 Event Reporting

In the event of an emergency, an individual at OU-4 would report it by:

1) Calling 6511
2) Using the radio, call "control"
3) Using the manual fire alarm pull boxes
4) Notifying the AEDO

16.3.3.2 Event Responses

All employees are trained annually in General Employee Training (GET). GET identifies the proper response to various warnings and alarms. Table 16-1 of the SSARR identifies the alarms and responses.

16.3.3.3 Personnel Accountability

There are two ways to account for all personnel on site:

1) In-place accountability where all personnel report to supervisors and managers without evacuating. The supervisors/managers then report their accountability information through departmental channels and, ultimately, to the Accountability Center.

2) Rally point accountability, which includes personnel evacuation to a designated rally point. Personnel accountability information is gathered there and reported to the Accountability Center. The Accountability Center is able to determine who is missing or unaccounted for.

16.4 Event Assessment

Subsection 16.3 of the SSARR discusses the initial assessment of an event's impact at the FEMP.

16.5 Event Categorization

Subsection 16.4 of the SSARR discusses event categories and their responses. The responses to accidents are based on their consequences and are governed by their observed consequences, not their potential as defined by analysis. Emergency response is based on the release estimate, not the accident type. Effluent monitoring is a prime means of evaluating the accident release to the environment, radiation monitors (e.g., dosimeters) are used in evaluating the exposure for radiation workers.

Section 2 of PL-3020, the *FEMP Emergency Plan* (Ref. 16.3) states that the collapse of the K-65 Silo dome by a tornado is an event with an "Alert" Emergency Action Level.

16.6 Event Notification

Subsection 16.5 of the SSARR discusses initial notification requirements to the DOE.

16.7 Facilities and Equipment

Subsection 16.6 of the SSARR discusses the facilities and equipment available at the FEMP.

16.8 Training

Subsection 16.7 of the SSARR discusses emergency training at the FEMP.

16.9 Recovery

Subsection 16.8 of the SSARR discusses event termination and recovery at the FEMP. System restart and contamination cleanup are identified in Section 18 of this PSAR.

16.10 References

16.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

16.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

16.3) FERMCO, March 22, 1993. *FEMP Emergency Plan*. PL-3020.

SECTION 17

MANAGEMENT, ORGANIZATION, AND THE INSTITUTIONAL SAFETY PROVISIONS

Each of the following subsections summarizes information for the FEMP as required by Attachment 1, Item 12, of DOE Order 5480.23, "Nuclear Safety Analysis Reports" (Ref. 17.1).

Operation of the FEMP is the responsibility of FERMCO, who is the prime contractor. Facility design, construction, and startup of the pilot plant are the ultimate responsibility of the CRU-4 Manager. The following subsections describe the organizational structures that implement site procedures to ensure the safety of facility personnel, protection of the environment, and compliance with applicable health, safety, and environmental statutes, regulations, orders, and standards.

Section 17 of the SSARR (Ref. 17.2) addresses common and generic aspects of management, organization, and institutional safety common throughout the FEMP. The following subsections discuss the aspects of these topics unique to this project.

17.1 Contractor Organization

The organization and management on a sitewide basis for the FEMP is provided in the SSARR. Figure 17-1 of this PSAR shows the management organization for CRU-4.

The functional structure and matrix of specific site organizations is presented in Section 17 of the SSARR. The site organization matrix implemented under the CRU-4 management includes the environmental, safety, and health; radiation protection; training; regulatory programs maintenance; and startup. The QA program provides oversight independent of CRU-4.

CRU-4 is responsible for CRU-4-specific design and construction, but the tasks are carried out by incorporating personnel matrixed from site Engineering, Regulatory, Training, Environmental Health and Safety, and Construction organizations. The CRU directly manages the Remedial Design Subcontractor, PARSONS. Generally, operation and maintenance is carried out by the site Remedial Support Operation which reports to the president, but is directed by the respective CRUs.

An independent global oversight of the CRU activities is maintained by Quality Assurance.

Fernald Environmental Restoration
Management Corporation
CERCLA/RCRA Unit 4

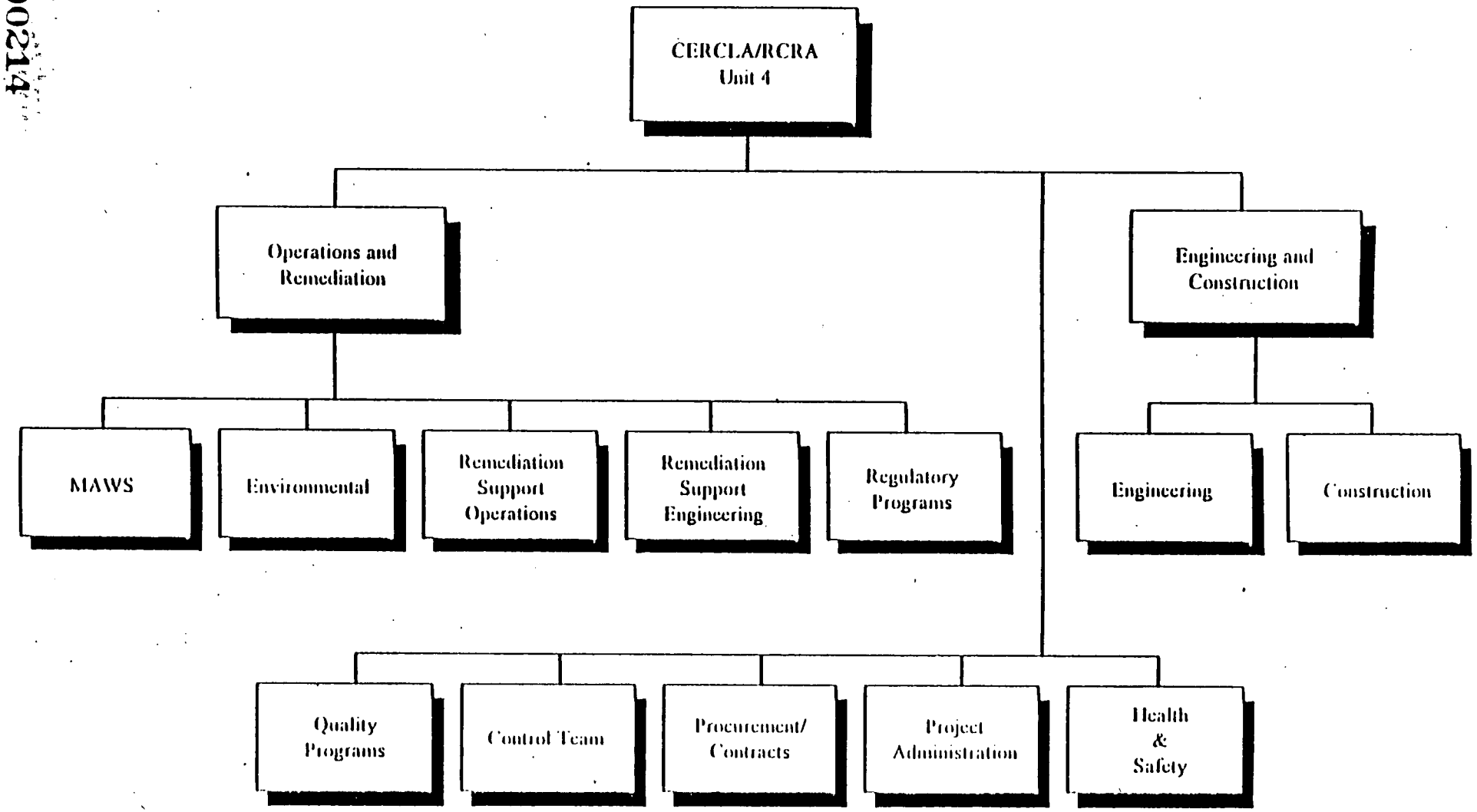


Figure 17-1 - CRU-4 Management Organization Structure

000214

17.1.1 Design, Construction, and Operation at Existing Facilities

The engineering for the silos was completed by Preload Enterprises, Inc. in 1951 and 1952 and the engineering for all support systems was completed by Catalytic Construction Co. under contract to the Atomic Energy Commission (AEC) (reorganized into the United States Department of Energy). The construction contractor was Catalytic Construction Co. under contract to the AEC. National Lead of Ohio (NLO) was the operating contractor to the AEC at the time of construction.

The operations and maintenance functions for the facility are both under the functional responsibility of the Site Services Department with the CRU-4 Manager as the facility owner. The CRU-4 Manager has the ultimate responsibility for facility operations, maintenance, and safety.

17.1.2 Construction, Operation, and Maintenance of Future Facilities

The Contractor Organization, as presented, will manage the construction, operation, and maintenance of future facilities.

17.2 Institutional Safety

Section 17 of the SSARR addresses the sitewide aspects of institutional safety.

The sitewide institutional safety programs are implemented by the CRU-4 organization. The safety programs implemented are:

1) Safety culture programs
2) Independent safety review and appraisal
3) Procedural and document controls
4) Monthly safety and housekeeping inspection
5) Fire protection and emergency response team
6) Configuration and document control

17.3 Occurrence Evaluation

Section 17 of the SSARR addresses the sitewide aspects of occurrence evaluation. For CRU-4, unusual events at the FEMP are documented by FERMCO. The events are analyzed and documented by the following sitewide guidance for:

1) Preparing occurrence reports

2) Selecting and analyzing information by deficiency trend analysis
3) Performing a root cause analysis
4) Providing corrective actions and feedback for the occurrences

17.4 Staffing, Training, and Qualifications

Section 17 of the SSARR addresses sitewide aspects of staffing, training, and qualifications. The CRU-4 management will implement staffing, training, and qualifications as discussed in the SSARR.

The areas for implementation will include:

1) Shift training
2) Personnel allocation
3) General FEMP training and qualification
4) Fitness for duty qualifications
5) Performance evaluation
6) Limitation for overtime worked
7) Project-specific staffing requirements

17.5 References

17.1) United States Department of Energy. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

17.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

SECTION 18

PROCEDURES AND TRAINING

This section of the PSAR is intended to provide a description of two administrative programs that provide safety through successful implementation. Section 18 of the SSARR contains a standard description of the procedures and training programs as they apply to all FEMP facilities. The following subsections describe the CRU-4-specific procedures that will be developed and the training that will be performed before operations begin. The project-specific procedures and training courses identified in Tables 18-1 and 18-2 do not currently exist. They will be developed as part of the design process and completed prior to startup. The FSAR will summarize the completed procedures and describe the details of the program-specific training.

18.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the Standards/ Requirements Identification Documents (S/RIDs) for Training and Qualifications. This S/RID (No. 16) identifies the requirements for training and qualifying personnel and developing accreditable programs for the FEMP per the FERMCO contract with the DOE; applicable Federal, State, and local laws; DOE Orders; and DOE guidance documents.

18.2 Procedures

Section 18.1 of the SSARR (Ref. 18.1) describes the FEMP program for the development of operating procedures in the following areas:

1) Responsibilities
2) Procedure development
3) Procedure content
4) Procedure changes and revisions
5) Procedure approval
6) Periodic review
7) Procedure use and availability

Table 18-1 identifies the activities that will be conducted and the basic tenets of the procedures that must be developed to ensure a safely operated facility. This table only represents the basic operations which must be made into procedures. They may be packaged into one procedure or divided into as many as is most appropriate. The FSAR will provide a more detailed discussion of the actual procedures.

Table 18-1 - Activities and Basic Procedural Tenets

Activity	Basic Tenets
Building HVAC	1. Required number of HEPA units for operation 2. Operating procedures 3. Actions to correct deficiencies
Work on top of Silos 1, 2, 3, and 4	1. Industrial safety issues 2. Radiological safety requirements 3. Maximum silo loading (Personnel or equipment) 4. Hazardous material safety requirements 5. Decontamination requirements
Caustic Soda/Flocculent/Additive handling/ Desiccant Handling	1. Industrial safety issues 2. Hazardous material safety requirements
Silo 3 Waste Removal	1. Operating procedures 2. Actions to correct deficiencies 3. Sampling requirements 4. Industrial safety issues 5. Hazardous material safety requirements 6. Radiological safety requirements
Silo 3 Surge Bin Transport	1. Industrial safety issues 2. Radiological safety requirements 3. Hazardous material safety requirements 4. Material transport issues
Hydraulic Waste Removal	1. Operating procedures 2. Actions to correct deficiencies 3. Sampling requirements 4. Radiological safety requirements 5. Hazardous material safety requirements

Table 18-1 - Activities and Basic Procedural Tenets (Continued)

Activity	Basic Tenets
Thickener	1. Rake operating procedure 2. Flocculent addition requirements 3. Modes of operation 4. Recycle water additives 5. Actions to correct deficiencies 6. Sampling requirements 7. Industrial safety issues 8. Hazardous material safety requirements 9. Radiological safety requirements
Feed Preparation	1. Thickener material to slurry tank transport procedure 2. Silo 3 material to slurry tank transport procedure 3. Slurry tank additive procedure 4. Slurry tank agitator operations 5. Actions to correct deficiencies 6. Sampling requirements 7. Radiological safety requirements 8. Hazardous material safety requirements
Furnace	1. Normal furnace operation 2. Heavy metal removal 3. Normal shutdown 4. Response to an accumulation of floating material 5. Emergency shutdown 6. Draining and restart 7. Actions to correct deficiencies 8. Sampling requirements 9. Industrial safety issues 10. Radiological safety requirements 11. Hazardous material safety requirements

Table 18-1 - Activities and Basic Procedural Tenets (Continued)

Activity	Basic Tenets
Product Forming Machine	1. Normal operations 2. Draining 3. Normal shutdown 4. Emergency shutdown 5. Actions to correct deficiencies 6. Sampling requirements 7. Industrial safety issues 8. Radiological safety requirements 9. Hazardous material safety requirements
Product Handling System	1. Storage issues 2. Industrial safety issues 3. Radiological safety requirements 4. Hazardous material safety requirements 5. Material transport issues
Process/Recycle Water	1. Process make-up requirements 2. Recycle water modes of operation 3. Filter/backflush requirements 4. Wastewater discharge issues 5. Actions to correct deficiencies 6. Sampling requirements 7. Radiological safety issues
Radon Treatment	1. RTS operating procedures 2. Silo 4 equipment enclosure 3. Actions to correct deficiencies 4. Radiological safety issues 5. Sampling requirements

Table 18-1 - Activities and Basic Procedural Tenets (Continued)

Activity	Basic Tenets
Off-Gas Treatment	1. Off-gas operating procedures 2. Caustic soda additive requirements 3. Desiccant replacement 4. Actions to correct deficiencies 5. Carbon bed vessel regeneration 6. Sampling requirements 7. Monitoring Requirements 8. Radiological safety requirements 9. Hazardous material safety requirements
Instrument Air Operation	1. Accumulation capacity 2. Filter lubrication requirements 3. Desiccant regeneration 4. Actions to correct deficiencies
HEPA Filters Testing	1. DiOctyl-Phthalate testing of filters 2. Radiological safety requirements 3. Hazardous material safety requirements
Instrument Calibration	1. Operating range 2. Alarm setpoints 3. Calibration frequency 4. Actions to correct deficiencies
Filter/Receiver Testing	1. DiOctyl-Phthalate testing of filters 2. Radiological safety requirements 3. Hazardous material safety requirements
Carbon Bed Vessel Testing	1. Percent radon adsorbed 2. Loading capacity 3. Monitoring requirements
Shielding	1. Temporary shield requirements 2. Radiological safety requirements
Construction	1. Industrial safety issues 2. ALARA principles

Table 18-1 - Activities and Basic Procedural Tenets (Continued)

Activity	Basic Tenets
Spill (slurry, molten glass, gems, water, flocculant, additive, desiccant) Cleanup	1. Evacuation until monitoring permits re-entry 2. Use of HEPA-filtered vacuum cleaners 3. Radiological safety requirements 4. Hazardous material safety requirements
Maintenance	1. Spare parts requirements 2. Scheduled maintenance requirements 3. Manufacturers recommendations 4. Radiological safety requirements 5. Hazardous material safety requirements
Maintenance Worker Protection	1. Industrial safety issues 2. Radiological safety requirements 3. Hazardous material safety requirements 4. Decontamination Methods
Conduct of Operations	1. Organization and staffing 2. Staff responsibilities 3. Lines of authority
Secondary Containment	1. Inspection requirements 2. Sampling methods 3. Removal methods
Decommissioning	1. Decontamination methods 2. Sampling requirements 3. Industrial safety issues 4. Radiological safety requirements 5. Hazardous material safety requirements
Refer to Table 19-1 of this PSAR for a list of systems/structures subject to maintenance.	

18.3 Training

Subsection 18.2 of the SSARR describes the FEMP program for the development of training courses concerning the following aspects:

1) FEMP training program description
2) FEMP training requirements for each worker classification

3) FEMP training program implementation
4) Initial training
5) Retraining
6) Development
7) Administration and records coordinated by Environmental, Safety, and Health for affected employees

All FEMP operations personnel are required to successfully complete and maintain current the GET requirements as stated in DOE Order 5480.20. The training program for the OU-4 Pilot Plant Program will comply with the requirements identified in Table 18-1 of the SSARR.

The OU-4 Pilot Plant training program will be established for the operating organizational personnel to develop or enhance their knowledge, skills, and ability to perform their job assignments. A systematic analysis of training requirements will be completed as required in RM-FMPC-0002. The following project-specific training and qualifications are required for the various operating and maintenance personnel who work on this project:

1) Equipment operators shall have evidence of current qualification for the type of equipment operated prior to the initiation of their activities. Training and qualification shall be current and directly applicable to the specific equipment that is to be operated.

2) Personnel responsible for operation of the OU-4 Pilot Plant Program will be trained and qualified in the operation activities identified in, but not limited to, Table 18-2, as applicable, prior to the start-up of the system. Personnel responsible for maintenance of the OU-4 Pilot Plant program will be trained and qualified in the maintenance activities identified in, but not limited to, Table 19-1, as applicable. This training will ensure proper and safe operation and maintenance of the systems.

3) All personnel working on the OU-4 Pilot Plant Program will be trained on the Project Task-Specific Health and Safety Plan.

4) The FEMP 24-Hour Emergency Response Team (ERT) will be trained on the project requirements prior to initiating work.

5) Personnel responsible for hoisting and rigging will be trained and qualified prior to initiating work.

6) Personnel assigned to work on the OU-4 Pilot Plant Program will be trained in heat and cold stress prior to initiating work.

7) Inspection personnel meet the requirements of the FERMCO Quality Assurance Program Description (RM-0012) and are certified in RSO/QC procedures based on ASNT-TC.1A or other national standard programs, as applicable. FERMCO manager/supervisors shall ensure that inspectors under their supervision are certified prior to performing or witnessing work on this project. FERMCO managers/supervisors shall also ensure that training required prior to certification is accomplished.

8) Training in energy isolation control, per the requirements for SSOP-0719, shall be completed by affected employees prior to any field activities related to this project. The training shall be coordinated by ES&H for affected employees.

Table 18-2 - System-Related Operational Training Requirements

Training to be Developed
Building HVAC Operation
Silo 4 Waste Removal and Transport
Silo 3 Waste Removal and Transport
Silo 1 and 2 Waste Removal and Transport
Thickener Operation
Feed Preparation
Furnace Operation
Product Formation
Product Handling
Process Water/Recycle Water Operation
Wastewater Transfer
Off-Gas System Operation
Instrument Air Operation
Radon Treatment System Operation

18.4 References

18.1) FERMCO, March 1994. *Sitewide Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

SECTION 19

INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

The grading of topics in Section 19 is determined by the safety analysis for this project and the recommendations of WHC-SP-0960, Graded Approach to Safety Analysis Reports (Ref. 19.1). As recommended, the depth of description considers the hazards and the duration of the project. The facilities in this project have a short mission time and are not complex. Because this project has a short mission time, the most significant element of Section 19 is initial testing. Inspection and tests documents will be prepared during Title III based on the identified systems or components' quality levels and site procedures.

WHC-SP-0960 (Ref. 19.1) recommends a level of descriptive detail of "V" for each subsection of Section 19. This would indicate no specific information is required for each subsection. However, this section identifies preliminary plans concerning initial testing, in-service surveillance, and maintenance. Section 19 of the SSARR addresses common and generic aspects of initial testing, in-service surveillance, and maintenance that apply to all facilities at the FEMP, including the to-be-constructed Pilot Plant.

19.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RIDs for Maintenance and for Operations. The maintenance S/RID (No. 7) identifies the requirements for establishing the equipment and systems maintenance methods and practices, providing equipment calibrations, and establishing preventative or routine maintenance for the FEMP per the FERMCO contract with the DOE; applicable Federal, State, and local laws; DOE Orders; and DOE guidance documents. The Operations S/RID (No. 11) identifies the requirements for executing and monitoring operational activities; operating methodologies and procedures; lockout and tagout; abnormal events investigation; and equipment or process labeling.

19.2 Testing

19.2.1 Testing of Existing Silos

The structural integrity of the silos is being evaluated by a test program currently underway. Discussion of the test program is included in Subsection 6.1.4.

19.2.2 Testing of New and Modified Facilities

A test program will be developed under the guidance of ENG-012-1803, "Startup and System Operability Test Procedure (Ref. 19.2), to determine the tests to be performed, their preparation, execution, and closeout. Construction acceptance tests, instrument calibrations, individual systems tests, pre-operational integrated systems tests, and a system operational test will be performed as necessary to certify that the new facility or system meets its design criteria.

19.2.3 Phase 1 Checkout and Start-Up Activities (Surrogate Material)

Following the successful completion of Construction Acceptance Testing (CAT), Systems Operability Testing (SOT) will occur for the waste retrieval and vitrification systems. Detailed CAT and SOT plans will be developed and approved prior to the start of test activities.

19.2.3.1 Phase I Checkout Activities

The following is a preliminary list of checkout activities to be included in the SOT plans:

1) Waste retrieval equipment (cranes, pumps, blowers, cameras, etc.) and the system as a whole will be tested for proper operation.

2) The thickener will be filled with water and allowed to overflow into the recycle water tank.

3) The recycle water tank level indication will be checked as the tank fills.

4) Flow indication to each slurry tank from the thickener will be calibrated against the rate of weight gain in each tank. Agitator operation will be checked concurrently.

5) Water will be pumped from the recycle water tank to the quench tower, and the flow control to the quench tower will be calibrated.

6) The level controller in the quench tower will be calibrated, and the quench tower water pump will be started, pumping water back to the thickener.

7) The exhaust fan will be started, and air flows from the process through the off-gas system will be measured and balanced.

8) The cooling tower will be filled with water and treatment chemicals will be added. The cooling tower pump will be run to purge air from the system. The cooling tower fan will be started and adequate air flow verified.

9) The filtration and transfer equipment for the glass additives will be operated to confirm proper operation.

10) Slurry tank discharge pumping will be tested in the recycle mode.

11) The furnace will be charged with appropriate glass frit, then heated to melt the frit and seal the refractory.

12) The wastewater filters will be water tested when sufficient feed is available in the recycle water tank.

13) During the checkout operations, the Distributed Control System will be monitored for correct indications of measured variables, control action, and status of motors and valves.

14) Safety alarms will be checked and emergency shut-offs will be tested for proper settings and function.

15) All support system components (e.g., pumps, valves, filters, and instruments) that are not tested via Items 1 through 14 of this list will be checked and/or tested for proper operation.

19.2.3.2 Phase I Start-Up Activities

Start-up activities for vitrification involve introducing surrogate material from Silo 4 into the system and inventorying tanks and bins so that continuous operation can be achieved. These activities consist of the following essential steps:

1) Furnace temperature control will be tested.

2) Molten glass draw and the product forming equipment will be tested in short runs to gain experience and to establish preliminary control parameters.

3) The slurry feed to the thickener will be transferred to a slurry tank when target percent solids are reached.

4) Additives will be added to the slurry tank and mixed with the slurry. After the additives are sufficiently mixed in the slurry tank, short furnace feeding runs will be used to test the furnace feed system to get an initial assessment of the response of the furnace to actual feed.

5) The process water system, off-gas treatment system, wastewater filters (as required), and cooling tower will all be operating during this time.

6) These start-up activities will cease when all systems have been tested sufficiently such that continuous operation is judged to be viable.

19.2.3.3 Phase I Pilot Plant Testing

The objective of this operational phase is to achieve design rates on a continuous operation basis and to determine steady-state and optimum parameters. The majority of the Phase I testing will simply entail equipment operation, observation, and subsequent process correction. Phase I vitrification testing is targeted to end when approximately 30 metric tons of surrogate material has been vitrified. Prior to the completion of Phase I testing, trace metallic elements and sulfates will be added to the surrogate material prior to being fed to the furnace to more closely simulate the vitrification of K-65 material. The following identify the specific component testing that will occur.

Silo Material Retrieval (Hydraulic)

Testing of silo material retrieval will entail the successful manipulation of the hydraulic mining device(s), demonstrating the off-gas and silo head space pressure, and removing silo material at the design rates. Slurry samples will be taken periodically to measure the variability in solids content. The mining device(s) operating pressure and volume flow will be adjusted to test their operating ranges and to determine optimum operating parameters.

Thickener

Thickener performance is mainly a function of achievable solids concentration. The solids effluent will be sampled and tested for weight percent solids (targeted at 50 percent). The overflow water will also be sampled for clarity. The addition of polymer flocculation agents to the thickener feed, at various rates, will be tested to determine the reagent consumption for desired settling efficiencies.

Slurry Tanks

The alternating batch operation of the two agitated slurry tanks will be tested. The ability to substantially empty the slurry tank to the furnace before receiving the next batch from the thickener will be demonstrated.

The agitator co-mingles the surrogate material and the additives so that a homogeneous mix is fed to the vitrification furnace. The slurry tank product will be inspected to ascertain the agitator's effectiveness.

Vitrification Furnace

Furnace operation will be carefully monitored and adjustments to temperature, hold time, feed, etc., will be made as required to ensure an acceptable glass product. Operation of the melter at its lower temperature range, coupled with the use of mechanical agitation, will be tested to determine the minimum temperature required to produce a good glass product. Also, trace metallic elements and sulfates will be added to the furnace feed to better simulate the K-65 material and test the furnace operation (i.e., heavy metal drain, effectiveness of mechanical agitation on glass phase separation). Final product testing will include compression testing and TCLP analysis to determine leachability.

Temperature Control

The furnace is expected to operate between 1,100 and 1,350 degrees C (2,012 - 2,462 degrees F). The ability to maintain a constant glass melt temperature during operations will be tested due to its importance to producing a uniform glass product that flows out of the furnace at a constant rate.

Foaming

Foaming occurs in a glass furnace with the release of decomposition gases at high temperature, mostly carbon dioxide from carbonates. The extent of foaming will be observed by remote video monitoring and the glass formulation adjusted accordingly since it is critical to be able to continuously operate the furnace without foaming problems.

Molten Glass Removal

Controlling the molten glass flow out of the furnace is important to the subsequent product forming operation. Testing will involve changing the flow rate to ensure that reasonable control of the glass level in the furnace can be maintained.

Product Forming

The product forming equipment will be a mechanical device which will cut molten glass streams from the furnace into small pieces and cool the pieces in a controlled way to produce a product with acceptable physical (crush strength), chemical (leach resistance), and radiological (radon retention - Phase II) properties. The operation and mechanical reliability of the system will be tested.

Quench Tower and Scrubber

The function of the quench tower and scrubber is to condense the water vapor and remove any acid gases produced in the furnace. During testing, it will be monitored for pressure drop, water inventory control, and water temperature rise.

Radon Treatment System (RTS)

Although there is no radon concern in Phase I, the RTS must be tested to demonstrate reliability and capability of handling the design throughput. It will consist of a dehumidification section, a carbon bed adsorption section, and a final HEPA filtration section. During testing, the parameters to be monitored are the temperature and humidity of the air entering the carbon bed and the pressure drop through the system.

Cooling Tower

Cooling water will be needed to cool the furnace electrodes, parts of the product forming equipment, and the quench tower effluent being recycled to the thickener. Cooling towers are generally simple and reliable and require minimal attention. Full-rate testing of the process will verify that adequate cooling capacity exists in the cooling tower.

Wastewater Treatment

The net amount of water removed from the process will exit through the recycle water tank and the wastewater filters. Suspended solids will be the only items requiring treatment in this water; therefore, treatment will consist only of a multi-media filtration system. Although this is a well known technology, the ability to successfully handle the bentonite clay must be tested.

Distributed Control System

The control system will gather data from the vitrification operations for display on screens in the control room. Likewise, control devices (valves, dampers, Silicon Control Rectifiers [SCRs] for furnace electrodes) and motors will have their status displayed. Pilot Plant operations testing will determine the reliability of this equipment and demonstrate its user friendliness.

19.2.4 Phase II Checkout and Start-Up Activities

Following the successful completion of Phase I, operating procedures will be modified to reflect all process changes and lessons learned.

19.2.4.1 Phase II Checkout Activities

The following is a preliminary list of checkout activities:

1) All liquid process lines will be flushed to remove residual materials used during Phase I testing.

2) Waste retrieval equipment (cranes, pumps, vacuum blowers, cameras, etc.) and the system as a whole will be tested for proper operation.

3) The thickener will be emptied of surrogate material and left filled with water to the point of overflow into the recycle water tank.

4) The recycle water tank will be checked to make sure it is at a 60 to 70 percent level indication.

5) The quench tower will be checked for proper (about 50 percent) water level.

6) The exhaust fan will be started, and air flows from the process through the off-gas system will be remeasured and balanced.

7) The cooling tower will be checked for proper water inventory and treatment chemicals will be added as needed. The cooling tower pump will be run to purge air from the system. The cooling tower fan will be started and adequate air flow verified.

8) The transfer equipment for the glass additives will be checked to confirm proper operation.

9) Slurry tanks will be emptied and flushed.

10) The furnace will be checked for proper temperature control.

11) Both of the wastewater filters will be backflushed and ready for use.

12) During the checkout operations, the Distributed Control System will be monitored for correct indications of measured variables, control action, and status of motors and valves.

13) Safety alarms will be checked and emergency shut-offs will be tested for proper settings and functionality.

14) The building ventilation system will be started and airflows through the building will be remeasured and balanced.

19.2.4.2 Phase II Start-Up Activities

Start-up activities at the silos involve filling the mobile hopper with Silo 3 material and inserting the slurry pump into Silo 1 or 2. Start-up activities for vitrification involve introducing K-65, Silo 3, and additive materials into the system and inventorying tanks and bins so that continuous operation can be achieved. These activities consist of the following essential steps:

1) The Silo 3 material mobile hopper will be filled and relocated to the Pilot Plant facility.

2) The K-65 Silo RTS will be started and checked for satisfactory operation.

3) The slurry pump will be inserted into Silo 1 or 2 and slurry transfer to the thickener will commence.

4) When adequate percent solids is reached in the thickener, the first "hot" melter feed batch will be initiated by transferring the correct amount of thickened solids to one of the slurry mix tanks.

5) Additives will then be added to the slurry tank. After the additives are sufficiently mixed in the slurry tank, short furnace feeding runs will be used to test the furnace feed system on this material and get an initial assessment of the response of the furnace to the feed.

6) Molten glass draw and the gem forming equipment will be tested in short runs to properly establish control parameters during the switchover from surrogate material to "hot" glass.

7) The recycle water system, off-gas treatment system, wastewater filters (as required), and cooling tower will all be operating during this time.

8) These start-up activities will cease when all systems have been tested sufficiently such that continuous operation is judged to be viable.

19.2.4.3 Phase II Pilot Plant Testing

The objective of this operational phase is to achieve design rates on a continuous operation basis and to determine steady-state and optimum parameters. The majority of this phase of Pilot Plant testing will entail equipment operation, sampling, observation, and subsequent process correction. Phase II vitrification testing is targeted to end when approximately 20-30 metric tons of K-65 and Silo 3 material have been vitrified. The following identify the specific component testing that will occur.

K-65 Silo Material Retrieval (Hydraulic)

Testing of K-65 silo material retrieval will entail successful manipulation of the slurry pump, demonstration of the ability to control radon emissions, and removal of silo material at the design rate. Slurry samples will be taken periodically to monitor the performance of the hydraulic mining system. The slurry pump operating pressure and flow will be adjusted to test its operating range and to determine optimum operating parameters.

Thickener

Thickener performance is mainly a function of achievable solids concentration. The solids effluent will be sampled and tested for weight percent solids (targeted at approximately 50 percent). The thickener overflow water will also be sampled for clarity. The addition of polymer flocculation agents to the thickener feed, at various rates, will be tested to determine the reagent consumption for desired settling properties. (Tests have shown that the presence of the bentonite clay will make the thickener operation more difficult, requiring high levels of polymer and possibly pH adjustment. The ability to adequately thicken K-65 residues plus bentonite is crucial to the success of the Phase II program).

Slurry Tanks

The alternating batch operation of the two agitated slurry tanks will be tested. The ability to substantially empty the slurry tank to the furnace before receiving the next batch from the thickener will be demonstrated.

The agitator blends the surrogate material and the additives so that a homogeneous mix is fed to the vitrification furnace. The slurry tanks will be sampled to ascertain the agitator's effectiveness and to determine the correct additive mix. Viscosity in the slurry tanks will be monitored via motor amps on the agitators.

Vitrification Furnace

Furnace operation will be carefully monitored and adjustments to temperature, hold time, feed, etc., will be made as required to ensure an acceptable glass product. Operation of the melter at its lower temperature range, coupled with the use of mechanical agitation, will be tested to determine the minimum temperature required to produce a good glass product. Of particular interest will be the effect of agitation on glass phase separation. Final product acceptance testing will include compression testing and TCLP analysis to determine leachability.

Temperature Control

The furnace is expected to operate between 1,100 and 1,350 degrees C (2,012 - 2,462 degrees F). The ability to maintain a constant glass melt temperature during operations will be tested due to its importance to producing a uniform glass product that flows out of the furnace at a constant rate.

Foaming

Foaming occurs in a glass furnace with the release of decomposition gases at high temperature, mostly carbon dioxide from carbonates. The extent of foaming will be observed by remote video monitoring and the glass formulation adjusted accordingly since it is critical to be able to continuously operate the furnace without foaming problems.

Molten Glass Removal

Controlling the molten glass flow out of the furnace is important to the subsequent product forming operation. Testing will involve changing the flow rate to ensure that reasonable control of the glass level in the furnace can be maintained.

Product Forming

The product forming equipment will be a mechanical device which will cut molten glass streams from the furnace into small pieces and cool the pieces in a controlled way to produce a product with acceptable physical (crush strength), chemical (leach resistance), and radiological (radon retention) properties. The operation and mechanical reliability of the system will be tested.

Quench Tower and Scrubber

The function of the quench tower and scrubber is to condense the water vapor from the furnace and remove any acid gases produced in the furnace. During testing, it will be monitored for pressure drop, water inventory control, and water temperature rise.

Radon Treatment System

The RTS must be tested to demonstrate reliability and capability of handling the design throughput. It will consist of a dehumidification section (desiccant tower), a carbon bed adsorption section, and a final HEPA filtration section. During testing, the parameters to be monitored are the volumetric flow rate, the temperature and humidity of the air entering the carbon beds, the pressure drop through the system, and the radon removal efficiency.

Cooling Tower

Cooling water will be needed to cool the water from the quench tower being recycled to the thickener and possibly the furnace electrodes and parts of the product forming equipment. Cooling towers are generally simple and reliable and require minimal attention. (Full-rate testing of the process in Phase I will verify that adequate cooling capacity exists in the cooling tower.)

Wastewater Treatment

The net amount of water removed from the process will exit through the recycle water tank and the wastewater filters. Suspended solids will be the only items requiring treatment in this water; therefore, treatment will consist only of a multi-media pressure filtration system. The ability to successfully handle the bentonite clay must be monitored.

Distributed Control System

The control system will gather data from the vitrification operations for display on screens in the control room. Likewise, control devices (valves, dampers, SCRs for furnace electrodes) and motors will have their status displayed. Phase II operations will continue to test the reliability of this equipment and provide information on any deficiencies of the control scheme to be used for final remediation.

19.3 Surveillance Testing and In-Service Inspection

The HEPA and carbon filters for the RTS and the vitrification off-gas systems will be periodically tested as well as the manual standby generator to ensure that they are capable of fulfilling their design functions. Because the facility has no safety classified structures, systems, or components, it has no associated TSRs mandating testing or inspection.

19.4 Maintenance

Section 19 of the SSARR identifies the considerations to be addressed in developing the OU-4 Pilot Plant Program maintenance plan to be in compliance with DOE Order 4330.4A, Maintenance Management Program (Ref. 19.3).

Table 19-1 identifies the structures and systems whose components' maintenance requirements will be, at a minimum, in accordance with manufacturer's specifications. The OU-4 Pilot Plant Program maintenance plan will be comprehensive, though actual scheduled maintenance may not be extensive, due to the short duration of this project.

Table 19-1 - Structures/Systems Subject to Maintenance

System or Structure
Silos 1, 2, 3 and 4
K-65 Silos Waste Removal and Transport Systems
Radon Treatment Systems
Thickener and Rake
Feed Preparation System
Furnace
Product Former
Recycle Water System
Wastewater Filter and Transfer System
Off-Gas System
Instrument Air System
Electrical Distribution System
Building HVAC
Building Lighting
Building Sumps
Double-Walled Pipe Leak Detection

19.5 References

19.1) Westinghouse Hanford Company, February 1993. *Graded Approach to Safety Analysis Reports*," Revision 1. WHC-SP-0960.

19.2) FERMCO, November 1993. ENG-02-1803, "Startup and System Operability Test Procedure," Draft.

19.3) United States Department of Energy, May 1992. DOE Order 4330.4A, "Maintenance Management Programs."

SECTION 20

DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

Technical Safety Requirements (TSRs) confirm the validity of assumptions made by the safety analysis which ensure that an acceptable dose/dosage is not exceeded. The basis for the assumption is described in this section of the project SAR. The DOE approves the basis for the TSR by accepting the project SAR. The FEMP implements the TSR through site procedures.

TSRs are formal commitments between a contractor and the DOE that are used to:

1) Identify safety limits that must not be exceeded
2) Define the limiting conditions of operations
3) Identify the surveillance requirements of the equipment
4) Impose administrative controls

TSRs are defined in DOE-STD-3005-YR (Ref. 20.1) as follows:

> Those requirements that define the conditions, safe boundaries, and the management or administrative controls necessary to ensure the safe operation of a nuclear *facility* and to reduce the potential risk to the *public* and *facility* workers from uncontrolled release of radioactive materials or from radiation exposure due to inadvertent criticality. A *TSR* consists of safety limits, operating limits, surveillance requirements, administrative controls, use and application instructions, and the basis thereof. *TSRs* were formally known as Operational Safety Requirements for nonreactor nuclear facilities and Technical Specifications for reactor facilities
>
> This standard also assigns *TSR* designation to those requirements that reduce the potential risk to the *public* and *facility* workers from uncontrolled release of non-radiological material or exposure to energy hazards. These *TSR*s would be subject to the enforcement provisions of 10 CFR 820 to the extent they also prevent uncontrolled release of radiological material.

However, TSRs are not intended to protect on- or off-site personnel who are safeguarded by normal industrial measures (e.g., OSHA, NFPA).

20.1 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the Standards/ Requirements Identification Document (S/RID) for Nuclear Safety. This S/RID (No. 9) identifies the

requirements for preparing TSRs at the FEMP per the FERMCO contract with the DOE; applicable Federal, State, and local laws; DOE Orders; and DOE guidance documents.

20.2 Discussion of Existing OSRs

Operational Safety Requirements (OSRs) (Ref. 20.2) were created and approved as part of the previous Safety Analyses of the K-65 Silos (Ref. 20.3) and the installation of bentonite. These OSRs will remain in effect until they are converted to TSRs, as appropriate, and issued concurrently with the FSAR.

20.3 References

20.1) United States Department of Energy, February 25, 1994. "Evaluation Guidelines for Accident Analysis and Safety Structures, Systems, and Components. DOE-STD-3005-YR.

20.2) PARSONS, November 1991. *Silos 1 and 2 Operational Safety Requirements*, Revision 4.

20.3) PARSONS, 1991. *Silos 1 and 2 Facility Safety Analysis Report*, Rev. 2.

SECTION 21

PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

This section provides information for D&D as required by DOE Order 5480.23, Attachment 1, Item 20 (Ref. 21.1). Section 21 of the SSARR (Ref. 21.2) addresses the generic aspects of decontamination and decommissioning (D&D) at the FEMP.

The grading of topics in this section is determined by the safety analysis for this project and the recommendations of WHC-SP-0960, *Graded Approach to Safety Analysis Reports* (Ref. 21.3). As recommended by WHC-SP-0960, the depth of description considers the hazards, complexity, life cycle (construction, operation), and duration of the project. The extent of the description is limited because of the relatively small effect this project has on D&D.

21.1 Project Function

The following components will require D&D as part of the remediation process:

1) Any temporary equipment used in the residue removal process.

2) The temporary facilities built to process the silo residues. These include the Vitrification Pilot Plant Facility and the associated utility services.

Prior to the start of these D&D activities, a complete structural and radiological characterization must be performed. This will provide baseline information and may influence decisions regarding decontamination equipment, techniques, and procedures which are most appropriate.

The principal objectives of this effort are:

1) To decontaminate the temporary facilities and equipment for reuse or release to the greatest extent possible, while minimizing exposure to individuals

2) To perform all work in such a manner as to minimize, to the extent possible, the quantity of waste to be packaged for interim storage on site

3) To perform all work in compliance with regulatory and site requirements commensurate with maintaining ALARA principles

21.2 D&D of New Facilities

The following subsections identify the equipment and activities necessary for the D&D of the temporary facilities, equipment, services, and utilities. The effort consists of stabilization and decontamination; processing of the resultant waste; preparation of the surfaces for demolition; the actual demolition (where required), removal, and packaging of the facilities, equipment, services, and utilities; and performance of a final assessment of the site(s). Because new pieces of process equipment have been designed with D&D in mind, only the equipment in direct contact with the residue material or process effluents will be significantly contaminated. The rest of the structures and equipment may be suitable for free release.

21.2.1 Preparation for D&D

Upon completion of the OU-4 Pilot Plant Program, the D&D of the equipment used during the vitrification study may begin. This equipment includes the Vitrification Facility Equipment and the associated miscellaneous material and utility services for the temporary remediation facilities.

An equipment inventory and radiological characterization will be completed to determine the decontamination techniques and final disposition for each piece of equipment and structure. A complete history of the facility's condition including construction, equipment, contamination levels, and operating history will be evaluated to establish the clean-up levels and final disposition of the equipment. Final disposition may include:

1) Free release

2) Packaging for disposal in an on-site disposal facility

3) Packaged, non-reusable items (rubble, miscellaneous concrete, building materials, etc.)

4) Reusable items by others on-site (certain utilities, power station, forklifts, other equipment, melter and associated components)

The final step is to establish health physics and operating procedures to comply with the radiological conditions of the facility as well as the regulatory requirements for the D&D of the facility. The health physics and pertinent operating procedures include area monitoring requirements, surface contamination area control, radiation area control, and airborne radioactivity area control. With these systems operational, identification and disposal of the surplus materials and equipment in the facility can be accomplished. Section 18 of the SSARR provides guidance for the development of operating procedures.

The required support material and modifications for operation will be identified. Areas which can be isolated and removed from the HVAC, electrical, and other service connections will be removed first.

The order of D&D for the equipment will be the equipment's activity level. Process flow diagrams and the services drawings will aid in the determination of the order of disconnection of services. The sequence of demolition will consider the need for staging areas for box transport and the movement of personnel.

Work will proceed from the most to least contaminated area. Demolishing, treating, and boxing activities for on-site use/storage must be set up with the contamination level in mind. Furthermore, classification of all materials into appropriate categories will be made as follows:

1) Contaminated, for processing and/or storage in the Interim Storage Facility (ISF)
2) Non-contaminated, non-reusable
3) Non-contaminated, reusable by other on-site activities

Within the isolation enclosure areas, vestibules are large enough to allow personnel and equipment to pass through. These vestibules will be provided at locations where there is actual or potential contamination that could spread from an area of high contamination to an area of lower contamination. Consideration may be made for primary, secondary, and tertiary confinement systems, based on the hazards being processed. The area will include provisions for radiological monitoring. HEPA filters are required between different ventilation zones and between airborne contaminated and non-contaminated zones. Existing HEPA filtration units will be used as much as possible. Where this is not practical, portable HEPA systems will be provided. Differential pressure instruments between zones supplement HVAC conditions so they can be easily monitored by D&D personnel. Easily accessible gauges/digital readouts that provide real time measurement of HVAC conditions will be provided.

Standby utilities which support the safety of the decontamination will be included for critical D&D operations and are described in Section 6. Standby power is also required for any system that may cause personnel exposure or environmental contamination (i.e., decontamination equipment, HVAC system, etc.; see Section 6).

Monitoring before, during, and after the D&D operation is important. Surface monitoring of the equipment and material assures that proper cleaning/stabilization has occurred to minimize contamination spread. Monitoring of all personnel prior to leaving the change/decontamination area is also required. Monitoring of all material (prior to boxing) and the monitoring of the exterior of the package is needed for inventory control records.

21.2.2 D&D of Equipment and Facilities

The D&D of the process equipment will occur in three distinct steps:

1) Equipment Removal

If the equipment is shielded, the shielding must be removed. Surveys of the shielding surrounding the pieces of equipment will determine if the shielding is potentially reusable by others on-site. General equipment removal will involve monitoring the equipment exterior, isolating the equipment from other processes, ensuring all tanks, vessels, and storage bins are empty by visual inspections. Volume reduction of large equipment prior to packaging may require size reduction prior to removal. Smaller equipment may be boxed whole.

2) Facility D&D

General facility D&D will involve preparing and cleaning the services and the demolition of the structures. Cleaning of all exposed surfaces (piping, conduit, ventilation ducts) will be performed. Stabilization of contaminated surfaces (paint, seal, etc.) including exposed horizontal surfaces (window sills, counter tops, tops of door frames) and cleaning around floor drains, light fixtures, exhaust fans, and electrical penetrations will also be performed. All piping will be flushed with the water going to the water treatment facility. Duct work and piping will be removed by cleaning and sealing the ends. During the removal of strippable coatings, special care will be taken to avoid creating any unnecessary dust. Extra care will be required around exposed welds, bolt threads, and the duct work flanges.

3) Building Demolition

Demolition of the building will start with cleaning debris off the floor, monitoring the area, and disconnecting any final service connections. Periodic monitoring of the material being removed will indicate contamination. Once the building has been emptied, the roof and walls will be removed, followed by removal of the floor, foundation, and slab. As material is brought into the holding or staging areas, the material and the exterior of the package will be surveyed and the pertinent data recorded for inventory control. When D&D of the holding or staging area begins, the boxes/packages will be segregated and transported from the holding area to another transfer location. When all demolition activity is complete and all associated contaminated soils removed, a complete and final assessment of the site will be performed. Complete description of all D&D activities as well as ongoing and final assessment results will be recorded.

21.2.3 Reusable Equipment and Facilities

Minimization of the waste quantities to be packaged for on-site interim storage has been incorporated through innovative use of the concept of "recycle and reuse." This minimization has been accomplished by segregation of the waste streams. The identification of non-contaminated equipment and material for potential reuse on site by other OUs will reduce the total waste quantity for interim on-site storage, while providing overall cost savings. This cost savings will be realized in the reduced cost for storage and by the avoidance of future procurement of this reusable material and equipment within the FEMP site.

Many components used in the Pilot Plant program have been identified as being potentially reusable for other on-site remediation projects and/or at other DOE facilities. The items identified are as follows:

1) The melter and associated control equipment from the Vitrification Facility

2) Material Handling Items
   (1) Frontloaders
   (2) Backhoes
   (3) Forklifts
   (4) Hydraulic Platforms

3) Miscellaneous equipment and material which include: electrical wire and conduit, TV cameras, fences, control instrumentation, electric poles, fuel tanks, telephones and associated wiring, alarm systems, paging/intercom systems, air compressors, lab equipment, portable lighting, hand tools, pumps, piping, generators, electrical substations, dry material storage bins, caustic and nitric acid storage tanks, various other storage tanks, temporary enclosure with HVAC, concrete drilling systems, concrete cutting systems, scaffolding, safety equipment, structural steel, mobile crane systems, overhead joist systems, administrative area HVAC, radiological identification and monitoring equipment, office equipment, desks, and chairs

Before actual D&D of equipment is performed, an equipment inventory and characterization must be completed to determine the disposal techniques used for each piece of equipment. The equipment should be characterized and determination made whether or not the equipment is reusable. This equipment may be stored if it can't be reused immediately.

21.3 References

21.1) United States Department of Energy, April 1992. DOE Order 5480.23, "Nuclear Safety Analysis Reports."

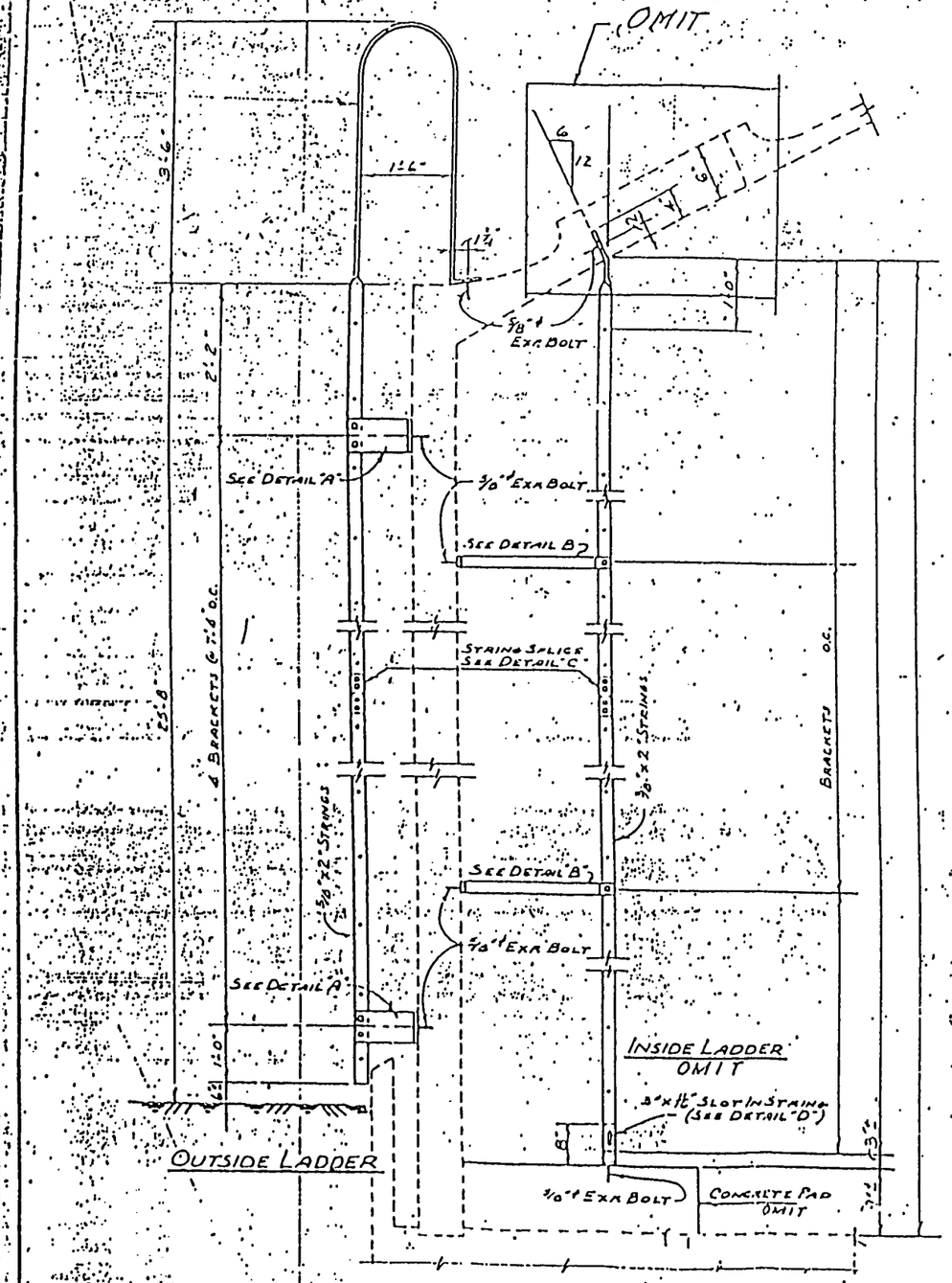
21.2) FERMCO, March 1994. *Site Safety Analysis Reference Report*, Rev. 1. FEMP-2319.

21.3) Westinghouse Hanford Company, February 1993. *Graded Approach for Safety Analysis Reports*. WHC-SP-0960, Rev. 1.

APPENDIX A

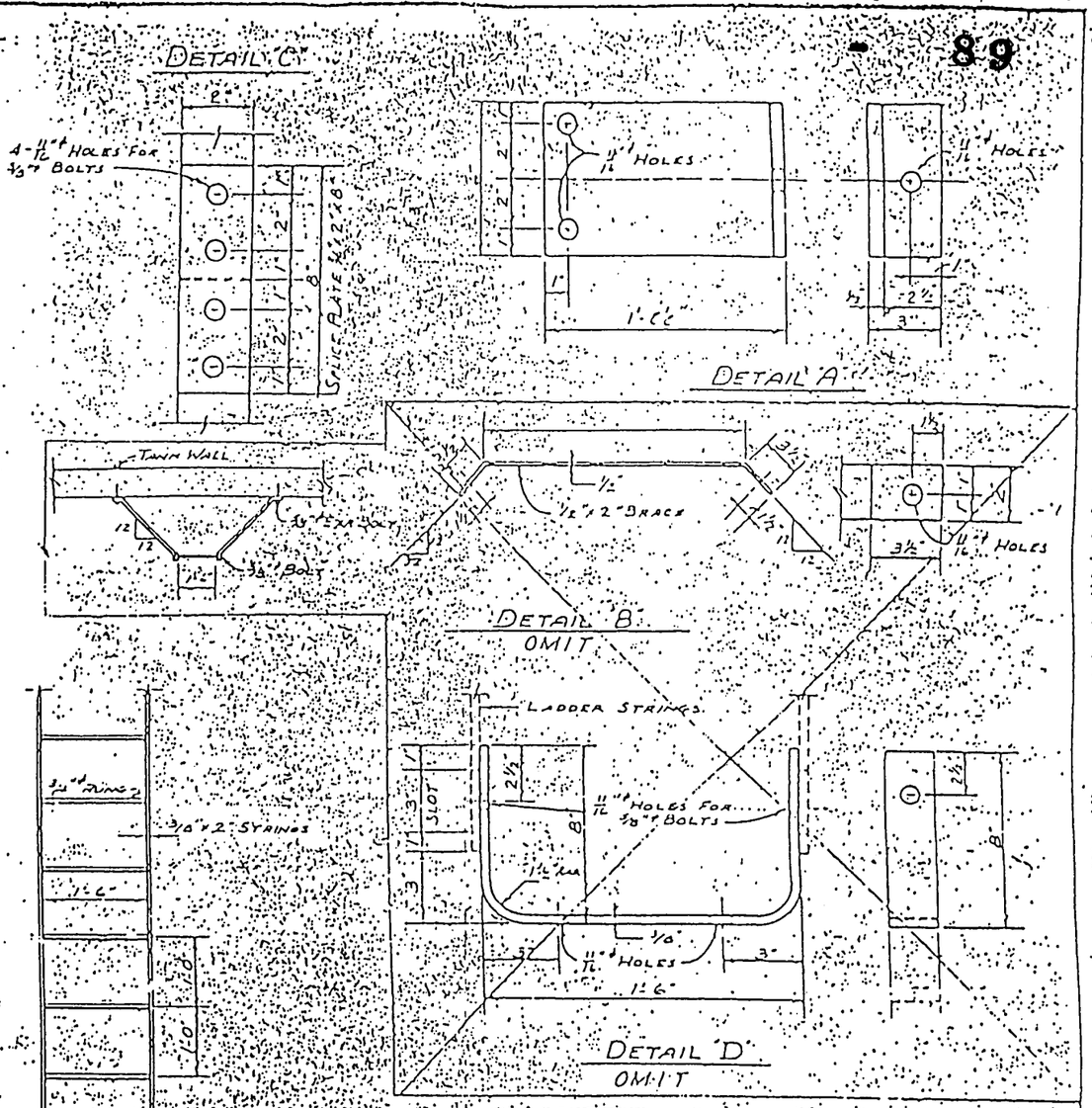
SILO AND EXISTING RADON TREATMENT SYSTEM DRAWINGS

LOCATE LADDER AT EACH VERTICAL ROW OF DECANT TAKE-OFFS.



TYPICAL WALL SECTION

NOTE: DECANT TAKE-OFFS NOT SHOWN.



FRONT ELEVATION OF LADDER

REFERENCE DRAWING
PRELOAD DWG. S1T20-3

REDUCED DRAWING
DO NOT SCALE

WORKING DRAWING

INDEX CODE			
PLANT	SYSTEM	P	SEQ NO
34X	1450	M	00088

REVISIONS			
NO.	DATE	DESCRIPTION	
1	9/11/51	REVISED. NAMES	F.D. C.C.

THIS DRAWING IS THE PROPERTY OF PRELOAD ENTERPRISES, INC. AND IS SUBJECT TO RETURN UPON DEMAND. IT CONTAINS FEATURES OF DESIGN NOT FOR USE OR REPRODUCTION WITHOUT WRITTEN PERMISSION OF PRELOAD ENTERPRISES, INC. DETRIMENTAL TO THE INTERESTS OF PRELOAD ENTERPRISES, INC. OR ITS LICENSEES.

INTERIM ISSUE ONLY

OUTSIDE LADDER

TWO 125,000 C.F. SLURRY STORAGE TANKS-TYPE X-65

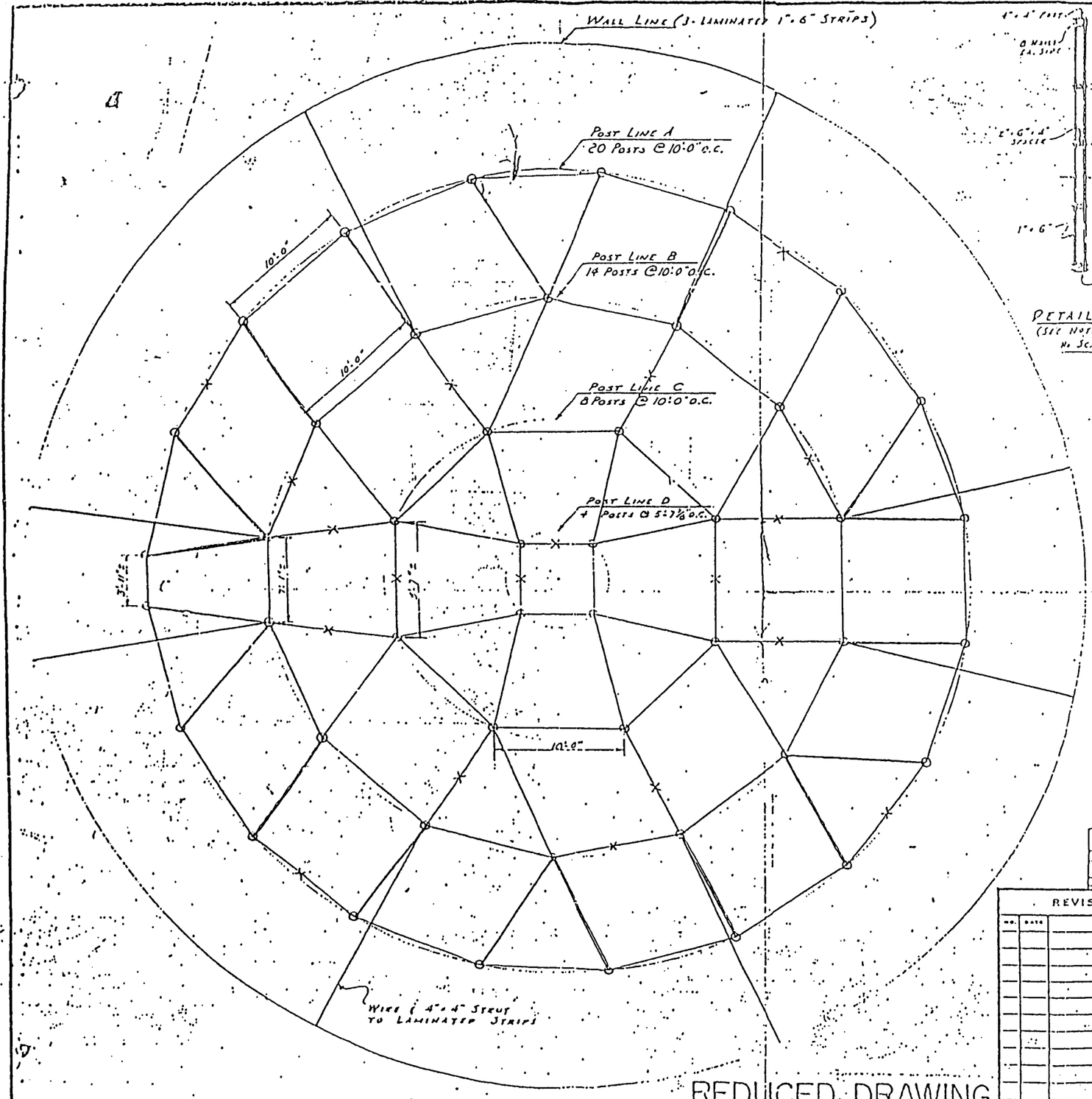
ATOMIC ENERGY COMMISSION

FERNALD, OHIO

PRELOAD ENTERPRISES, INC.
211 EAST 37TH ST. NEW YORK 16, N.Y.

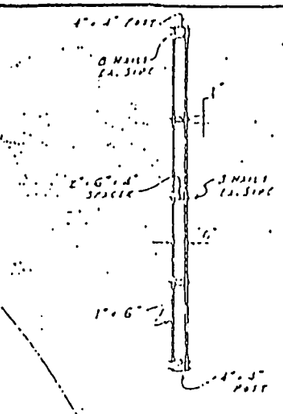
DRAWN: F.D.	SCALE: N.T.S.	DATE: 7-16-51
CHECKED: N.R.	PRELOAD	CONTRACT NUMBER: S1 WY 12
APPROVED:		DRAWING: S1T20-6

000246

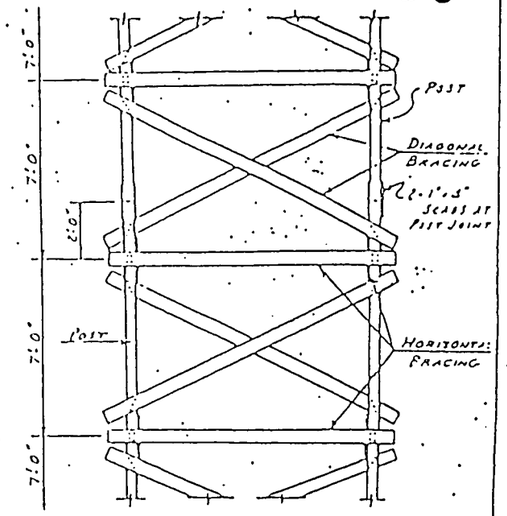


PLAN OF BRACING
SCALE: 1/16" = 1'-0"

REDUCED DRAWING
DO NOT SCALE



DETAIL "B"
(SEE NOTE # 2)
NO SCALE



DETAIL "A"
TYPICAL BRACING
SCALE: 1/4" = 1'-0"

START FROM FLOOR WITH 16'-0" LG. 4"x4" POSTS, THEN USE 14'-0" LENGTHS ABOVE IN ORDER TO BRING SHORT SPLICE ALWAYS 2'-6" ABOVE HORIZONTAL BRACING.

NOTES

1 - PLACE DIAGONAL BRACING IN ALL SPANS WHERE CROSSES ARE SHOWN.
2 - USE 1-1"x6" FOR DIAGONAL AND HORIZONTAL BRACING IN ALL SPANS WHERE SINGLE LINE IS SHOWN. USE 2-1"x6" WHERE DOUBLE LINE IS SHOWN (AS PER DETAIL "D").

REFERENCE SKETCHES.
THIS DRAWING IS BASED ON SKETCHES & COMPUTATIONS OF J. M. CROM, DATED AUGUST 18TH 1951, SHEETS Nº 1 TO 4 INCL.

INDEX CODE			
PL. & AR.	DWG.	CL.	W.A. NO.
34X	1450	S	00091

WORKING DRAWING

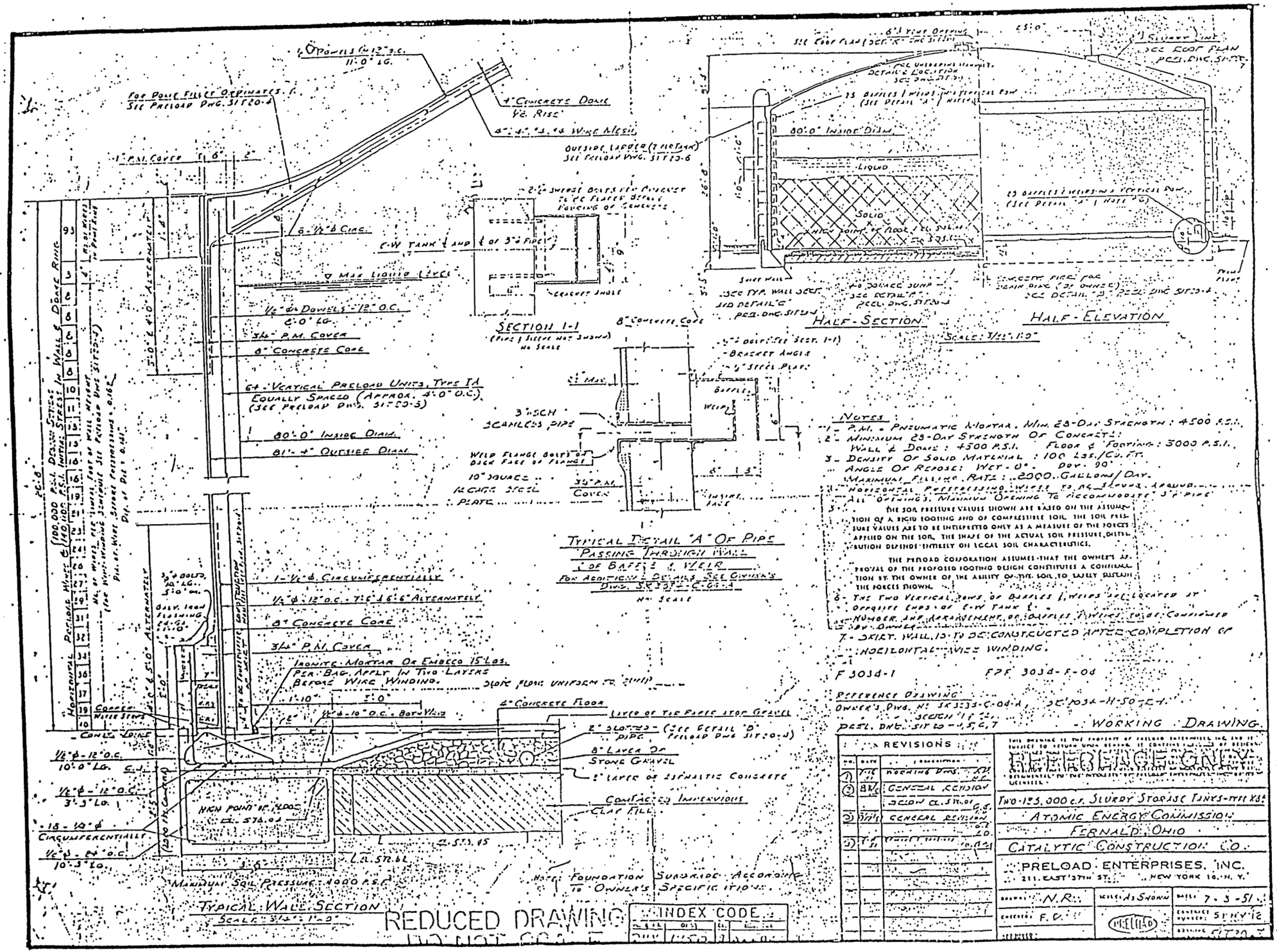
REVISIONS		
NO.	DATE	DESCRIPTION

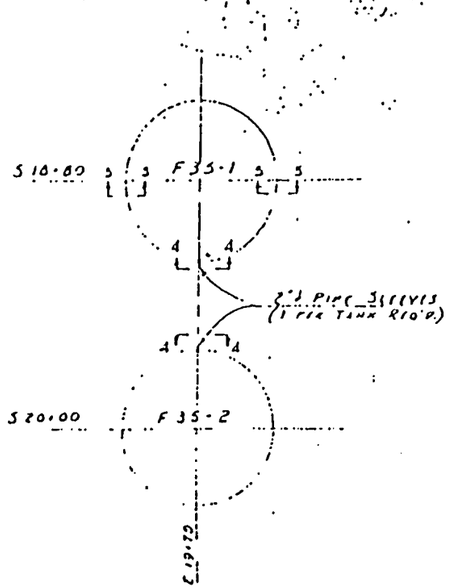
THIS DRAWING IS THE PROPERTY OF PRELOAD ENTERPRISES, INC. AND IS SUBJECT TO RETURN UPON DEMAND. IT CONTAINS FEATURES OF DESIGN NOT TO BE REPRODUCED OR DISCLOSED WITHOUT WRITTEN PERMISSION. CONDITION THAT IT IS NOT TO BE USED IN ANY WAY DETRIMENTAL TO THE INTERESTS OF PRELOAD ENTERPRISES, INC. OR ITS LICENSEES.
REFERENCE ONLY

TWO 125,000 C.F. SLURRY STORAGE TANKS
ATOMIC ENERGY COMMISSION
FERNALD, OHIO.
DOME FORMWORK - BRACING DETAILS

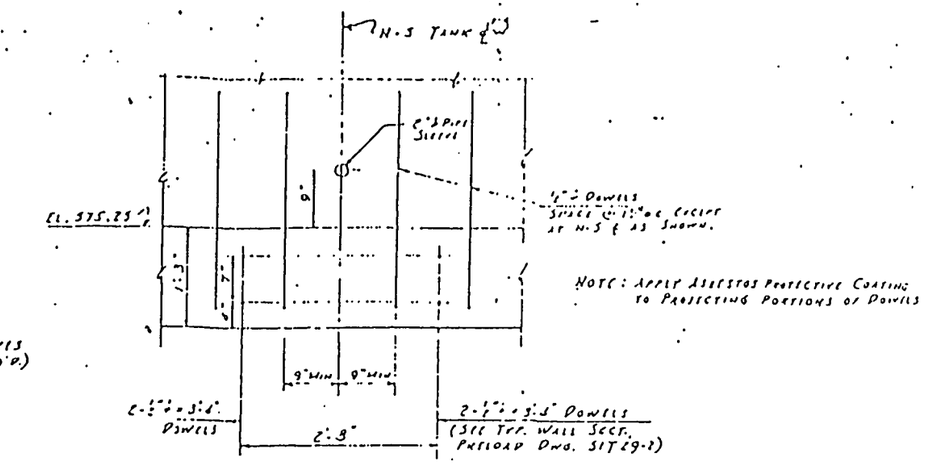
PRELOAD ENTERPRISES, INC.
211 EAST 37TH ST. NEW YORK 16, N. Y.

DRAWN: N.R.	SCALE: AS SHOWN	DATE: 9-20-1951
CHECKED: F.D.	PRELOAD	CONTRACT NUMBER: SINY12
APPROVED:		DRAWING NUMBER: S1T20-8

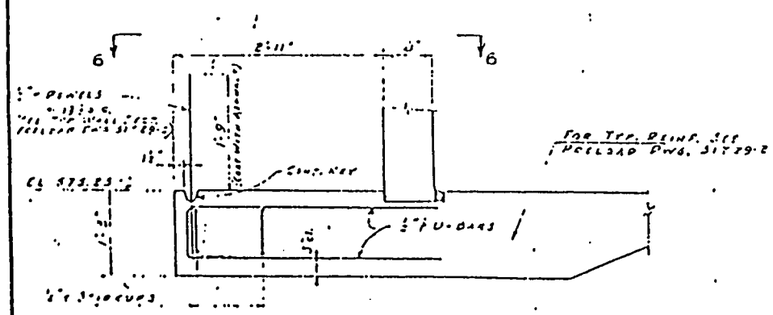

4" Concrete Dome
1/2" Rise
Outside Ladder (7 Rungs)
See Preload Dwg. S1F20-6
80'-0" Inside Diam.
Liquid
Solid
Half-Section
Half-Elevation
Scale: 3/32" = 1'-0"
Section 1-1
(Pipe & Sleeve Not Shown)
No Scale
8" Concrete Core
3/4" P.M. Cover
64 - Vertical Preload Units, Type IA
Equally Spaced (Approx. 4'-0" O.C.)
(See Preload Dwg. S1F20-5)
80'-0" Inside Diam.
81'-4" Outside Diam.
3" Sch 40 Seamless Pipe
Typical Detail "A" Of Pipe
Passing Through Wall
Of Baffle & Weir
For Addition - Details - See Owner's
Dwg. SK3533-C-04-A
No Scale
Typical Wall Section
Scale: 3/4" = 1'-0"
Maximum Soil Pressure 4000 P.S.F.
Note: Foundation Subgrade According To Owner's Specification
Notes
1 - P.M. = Pneumatic Mortar, Min. 28-Day Strength: 4500 P.S.I.
2 - Minimum 28-Day Strength Of Concrete:
Wall & Dome: 4500 P.S.I. Floor & Footing: 5000 P.S.I.
3 - Density Of Solid Material: 100 Lbs./Cu. Ft.
Angle Of Repose: Wet - 0°. Dry - 90°.
Maximum Filling Rate: 2000 Gallons/Day.
Horizontal Prestressing Wires To Be Spaced Around.
All Openings, Minimum Opening To Accommodate 3" Pipe
5 - The soil pressure values shown are based on the assumption of a rigid footing and of compressible soil. The soil pressure values are to be interpreted only as a measure of the forces applied on the soil. The shape of the actual soil pressure distribution depends entirely on local soil characteristics.
The Preload Corporation assumes that the owner's approval of the proposed footing design constitutes a confirmation by the owner of the ability of the soil to safely sustain the forces shown.
6 - The two vertical rows of baffles & weirs are located at opposite ends of the tank.
Number and arrangement of baffles and weirs to be confirmed by owner.
7 - Skirt wall is to be constructed after completion of horizontal wire winding.
F 3034-1
FPF 3034-F-08
Reference Drawing
Owner's Dwg. No. SK3533-C-04-A, SC3034-H-50-F-4
Sketch 1 F 22
Preel. Dwg. S1F20-1, 5, 6, 7
Working Drawing
Revisions
Reference Only
Two-1,133,000 C.F. Slurry Storage Tanks - Type XB
Atomic Energy Commission
Fernald, Ohio
Catalytic Construction Co.
Preload Enterprises, Inc.
211 East 37th St. New York 16, N. Y.
N.R.
As Shown
7-3-51
F.C.
Reduced Drawing
Do Not Scale
Index Code



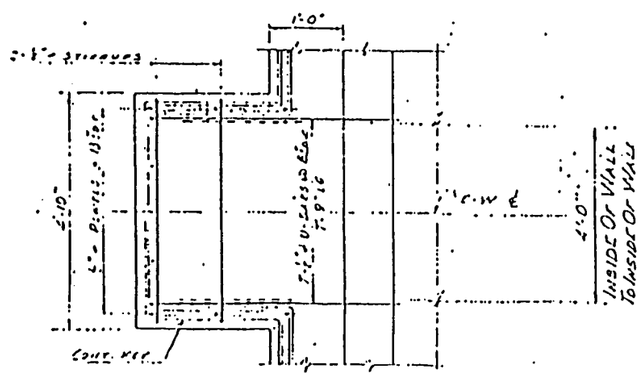
KEY PLAN



SECTION 4-4
SCALE: ½" = 1'-0"
ONE THUS PER TANK



SECTION 5-5
SCALE: ½" = 1'-0"



SECTION 6-6
NO SCALE
2 THUS PER TANK
(ONE AT EITHER END OF E-W ℄)

INDEX CODE			
PLANT	DIVISION	CLASS	ACCT. NO.
3YX	1150	M	00014

REFERENCE DRAWING
PRELOAD DWG. 51T29-2

REDUCED DRAWING
DO NOT SCALE

FPF 3035-F-04

WORKING DRAWING

REVISIONS

NO.	DATE	DESCRIPTION
1	[illegible]	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]

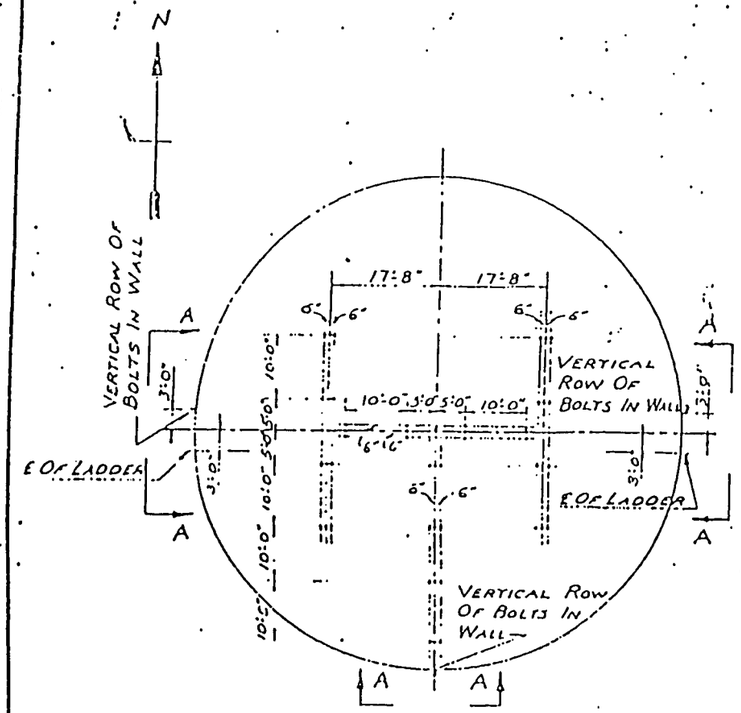
THIS DRAWING IS THE PROPERTY OF PRELOAD ENTERPRISES, INC. AND IS SUBJECT TO RETURN UPON DEMAND. IT CONTAINS PRIVATE DESIGN [illegible] REFERENCE ONLY [illegible] RESPONSIBLE TO THE INTERESTS OF PRELOAD ENTERPRISES, INC. OR ITS LICENSEES.

TWO 125,000 C.F. TANKS
ATOMIC ENERGY COMMISSION
FERNALD, OHIO
DETAILS

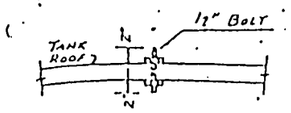
PRELOAD ENTERPRISES, INC.
211 EAST 37TH ST. NEW YORK 16, N.Y.

DRAWN: F.O.	SCALE: AS SHOWN	DATE: 10-26-51
CHECKED: N.S.	PRELOAD	CONTRACT NUMBER: 51 NY 12
APPROVED: [illegible]		DRAWING NUMBER: 51T 29-5

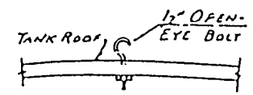
000249



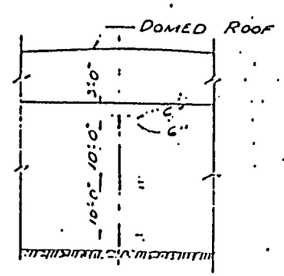
ROOF PLAN OF NORTH TANK
SOUTH TANK OPPOSITE HAND ABOUT E-W ℄
SCALE: 1/16" = 1'-0"



DETAIL OF BOLTS IN ROOF
48 REQ'D PER TANK
NO SCALE



DETAIL OF ANCHORS FOR GUY WIRES ON K-65 VENTS
4 REQ'D PER TANK. LOCATED 15'-0" FROM VENT & DIRECTLY NORTH, SOUTH, EAST & WEST OF VENT.
NO SCALE



SECTION: A-A
BOLTS IN WALL SHALL BE 12" POWER-DRIVEN BOLTS & SHALL BE SET AFTER WALL IS BUILT BUT BEFORE WIREWINDING.
27 REQUIRED PER TANK
SCALE: 1/16" = 1'-0"

NOTE:
THIS DRAWING TO BE USED FOR BOTH K65 & METAL OXIDE TANKS.

REFERENCE DRAWINGS:
PRELOAD DWG. SIT 29-2 REV 5
OWNER'S SKETCH #7 JOB # 3034 & 3035.

REDUCED DRAWING
DO NOT SCALE

INDEX CODE			
PL. & AR.	OWG.	CL.	SEQ. NO.
34X	1450	M	00095

FPF 3035-F-07

WORKING DRAWING

REVISIONS

NO.	DATE	DESCRIPTION
1	[illegible]	[illegible]
2	[illegible]	[illegible]

THIS DRAWING IS THE PROPERTY OF PRELOAD ENTERPRISES, INC. AND IS SUBJECT TO RETURN UPON DEMAND. IT CONTAINS FEATURES OF DESIGN WHICH ARE FULLY COVERED BY PATENTS, PATENTS PENDING AND CONTROL. REPRODUCTION IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION IS PROHIBITED. LICENSEES.
REFERENCE ONLY

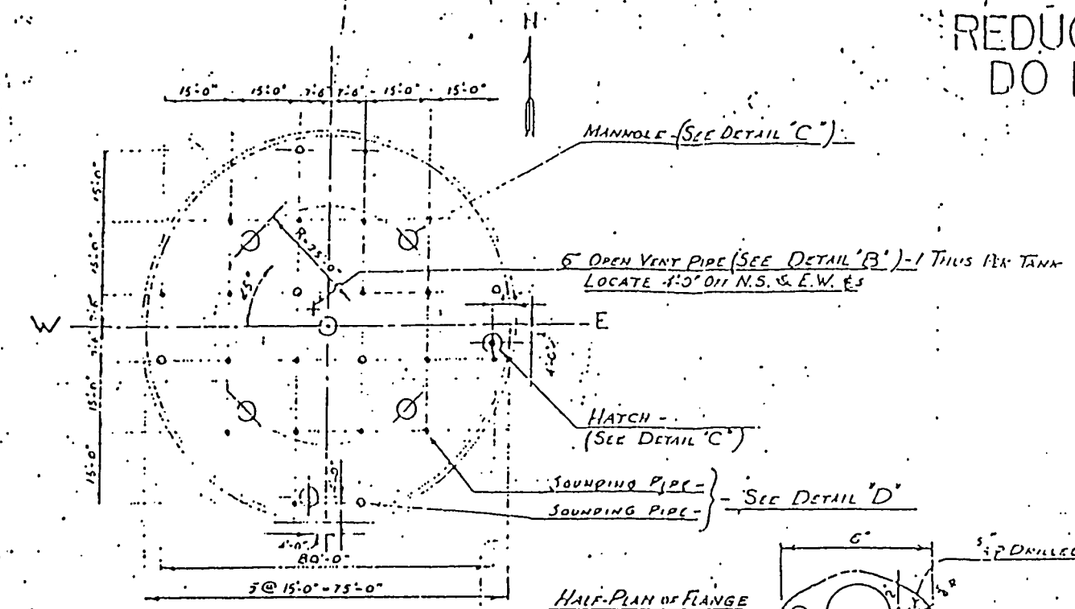
ANCHOR BOLTS FOR PIPE SUPPORTS
2-115,000 FT³ K65 & METAL OXIDE TANKS
ATOMIC ENERGY COMMISSION
FERNALD, OHIO

PRELOAD ENTERPRISES, INC.
211 EAST 37TH ST. · NEW YORK 16, N. Y.

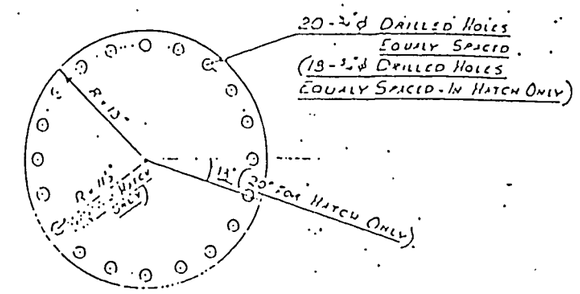
DRAWN: M. C.	SCALE: As Shown	DATE: 11-13-51
CHECKED: A. J. A.	PRELOAD	CONTRACT NUMBER: 51NY12
APPROVED:		DRAWING NUMBER: SIT 29-6

000250

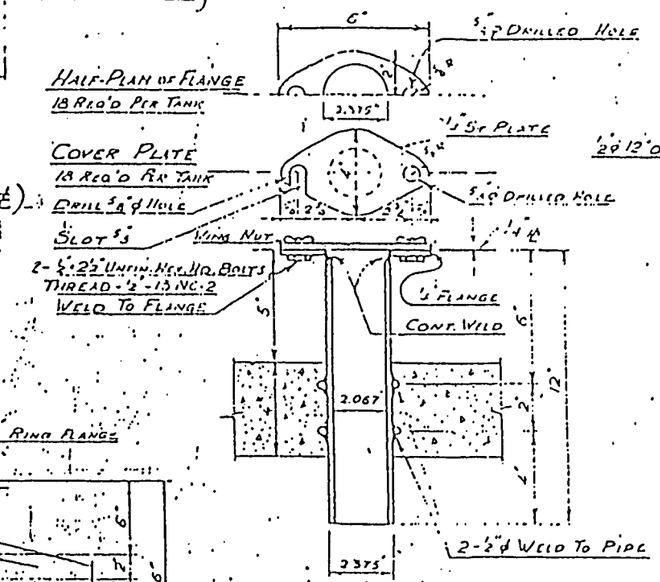
REDUCED DRAWING
DO NOT SCALE



ROOF-PLAN
NORTH TANK
(SOUTH TANK SYMM. ABT. E-W ℄)
SCALE: 3/8" = 1'-0"



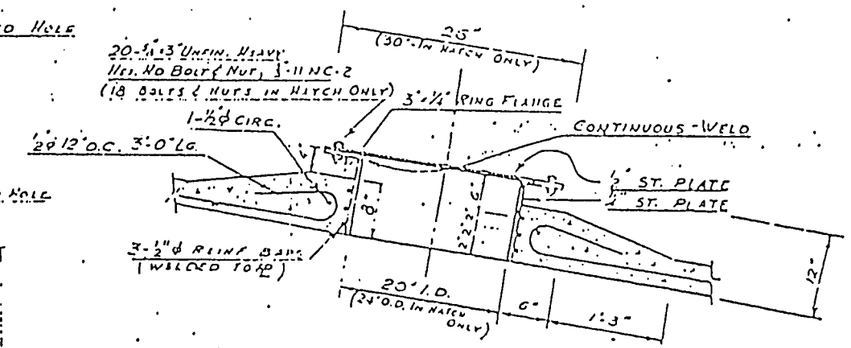
PLAN
1/2" STEEL PLATE



DETAIL "D"

SOUNDING PIPES - 18 THUS PER TANK
SOUNDING PIPES - (SIMILAR TO SOUNDING PIPE AS SHOWN EXCEPT STANDARD ROUND 2"-150# FLG. IS SUBSTITUTED FOR COVER PLATE & FLANGE SHOWN) - 6 THUS PER TANK
THE SUBSTITUTED FLG. IS TO BE WELDED TO THE 2" SCH. 40 PIPES IN MANNER SIMILAR TO THAT SHOWN.

SCALE: 3" = 1'-0"

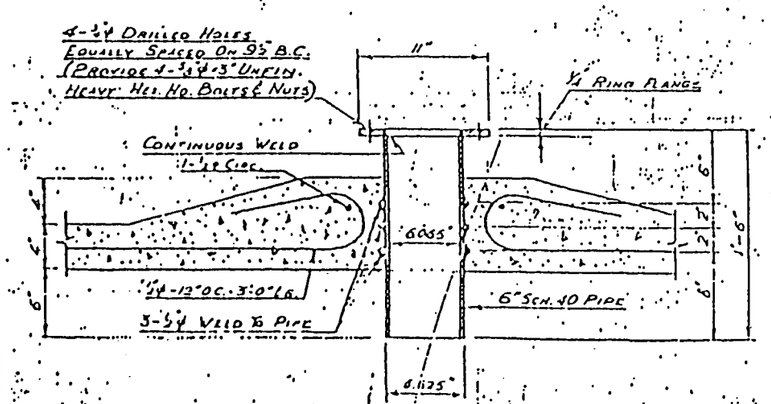


SECTION

DETAIL "C"

MANHOLES - 6 THUS PER TANK
HATCH (SIMILAR EXC. AS NOTED) - 1 THUS PER TANK

NO SCALE.



DETAIL "B"

OPEN VENT PIPE

SCALE: 1" = 1'-0"

INDEX CODE			
FL. & AR.	O.NO.	CL.	SER. NO.
3YX	1850	7	00096

REFERENCE DRAWING:
PRELOAD DWG. 51T29-2
CATALYTIC CONST. CO. DWG. NO. 3035-SKETCH 1.

FPF 3035-F-08

WORKING DRAWING

REVISIONS		
NO.	DATE	DESCRIPTION
1	3/17/52	PER CODE NO. 75

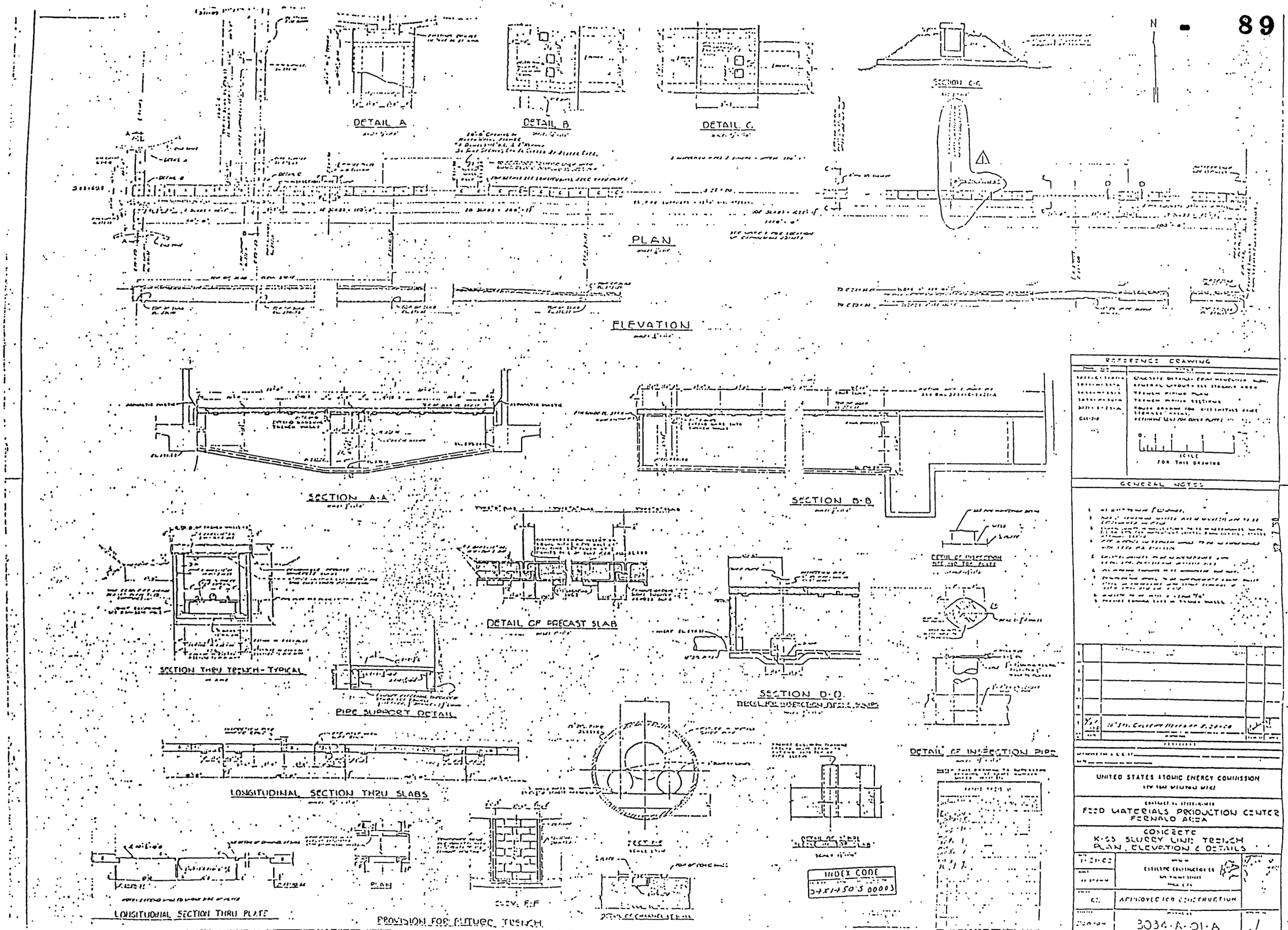
THIS DRAWING IS THE PROPERTY OF PRELOAD ENTERPRISES, INC. AND IS SUBJECT TO RETURN UPON DEMAND. IT CONTAINS FEATURES OF DESIGN DETRIMENTAL TO THE INTERESTS OF PRELOAD ENTERPRISES, INC. OR ITS ASSIGNEES.
FOR REFERENCE ONLY

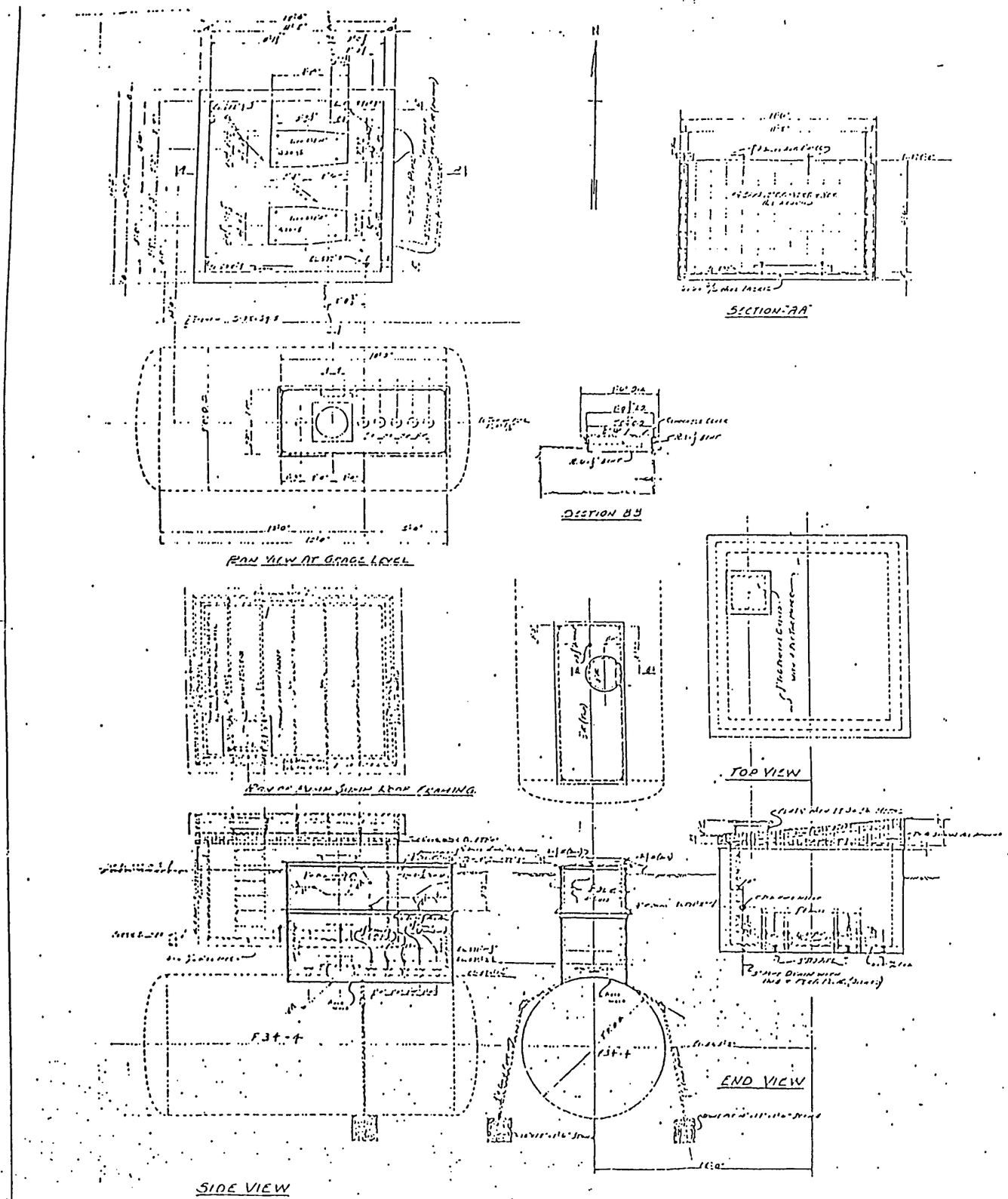
TWO METAL OXIDE TANKS
ATOMIC ENERGY COMMISSION
FERNALD, OHIO.
ROOF PIPING PLAN

PRELOAD ENTERPRISES, INC.
211 EAST 37TH ST. NEW YORK 16, N. Y.

DRAWN: J.P.	SCALE: AS SHOWN	DATE: 2-13-52
CHECKED: F.P.	PRELOAD	CONTRACT NUMBER: 51 NY 12
APPROVED:		DRAWING NUMBER: 51T29-7

000251


DETAIL A
DETAIL B
DETAIL C
SECTION C-C
PLAN
ELEVATION
SECTION A-A
SECTION B-B
SECTION THRU TRENCH - TYPICAL
DETAIL OF PRECAST SLAB
PIPE SUPPORT DETAIL
SECTION D-D
DETAIL OF INSPECTION PIPE
LONGITUDINAL SECTION THRU SLABS
LONGITUDINAL SECTION THRU PLATE
PLAN
PROVISION FOR FUTURE TRENCH
INDEX CODE
REFERENCE DRAWING
SCALE FOR THIS DRAWING
GENERAL NOTES
UNITED STATES ATOMIC ENERGY COMMISSION
FEED MATERIALS PRODUCTION CENTER
FERNALD AREA
CONCRETE
K-65 SLURRY LINE TRENCH
PLAN, ELEVATION & DETAILS
APPROVED FOR CONSTRUCTION
3034-A-01-A
1



NOTES:

(1) REINFORCING STEEL SHALL BE INTERMEDIATE BASE BILLET STEEL BARS IN ACCORDANCE WITH LATEST REVISION OF ASTM SPECS A15 & A305

(2) CONCRETE SHALL BE CLASS "B" (3500#) 3000 P.S.I. EXCEPT FOR FLOOR SLABS WHICH SHALL BE CLASS "D" (3750#) 3000 P.S.I.

(3) ALL CONSTRUCTION JOINTS SHALL BE KEYED IN ACCORDANCE WITH C.C.C. SPECS. 019-313-314.

(4) BEARING VALUE OF SOIL 3000# SQ. FT.

(5) TRENCH EXCAVATION SHALL BE NEAT AND TRENCH SHALL BE INSTALLED ABOVE BUT AND ADJACENT SECTION OF TRENCH AS SOON AS POSSIBLE AFTER EXCAVATION HAS BEEN COMPLETED, BACKFILL WITH A GRANULAR FILL.

(6) PAINTING: ONE COAT RED LEAD PRIMER FOLLOWED BY TWO (2) COATS SILVER ALUMINUM. PAINT COLOR FOR PIPE WITH ONE COAT WHITE LEAD OR EQUAL (2 COATS)

REFERENCE DRAWINGS	
TITLE	DRAWING NUMBER
SHEET & TRENCH	3034-A-01A
TRENCH PIPING PLAN	3034-A-01B
TRENCH PIPING PLAN	3034-A-01C

SCALE FOR THIS DRAWING

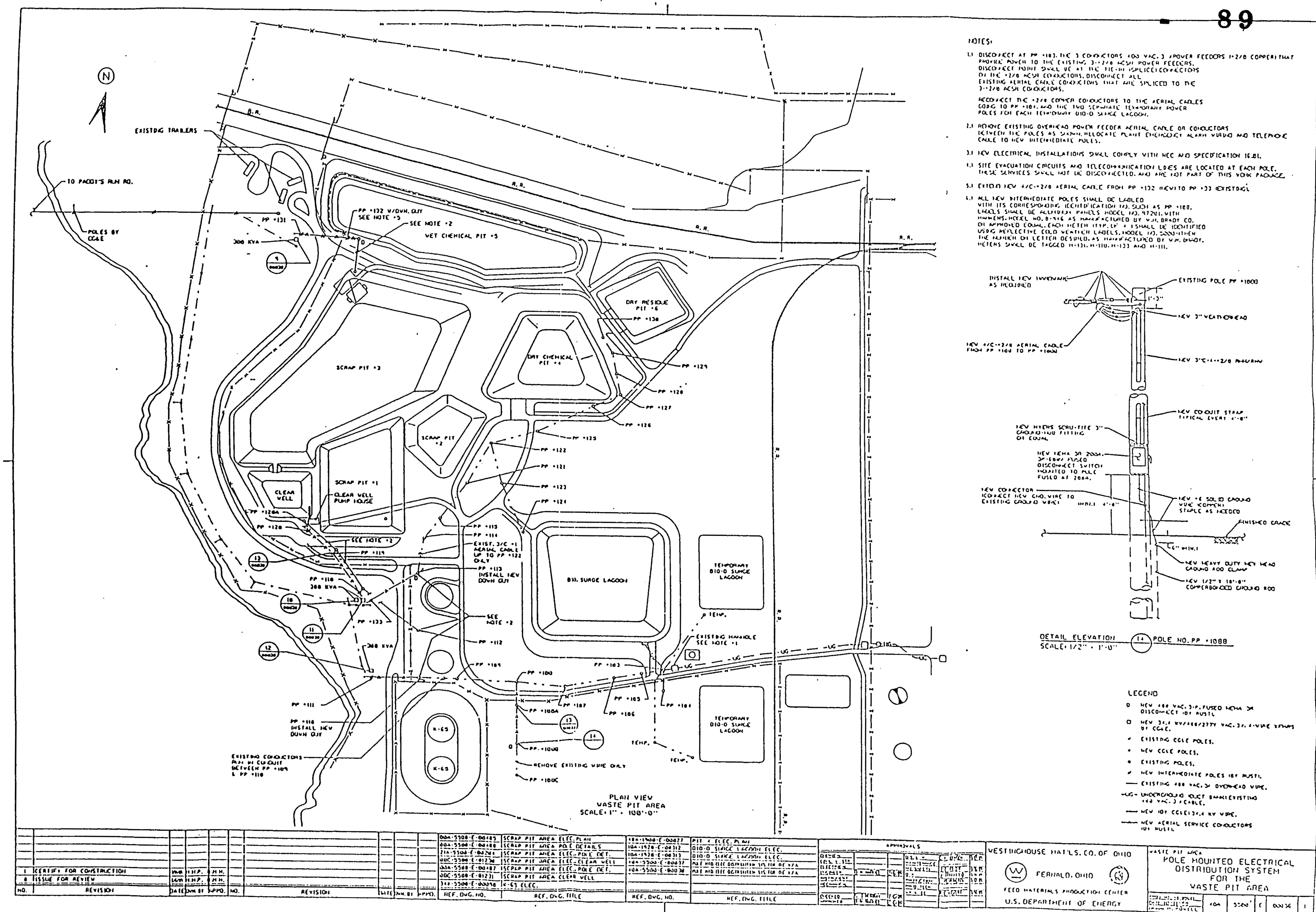
UNITED STATES ATOMIC ENERGY COMMISSION
NEW YORK OPERATIONS OFFICE

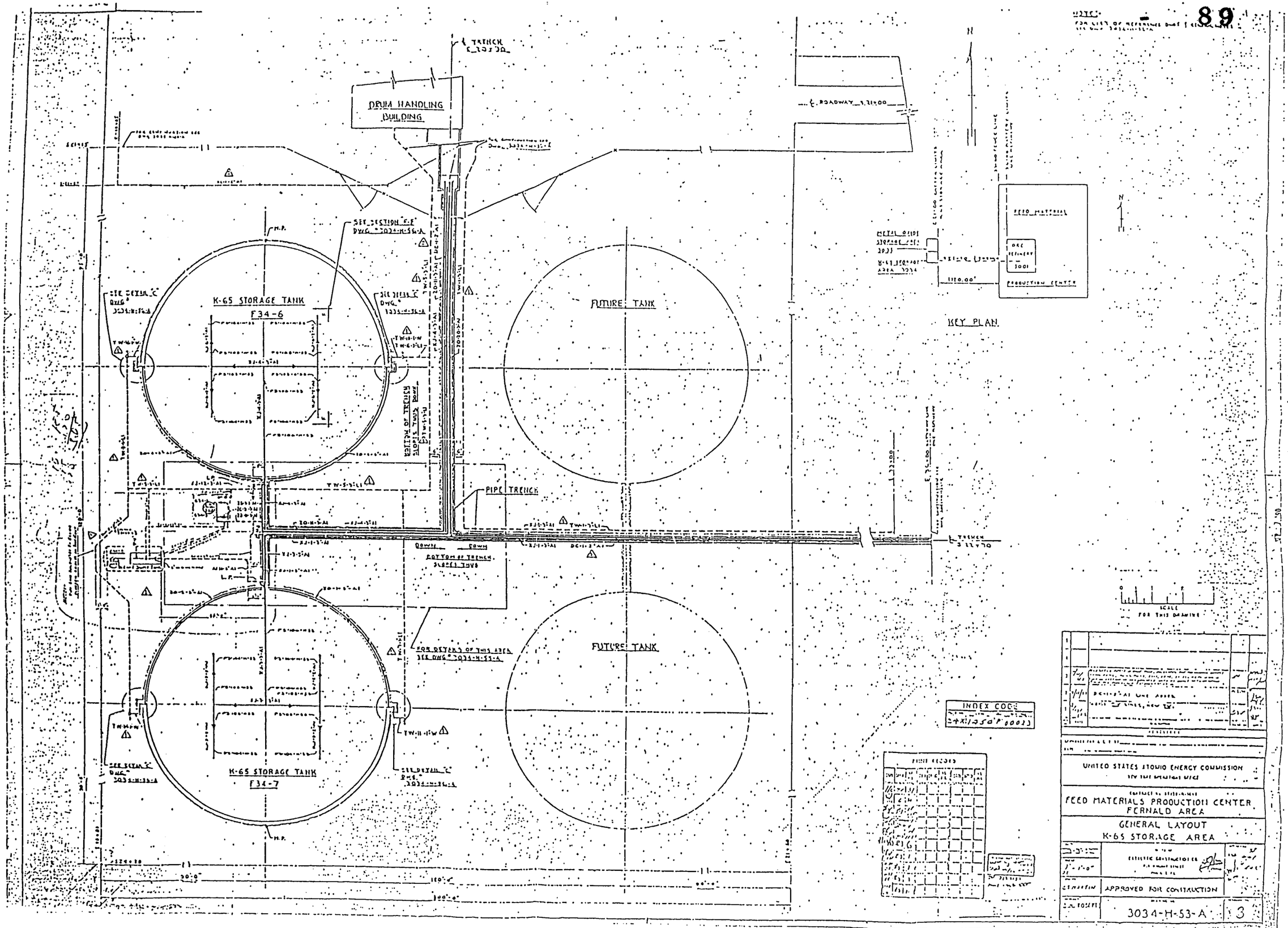
FEED MATERIALS PRODUCTION CENTER
FERNALD AREA

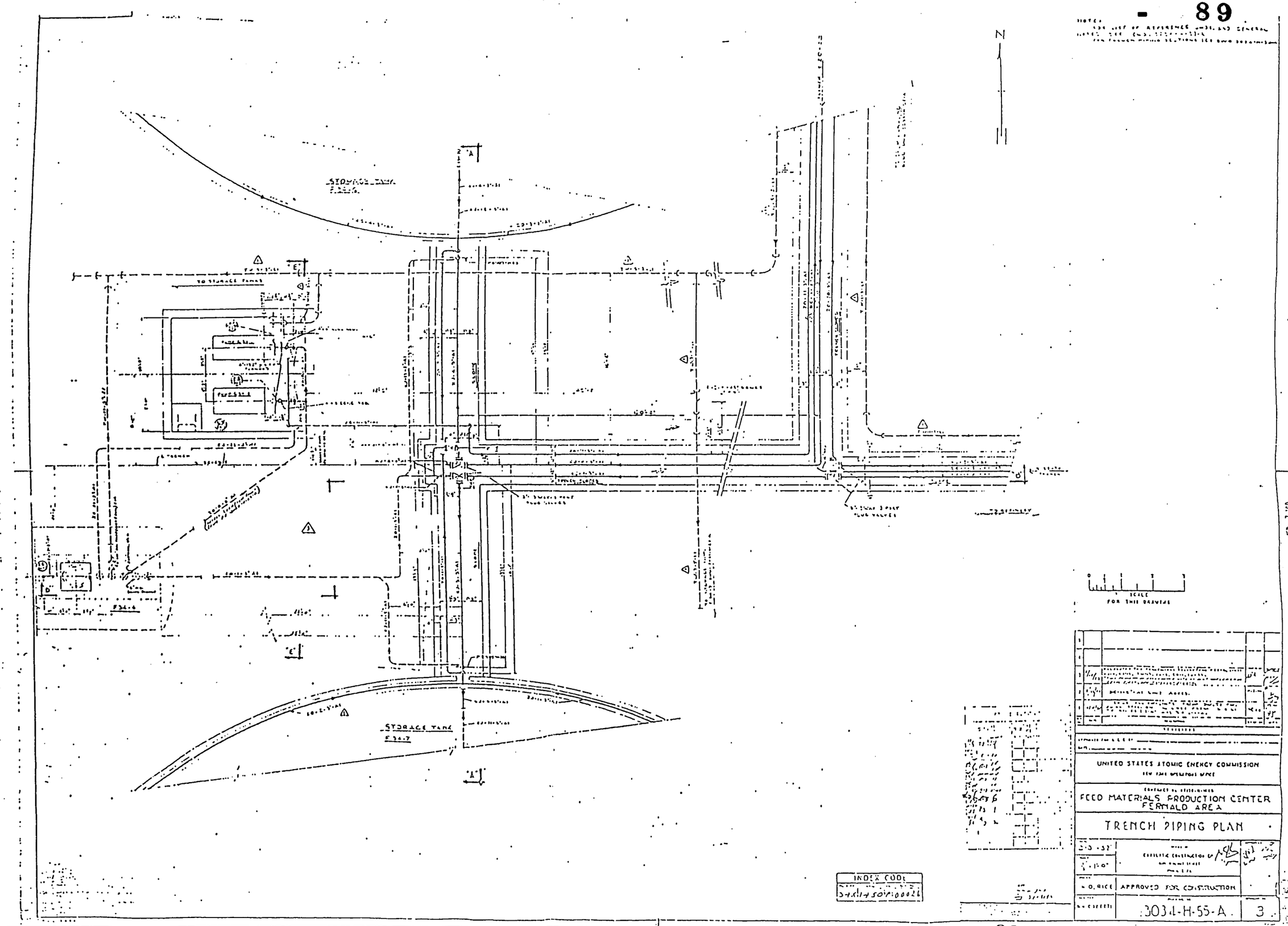
STRUCTURAL
PUMP PIT & PIPING ACCESS COMPARTMENT FOR RECEIVING & STORAGE AREA

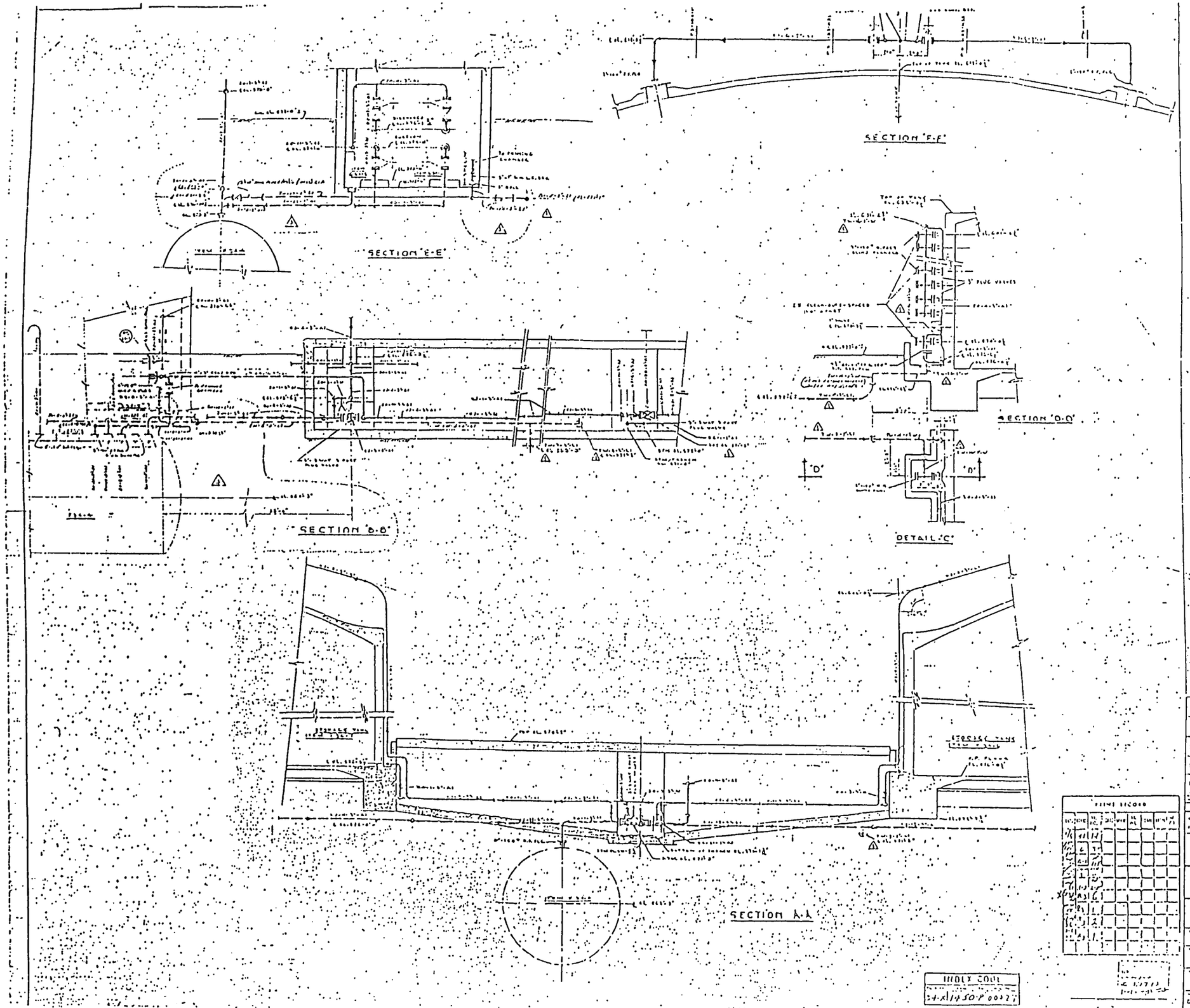
3-19-62	STATE CONTRACTOR	
012	APPROVED FOR CONSTRUCTION	
	3034-A-02-A	

INDEX CODE
D4K19503-0000-1


NOTES:
3.) NEW ELECTRICAL INSTALLATIONS SHALL COMPLY WITH NEC AND SPECIFICATION 16.01.
4.) SITE EVACUATION CIRCUITS AND TELECOMMUNICATION LINES ARE LOCATED AT EACH POLE. THESE SERVICES SHALL NOT BE DISCONNECTED, AND ARE NOT PART OF THIS WORK PACKAGE.
EXISTING TRAILERS
TO PADDY'S RUN RD.
POLES BY CG&E
SCRAP PIT #3
SCRAP PIT #2
SCRAP PIT #1
CLEAR WELL
CLEAR WELL PUMP HOUSE
DRY CHEMICAL PIT #4
DRY RESIDUE PIT #6
BIO. SURGE LAGOON
TEMPORARY BIO-D SURGE LAGOON
K-65
R.R.
PLAN VIEW
WASTE PIT AREA
SCALE: 1" = 100'-0"
DETAIL ELEVATION
POLE NO. PP #1088
LEGEND
EXISTING POLES.
WESTINGHOUSE MAT'LS. CO. OF OHIO
FERNALD, OHIO
FEED MATERIALS PRODUCTION CENTER
U.S. DEPARTMENT OF ENERGY
WASTE PIT AREA
POLE MOUNTED ELECTRICAL
DISTRIBUTION SYSTEM
FOR THE
WASTE PIT AREA
CERTIFY FOR CONSTRUCTION
ISSUE FOR REVIEW
REVISION
REF. DWG. NO.
REF. DWG. TITLE


DRUM HANDLING BUILDING
K-65 STORAGE TANK
F34-6
FUTURE TANK
PIPE TRENCH
K-65 STORAGE TANK
F34-7
FUTURE TANK
KEY PLAN
INDEX CODE
UNITED STATES ATOMIC ENERGY COMMISSION
FEED MATERIALS PRODUCTION CENTER
FERNALD AREA
GENERAL LAYOUT
K-65 STORAGE AREA
APPROVED FOR CONSTRUCTION
3034-H-53-A
3


N
STORAGE TANK
STORAGE TANK
SCALE
FOR THIS DRAWING
UNITED STATES ATOMIC ENERGY COMMISSION
FEED MATERIALS PRODUCTION CENTER
FERNALD AREA
TRENCH PIPING PLAN
APPROVED FOR CONSTRUCTION
3034-H-55-A
3
INDEX CODE



SCALE FOR THIS DRAWING

3			
2			
1			
3			
2			
1			
NO.			

REVISIONS RECORD

UNITED STATES ATOMIC ENERGY COMMISSION

FEED MATERIALS PRODUCTION CENTER
FERNALD AREA

TRENCH PIPING SECTIONS

3-3-52

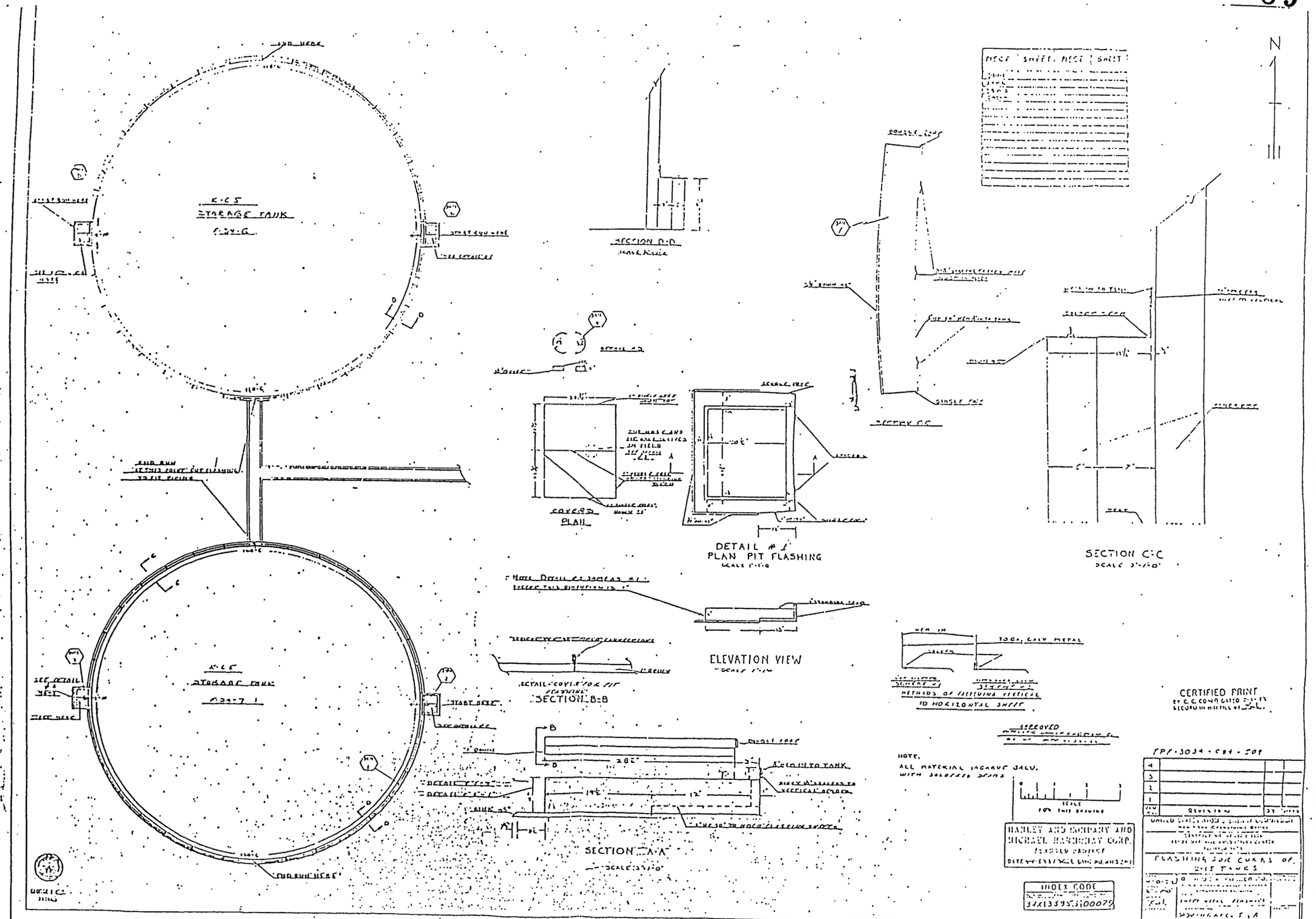
1"=1'-0"

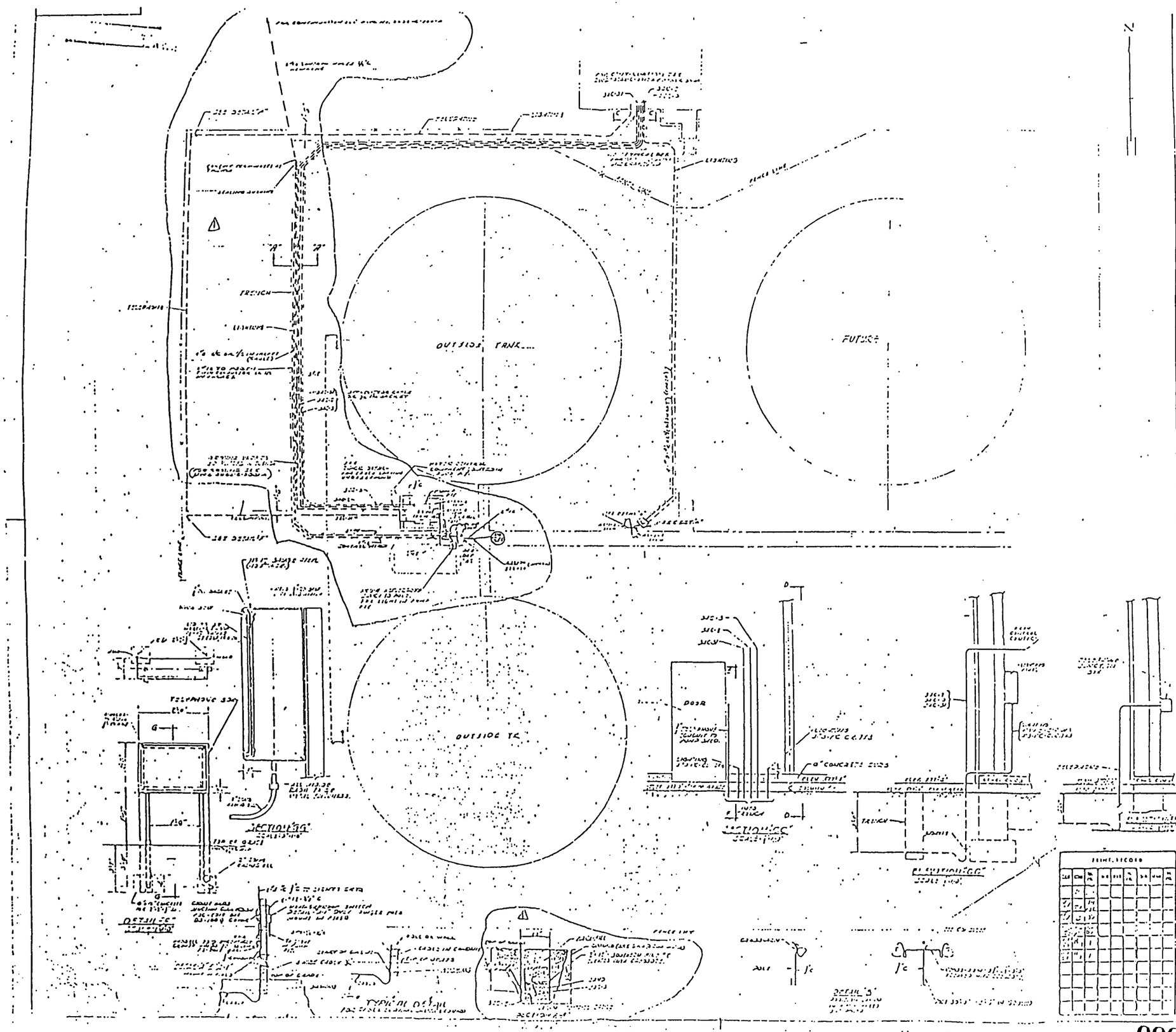
H.O. REED

APPROVED FOR CONSTRUCTION

3034-H-56-A

3


N
K-C S
STORAGE TANK
SECTION D-D
SECTION C-C
COVERED PLAN
DETAIL # 1
PLAN PIT FLASHING
SECTION C-C
ELEVATION VIEW
SECTION B-B
METHODS OF FASTENING VERTICAL TO HORIZONTAL SHEET
SECTION A-A
CERTIFIED PRINT
NOTE,
ALL MATERIAL INCAVUE GALV.
WITH SOLDERED SEAMS
SCALE
FOR THIS DRAWING
HAMLET AND COMPANY AND
MICHAEL HARDINAY CORP.
INDEX CODE
FLASHING FOR COVERS OF
K-C S TANKS
REVISION
000258



REFERENCE DRAWINGS

SCALE FOR THIS DRAWING

INDEX CODE

UNITED STATES ATOMIC ENERGY COMMISSION

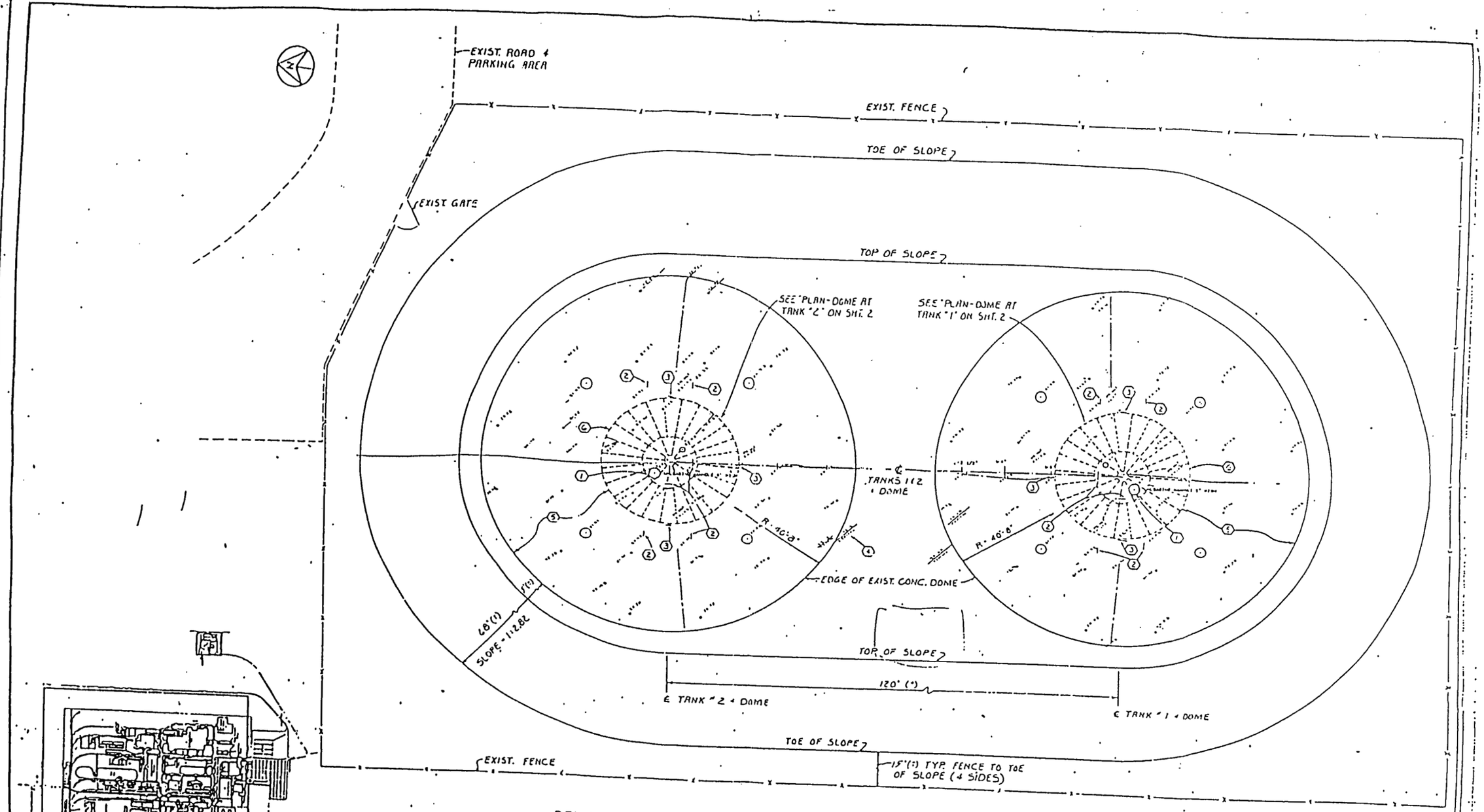
FEED MATERIALS PRODUCTION CENTER
FERNALD AREA

PLOT PLAN-LIGHTING & POWER OUTSIDE TANK
CROW ANNEXING BUILDING

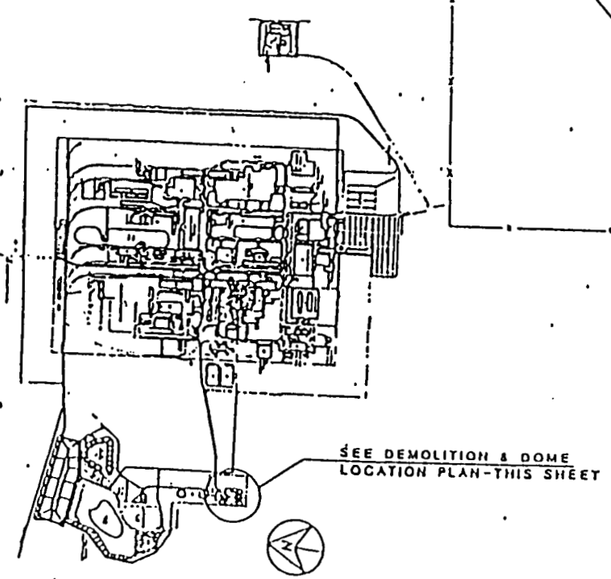
ISSUED FOR CONSTRUCTION

G.O. 30034-C-3011-A 1

000259



DEMOLITION AND DOME LOCATION PLAN
NO SCALE



SITE PLAN

GENERAL NOTES

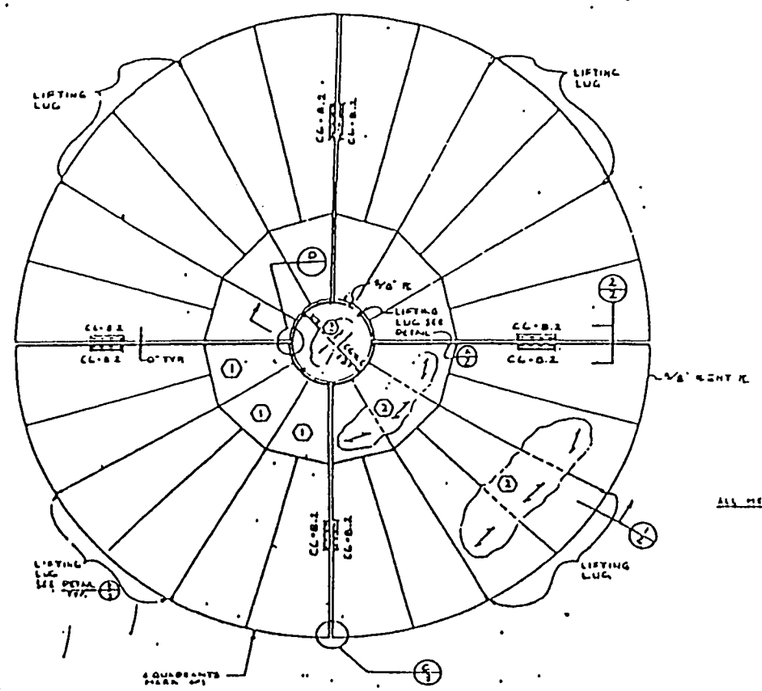
1. FOR FUTURE DOME DESIGN THAT MODULE REMOVABLE PANEL IS CENTERED OVER EXISTING INSTRUMENT PANNELS. REFER TO PLANS AS REFER 2 FOR LOCATION OF REMOVABLE PANEL IN DOME.
2. CUT AND EXISTING 40" WIDE METAL BASE STRUCTURE TO 6" ABOVE TOP OF CONCRETE. FOR ANY CUT MEMBERS THAT ARE BROKEN, PROVIDE A METAL FOR TACK WELDED IN PLACE.
3. CUT ** EXISTING 40" OR 6" WIDE METAL BASE STRUCTURE LEVEL WITH TOP OF CONCRETE.
4. ELEVATIONS SHOWN ARE TAKEN FROM AN ASSUMED ELEVATION OF 100.00 FEET AT THE EDGE OF THE EXISTING CONCRETE TANK DOME TOP AS SHOWN.
5. STATES OF FLUID APPLIED MEMBRANE ARE FROM INSPECTION OF TENCOTE CAS SHOWN ON DETAIL 3 ON SHEET 3 TO 1'-0" BELOW EDGE OF CONCRETE DOME.
6. INSPECTION TO USE EXTREME CAUTION WHEN REMOVING NEW STRUCTURE ON TOP OF EXISTING CONCRETE DOME TO AS NOT TO DAMAGE THE EXISTING STRUCTURE TO INTACT CONDITION.

LEGEND

DO NOT SCALE REDUCED DRAWING

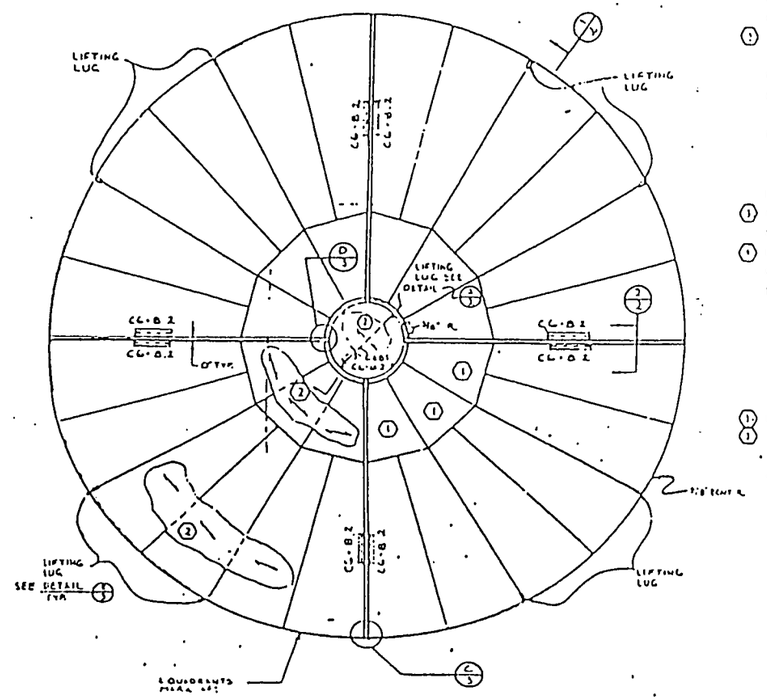
0	JAS	ISSUED FOR CONSTRUCTION	

JAS	F.M.P.C. FERNALD, OHIO PROTECTIVE COVER SYSTEM FOR K-65 TANKS	NONE
JAS	SITE, DEMO & LOCATION PLANS	12-16-85 / 3-8-90
	CANARGO ASSOCIATES, LIMITED	1
	34X-5500-S-00109	0



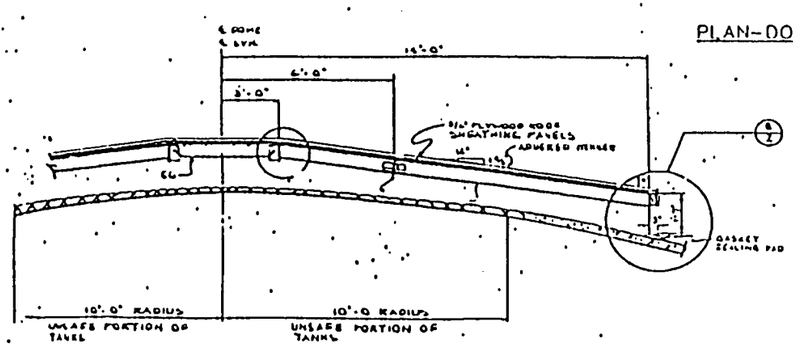
ALL MEMBERS WL-4 U.U.

PLAN – DOME AT TANK #2

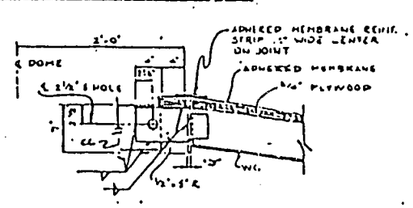


PLAN – DOME AT TANK #1

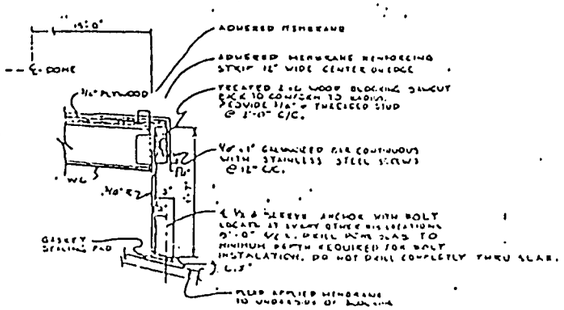
PLAN–DOMES AT K-65 STORAGE TANKS



SECTION



DETAIL

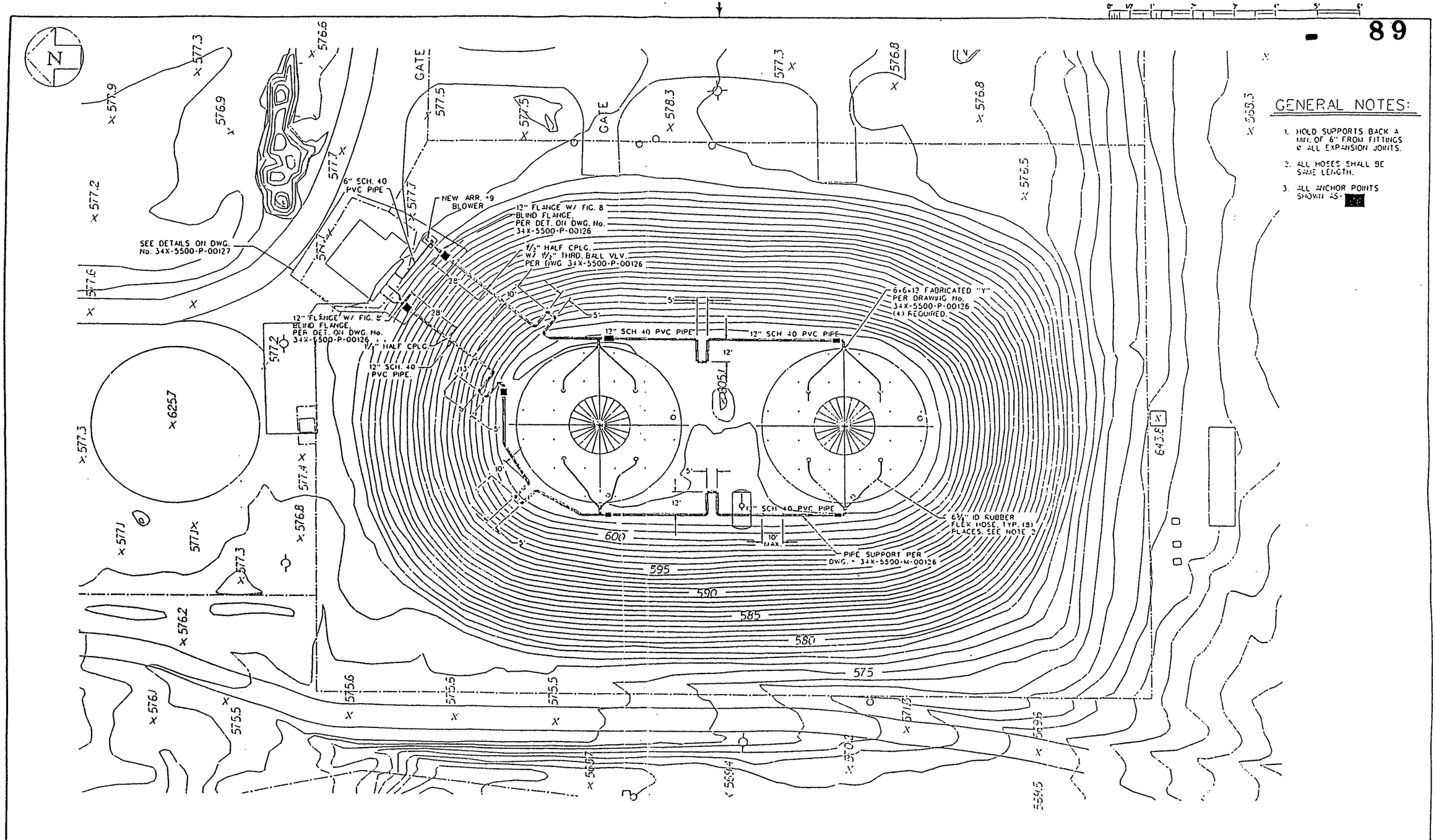


DETAIL

DO NOT SCALE REDUCED DRAWING

0	JAS	ISSUED FOR CONSTRUCTION	12-14-88

E.G.C.	F.M.P.C., FERNALD, OHIO PROTECTIVE COVER SYSTEM FOR K-65 TANKS	NOTED
J. SCHUERER		12-14-88
E.G.C.	DOME PLANS & DETAILS	S6-0-03
	CAMAROD ASSOCIATES, LIMITED	2
	34X-5500-S-00109	0



NO	REVISIONS	DATE	DWN. BY	APPD.	NO.	REVISIONS	DATE	DWN. BY	APPD.	REF. DWG. NO.

NOTE: WENCO C.A.D. DRAWING NOT TO BE REVISED MANUALLY

APPROVALS

CIVIL & STR			SAFETY ENG MAINTENANCE	
ELECTRICAL				
ENGINEER			O.A.	
INSTRUMENT				
MECHANICAL			FMC PROJECT	
			WASTE MANAGE	
CHECKED			O.O.E.	
APPROVED			SECURITY	

WESTINGHOUSE ENVIRONMENTAL MANAGEMENT CO. OF OHIO
FERNALD, OHIO
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
U.S. DEPARTMENT OF ENERGY

RADON TREATMENT SYSTEM IMPROVEMENTS
PIPING LAYOUT
SCALE 1" = 20'

34X-5500-P-00125 | 0

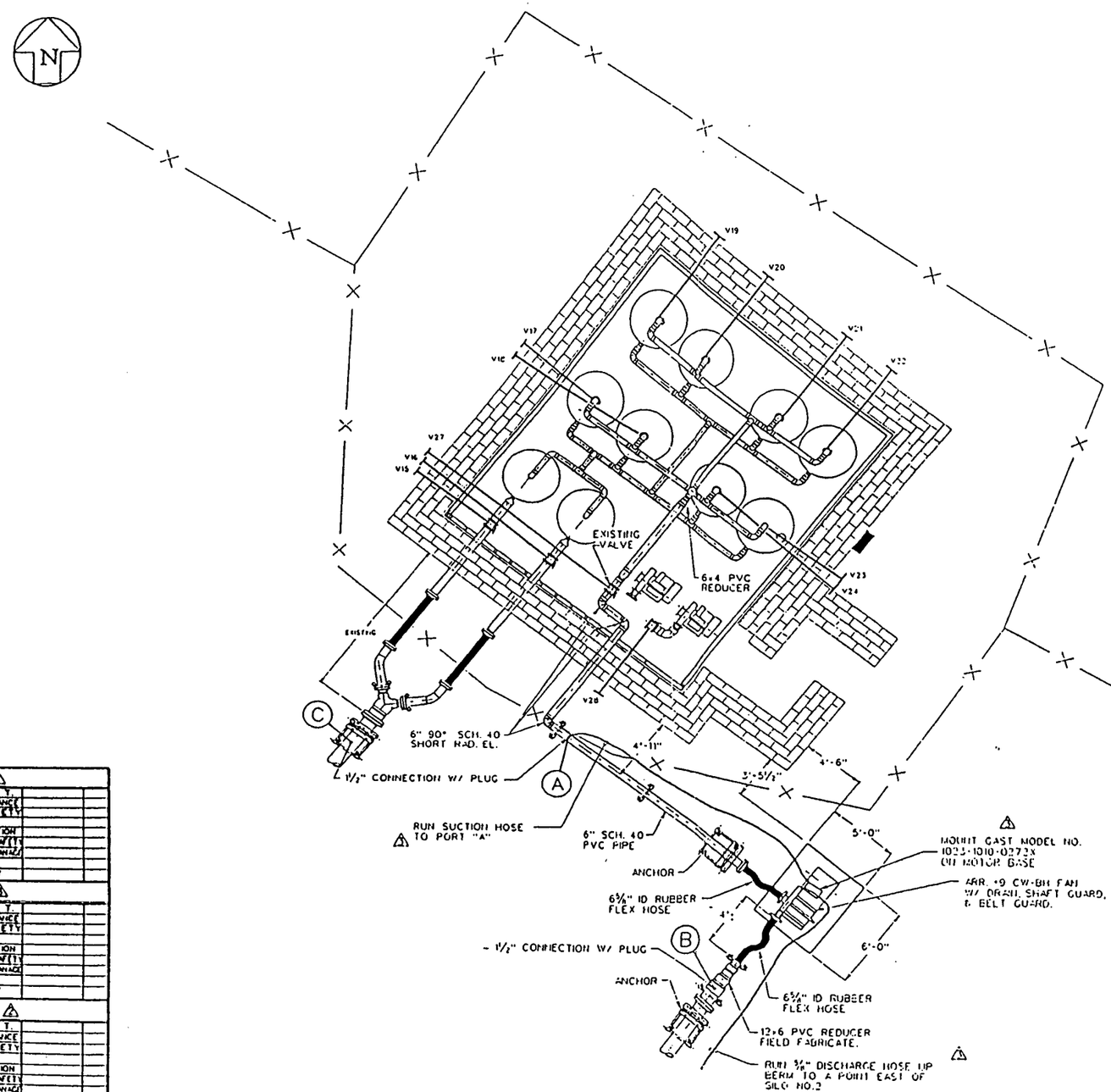
FILE NAME:

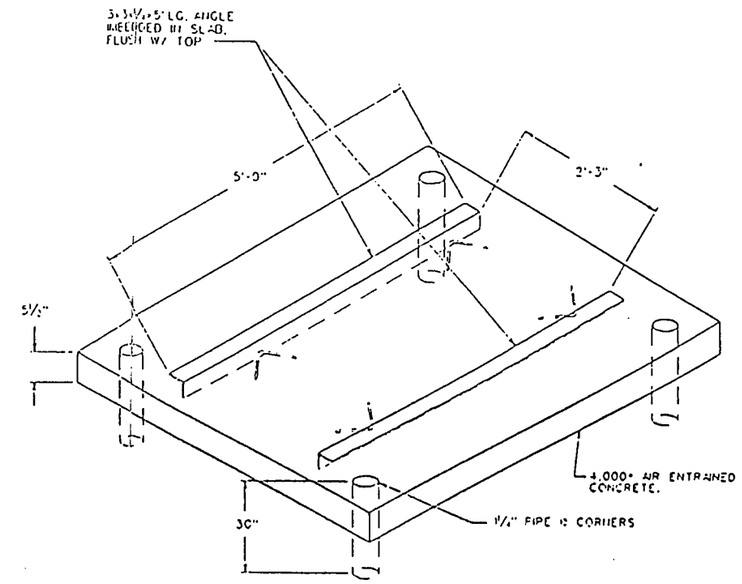
000262

APPENDIX B

VITRIFICATION FACILITY DRAWINGS

R34xp00127.m(2936.ws317) po101@ws317. Wed Dec 29 09:26:54 CST 1993





FAN FOUNDATION

MOUNT CAST MODEL NO. 1023-1010-0273X ON MOTOR BASE

ARR. #9 CW-BH FAN W/ DRAIN, SHAFT GUARD, & BELT GUARD.

RADON TREATMENT SYSTEM UPGRADE PROJECT

APPROVALS				
OU #4 MGR			I.R.S.L.T.	
PROJ ENG			MAINTENANCE	
ELECTRICAL			NU. SAFETY	
ENGINEER			O.A.	
INSTRUMENT			PRODUCTION	
MECHANICAL			FIRE & SAFETY	
HVAC ENG			WASTE MANAGE	
CHECKED			D.O.E.	
APPROVED			SECURITY	

APPROVALS				
OU #4 MGR			I.R.S.L.T.	
PROJ ENG			MAINTENANCE	
ELECTRICAL			NU. SAFETY	
ENGINEER			O.A.	
INSTRUMENT			PRODUCTION	
MECHANICAL			FIRE & SAFETY	
HVAC ENG			WASTE MANAGE	
CHECKED			D.O.E.	
APPROVED			SECURITY	

APPROVALS				
OU #4 MGR		SDB	I.R.S.L.T.	
PROJ ENG		SDB	MAINTENANCE	
ELECTRICAL			NU. SAFETY	
ENGINEER		SBB	O.A.	
INSTRUMENT			PRODUCTION	
MECHANICAL			FIRE & SAFETY	
HVAC ENG			WASTE MANAGE	
CHECKED		SBB	D.O.E.	
APPROVED		SBB	SECURITY	

NO	REVISIONS	DATE	DWN. BY	APPD.
4	ADDED REV. #3 APPROVAL BOX	07/11		
3	ADDED VACUUM PUMP & HOSE.	01/11		
2	ADDED REVISION APPROVAL BOX	5/11/11		
1	REVISED SCOPE OF WORK	5/11/11		

NO.	REVISIONS	DATE	DWN. BY	APPD.	REF. DWG. NO.

NOTE: WEMCO C.A.D. DRAWING NOT TO BE REVISED MANUALLY

APPROVALS				
CIVIL & STR			SAFETY ENG	
ELECTRICAL			MAINTENANCE	
ENGINEER			O.A.	
INSTRUMENT				
MECHANICAL			FIRE PROTECT	
ENVIRON ENG			WASTE MANAGE	
CHECKED			D.O.E.	
APPROVED			SECURITY	

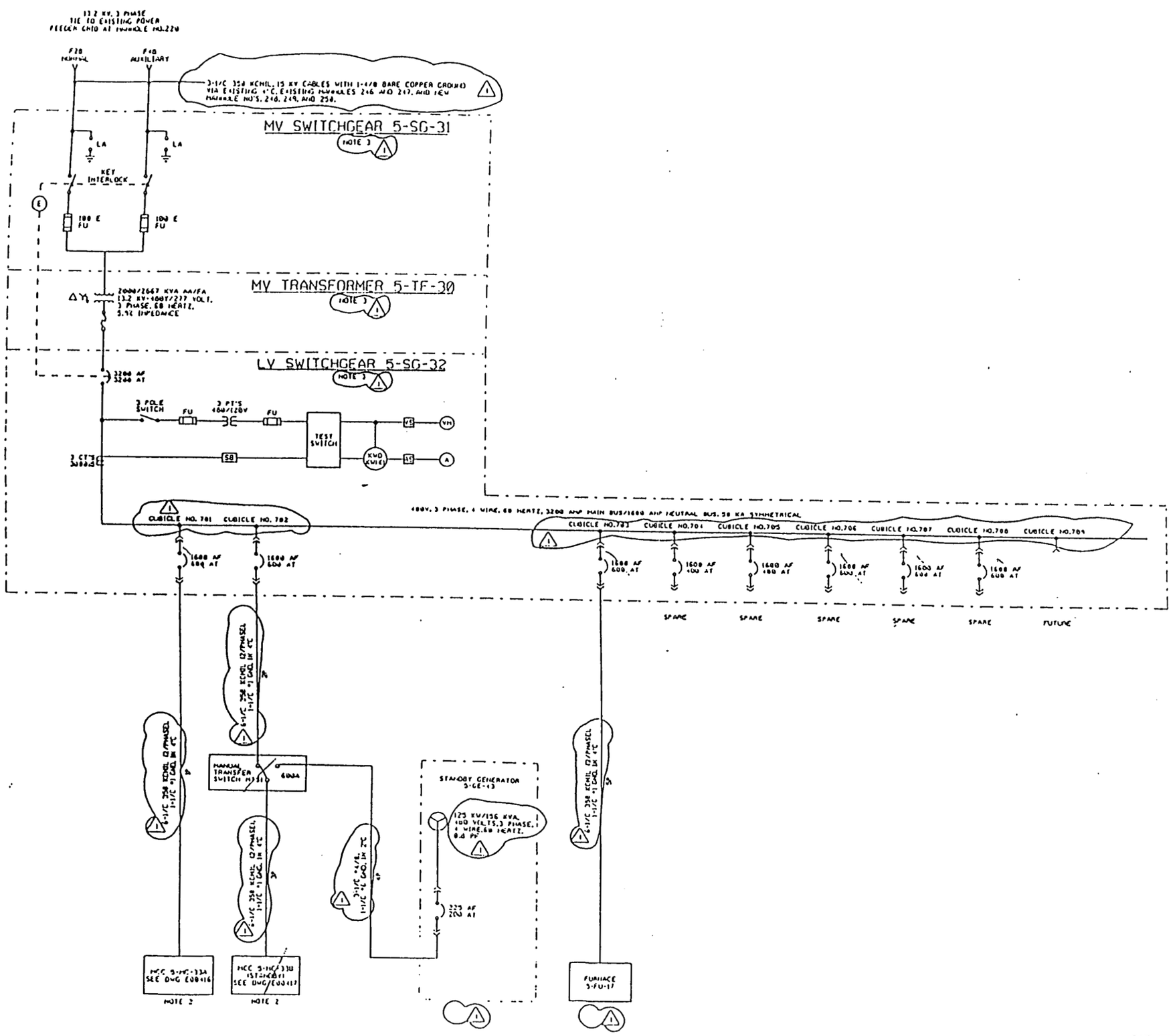
WESTINGHOUSE ENVIRONMENTAL MANAGEMENT CO. OF OHIO
FERNALD, OHIO
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
U.S. DEPARTMENT OF ENERGY

K-65 SILOS GRID #31
RADON TREATMENT SYSTEM IMPROVEMENTS
DETAILS

34X-5500-P-00127 | 4

FILE NAME: 2FA1E000.4133xP00127.DGN

94e00415.m(3744.ws3019) po85@ws3019. Tue Feb 1 10:35:08 CST 1994



NOTES

1. SEE DRAWING 94X-5900-E-00353 FOR DRAWING INDEX.
2. MCC'S - 600 AMP, 480 VOLT, 3 PHASE, 4 WIRE, 60 HERTZ, 42 KA SYMMETRICAL.
3. EXISTING MS-8 UNIT SUBSTATION FROM PLANT 5 RELOCATED TO NEW VITRIFICATION PILOT PLANT FACILITY.

REF DWG NO.	DRAWING TITLE
94X-5900-E-00353	DRAWING INDEX - SHEET 1 OF 1
94X-5900-E-00416	SINGLE LINE DIAGRAM
94X-5900-E-00417	SINGLE LINE DIAGRAM

1	GENERAL REVISIONS		
0	APPROVED FOR CONSTRUCTION	R.E.	R.E.

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. • PARSONS INTL INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

VITRIFICATION PILOT PLANT DESIGN
CRU4 - ONE METRIC TON

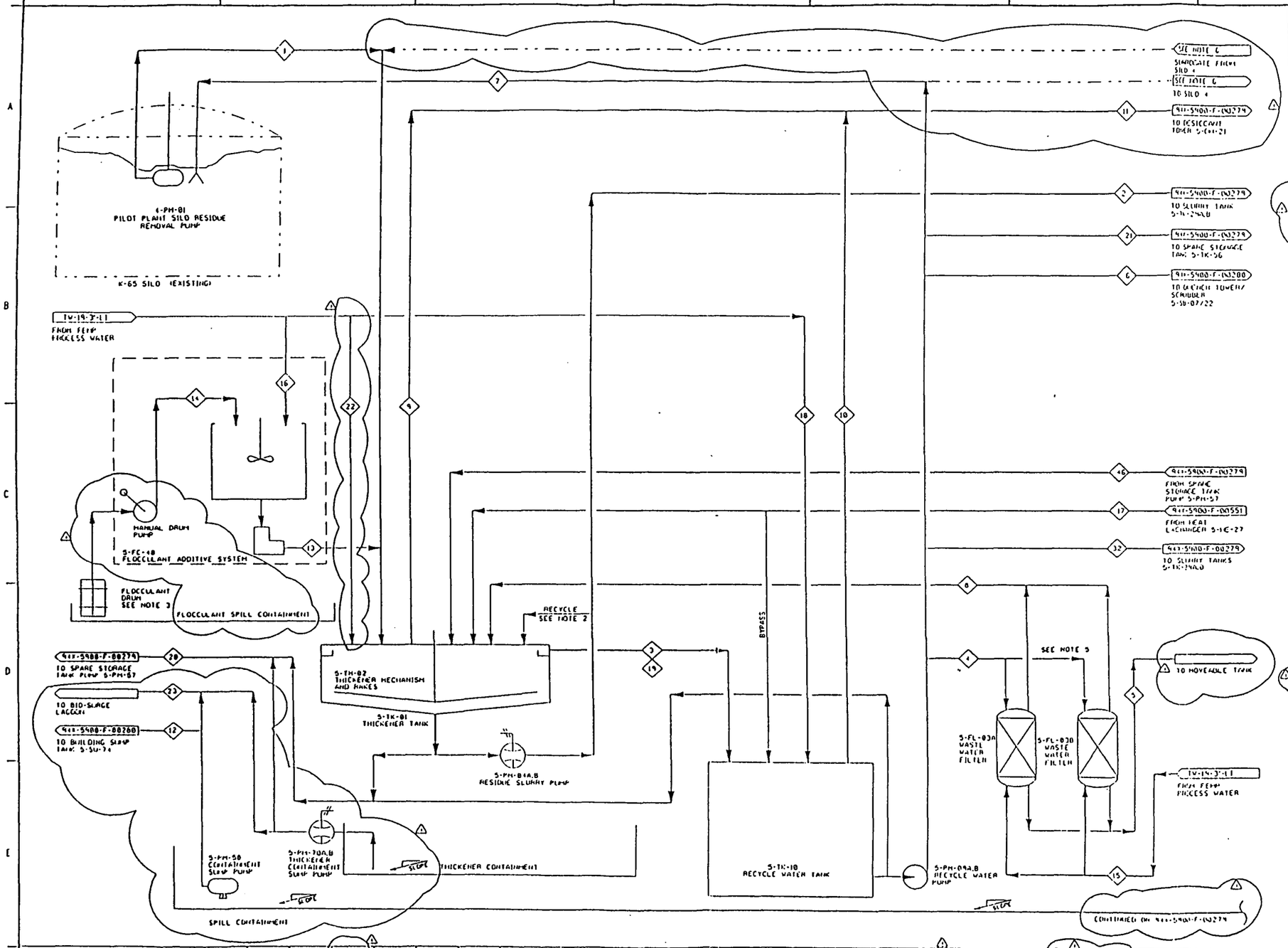
ELECTRICAL-
SINGLE LINE DIAGRAM
PILOT PLANT

R.REMENSKI 11-2-93
R.EMERICK/R.CLARKE 11-2-93

94X-5900-E-00415 | E0005 | 1

CRU4/P065

R94f00278.m(1405.ws426) po85@ws426. Fri Mar 18 09:25:01 EST 1994



NOTES

1. FOR DRAWING INDEX SEE 94X-5900-F-00353.
   FOR SYMBOLS AND LEGEND SHEET SEE 94X-5900-F-00277.
2. THICKENER OVERFLOW WILL BE RECYCLED WHENEVER THE DENSITY IS BEYOND LIMITS ON WHICH NOT BEING SENT TO SLURRY TANKS. FLOW RATE WILL BE THE SAME AS FOR STREAM 2. THICKENER OVERFLOW WILL EQUAL STREAM 17 PLUS ANY OTHER WATER INPUT WHEN STREAM 1 IS NOT OPERATING.
3. FLOCCULANT WILL BE SUPPLIED IN 55 GALLON DRUMS CONTAINING ABOUT 450 POUNDS EACH. CONSUMPTION IS EXPECTED TO AVERAGE 0.2 POUNDS FLOCCULANT/TON SOLIDS WITH A 0.1% SOLUTION BUT MAY VARY DEPENDING ON SETTLING CHARACTERISTICS.
4. STANDARD CONDITIONS 70 DEGREES F AND 407.2 INCHES OF WATER ABSOLUTE AT SEA LEVEL. THE EQUIPMENT OFF-GAS VENTS WERE ASSUMED TO BE 77 DEGREES F AT 100% SATURATION. INTERMITTENT FLOWS WERE NOT TAKEN INTO ACCOUNT FOR THE WATER BALANCE.
5. WASTEWATER FILTERS WILL BE DESIGNED FOR A MAXIMUM OF 10 GALLONS/MINUTE.
6. 150 GALLONS/MINUTE OF SLURRIED SURROGATE MATERIAL WILL BE PUMPED DIRECTLY FROM SILO 4 TO THE THICKENER. THIS WILL TAKE PLACE BEFORE EXTRACTION OF K-65 MATERIALS. RECYCLE WATER AT THE RATE OF APPROXIMATELY 120 GPM WILL BE USED TO SLURRY THE SURROGATE. SEE THE DESIGN DETAILS FOR PARSONS PROJECT ORDER 92 ON DRAWING 94X-5900-F-00492. THE MATERIAL BALANCE BELOW IS BASED ON K-65 SILO MATERIALS ONLY.

REF DWG NO.	DRAWING TITLE
94X-5900-F-00353	DRAWING INDEX - SHEET 1 OF 4
94X-5900-F-00277	SYMBOLS AND LEGEND SHEET
94X-5900-F-00279	FEED PREPARATION AND VITRIFICATION
94X-5900-F-00280	OFF-GAS TREATMENT
94X-5900-F-00551	PROCESS COOLING WATER
94X-5900-F-00492	HYDRAULIC SURROGATE WASTE REMOVAL

1	GENERAL REVISIONS			
0	APPROVED FOR CONSTRUCTION	RAZ 11-01-93	RCE 11-01-93	
REV	ISSUE TO REFER REMOVE - DESCRIPTION			

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. · PARSONS MAINE INC. · ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

VITRIFICATION PILOT PLANT DESIGN
CRU4 - ONE METRIC TON

PROCESS
PROCESS FLOW DIAGRAM
HYDRAULIC WASTE RETRIEVAL AND DEWATERING

STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12
COMPONENT	FEED TO THICKENER	THICKENER UNDER-FLOW	THICKENER OVER-FLOW	WASTE-WATER BLEED	PRETREAT WATER TO FLOC	RECYCLE WATER TO OVERFLOW	RECYCLE WATER TO SILO	FILTER BACKWASH	THICKENER OFF-GAS VENT	WATER TK OFF-GAS VENT	PROCESS OFF-GAS VENT	SLURP PUMP DISCHARGE
OPERATING HR/DAY	0.22	0.22	0.22	0.6	24	24	0.22	0.2	24	24	24	INTERMIT
SOLIDS LBS/HR	5759.6	5759.6		NEGLIGIB								
WATER LBS/HR	23038.4	5759.6	37916	4504	20000	20570	12500	12500	3.6	3.6	7.2	
AIR (GAS) LBS/HR									179.8	179.8	359.7	
TOTAL LBS/HR	28798	11519.2	37916	4504	4504	20000	20570	12500	183.4	183.4	366.9	
SPECIFIC GRAVITY - DRY SOLIDS	2.50	2.50										
SPECIFIC GRAVITY - SLURRIES	1.151	1.467	1.0	1.0	1.0	1.0	1.0	1.0				1.0
BULK DENSITY LBS/CFT												
SOLIDS FLOW (CFM)												
LIQUID FLOW (GPM)	50	12.5	75.6	9.0	9.0	40	41.1	25				25
GAS FLOW (SCFM)									41.3	41.3	82.6	
TEMPERATURE (DEG F)				40	40	40	40		77	77	77	
PRESSURE (INCHES W.C.)									40.5	40.5	40.5	
NOTES		2	2	5	5				4	4	4	

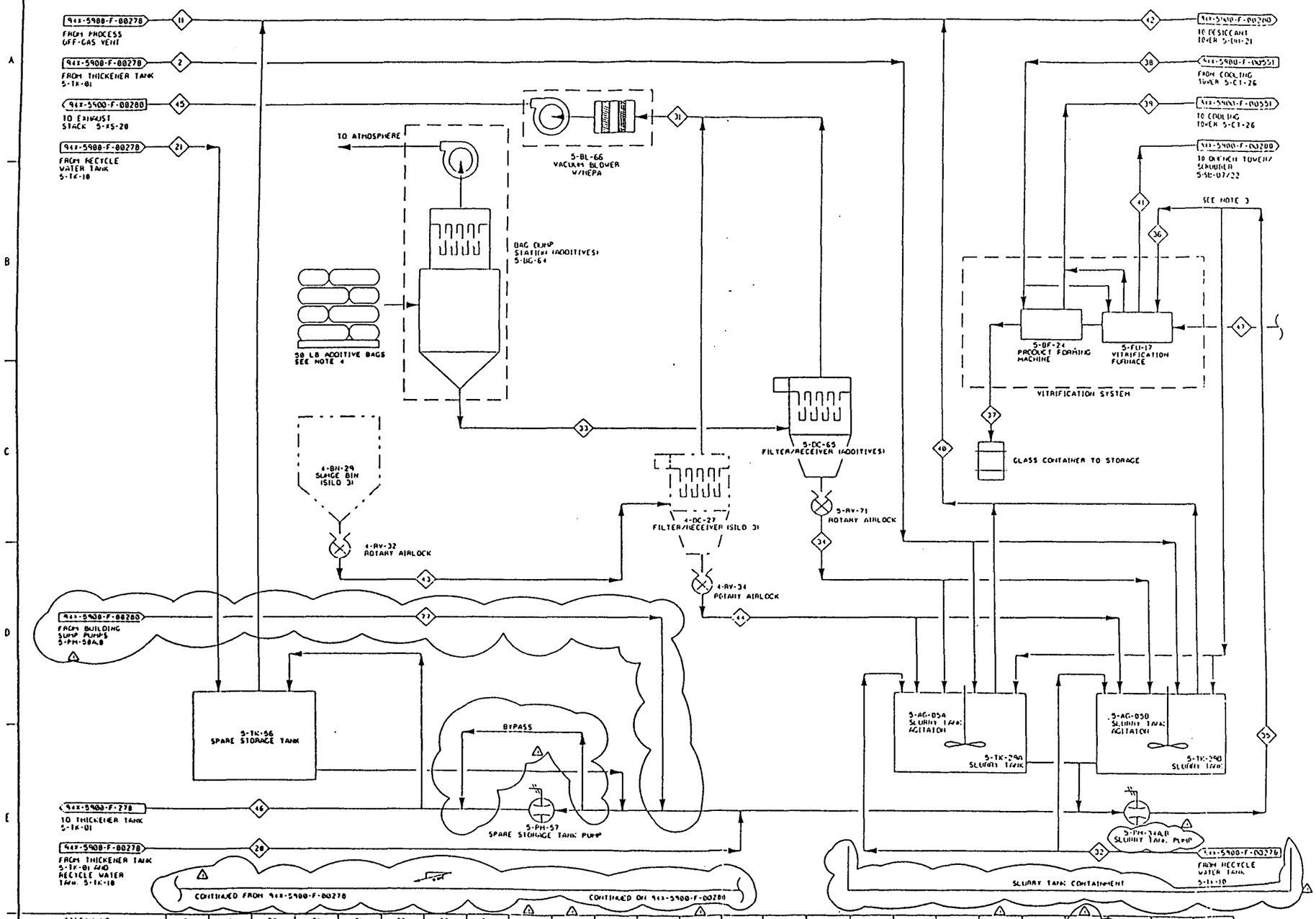
STREAM NO.	13	14	15	16	17	18	19	20	21	22	23	32	46
COMPONENT	FLOCC ADDITION TO THICK	FLOCC MAKE-UP ADDITION	FILTER BACKWASH WATER	FLOCULANT MAKE-UP WATER	RECYCLE WATER TO THICKENER	MAKE-UP WATER TO TANK	OVERFLOW TO RECYCLE	DISCHARGE TO STORAGE	RECYCLE WATER TO STORAGE	MAKE-UP WATER TO THICKENER	RAINWATER TO BIO-LAGOON	RECYCLE WATER TO SLURRY	DISCHARGE TO THICKENER
OPERATING HR/DAY	0.22	INTERMIT	0.2	INTERMIT	24	INTERMIT	23.78	INTERMIT	INTERMIT	INTERMIT	INTERMIT	0.04	INTERMIT
SOLIDS LBS/HR					NEGLIGIB								
WATER LBS/HR	576		12500		20064.6		20066.3					14560	
AIR (GAS) LBS/HR													
TOTAL LBS/HR	576		12500		20064.6		20066.3					14560	
SPECIFIC GRAVITY - DRY SOLIDS													
SPECIFIC GRAVITY - SLURRIES	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0-1.5	1.0	1.0	1.0	1.0	1.0-1.5
BULK DENSITY LBS/CFT													
SOLIDS FLOW (CFM)													
LIQUID FLOW (GPM)	1.2	0.1	25	25	40.1	25	40.1	50	25	40	25	29	50
GAS FLOW (SCFM)													
TEMPERATURE (DEG F)					40		40						
PRESSURE (INCHES W.C.)													
NOTES	3	3					2						

CRU4/PO85

R. A. ZIEMINSKI 11-01-93 · R. C. EVERTON 11-01-93 · S. C. VOGLER 11-01-93

94X-5900-F-00278 F0002 1

R94F00279.m(3396.ws421) po85@ws421. Mon Mar 14 13:03:48 EST 1994



STREAM NO.	2	11	28	21	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	77
COMPONENT	THICKNER UNDER-FLOW	PROCESS OFF-GAS VENT	DSCHARGE TO STORAGE	RECYCLE WATER TO STORAGE	OFF-GAS TO BLOWER	RECYCLE WATER TO SLURRY	ADDITIVE TO RECEIVER	ADDITIVE FEED TO SLURRY	FURNACE FEED LOOP	FURNACE FEED	GLASS PRODUCT	COOL WTR TO VITRIF	COOL WTR FROM VITRIF	SLURRY TANK OFF GAS VENT	FURNACE OFF-GAS	VENT TO DESICCANT	SILO 3 FEED TO RECEIVER	SILO 3 FEED TO SLURRY	BLOWER EXHAUST TO STACK	DSCHARGE TO THICKNER	ATMOS AIR TO FURNACE	SUMP TO STORAGE PUMP
OPERATING HR/DAY	8.22	24	INTERMIT	INTERMIT	INTERMIT	0.04	0.14	0.14	24	24	24	24	24	24	24	24	0.04	0.04	INTERMIT	INTERMIT	24	INTERMIT
SOLIDS LBS/HR	5759.6									75.9	91.9						6000	6000				
WATER LBS/HR	5759.6	7.2				14560				75.3		35000	35000	3.2	85.9	10.4	383	383			10.6	
AIR (GAS) LBS/HR		359.7												157.3	559.6	517					540	
ADDITIVES LBS/HR							6000	6000		35.5												
TOTAL LBS/HR	11519.3	366.9				14560	6000	6000		186.7	91.9	35000	35000	160.5	645.5	527.4	6383	6383			550.6	
SPECIFIC GRAVITY - DRY SOLIDS	2.98						2.5	2.5	2.7	2.7							2.41	2.41				
SPECIFIC GRAVITY - SLURRIES	1.487		1.0-1.5	1.0		1.0			1.6	1.6		1.0	1.0							1.0-1.6		1.0-1.4
BULK DENSITY LBS/CU FT								60										60				
SOLIDS FLOW (GPM)								0.2										0.2				
LIQUID FLOW (GPM)	15.5		90	25		29			40	0.2		70	70							40		25
GAS FLOW (SCFM)		83.6			350		350							30.1	153.5	110.7	350		350		120	
TEMPERATURE (DEG F)		77			AMBIENT		AMBIENT					85		77	84.4	77	AMBIENT		77 AMB		AMBIENT	
PRESSURE (INCHES W.C.)		-0.5			-124		-110							-0.5	-0.5	-0.5	-110		-0.5			
NOTES		2				5	4	4		3, 4						6						

NOTES

1. FOR SYMBOLS AND LEGEND SHEET SEE 94X-5900-F-00277. FOR DRAWING INDEX SEE 94X-5900-F-00353.
2. STANDARD CONDITIONS = 70 DEGREES F AND 407.2 INCHES WATER ABSOLUTE AT SEA LEVEL. AIR IN EQUIPMENT OFF-GAS VENTS IS ASSUMED TO BE SATURATED AT 77 DEGREES F BUT IS NOT TAKEN INTO ACCOUNT FOR THE WATER BALANCE.
3. FURNACE FEED RATE MAY BE INTERMITTENT AT A HIGHER FLOW RATE.
4. TOTAL ADDITIVES ARE SHOWN AS 852.3 POUNDS/DAY PER BATTELLE FORMULATION FOR MATERIAL BALANCE PURPOSES. ACTUAL AMOUNTS WILL VARY TO OPTIMIZE GLASS PROPERTIES ONCE PILOT PLANT OPERATIONS BEGIN. THE WASTE MATERIAL RATIO SHOWN AS POUNDS/HOUR SOLIDS WAS CALCULATED AT 70:30 X-65/SILO 3. SPECIFIC GRAVITY OF FURNACE FEED IS BASED ON SODA ASH SOLUTION.
5. THICKENER UNDERFLOW AT 50% SOLIDS BY WEIGHT TO THE SLURRY TANKS WILL BE RAISED TO A HIGHER % SOLIDS WITH ADDITION OF DRY ADDITIVES AND SILO 3 MATERIAL. RECYCLE WATER WILL BE ADDED TO LOWER THE % SOLIDS IN THE SLURRY TANKS TO APPROXIMATELY 60.
6. THE FURNACE OFF-GAS POUNDS/HOUR ACCOUNTS FOR TOTAL POUNDS/HOUR OF GAS IN TERMS OF AIR INLEAKAGE (540) + CARBON DIOXIDE (12.0) + SULFUR DIOXIDE (4.9) + NITROUS OXIDES (1.4). THE EXTRA WATER IN STREAM 41 COMPARED TO STREAM 36 COMES FROM MOISTURE IN THE AIR INLEAKAGE.

REF DWG NO.	DRAWING TITLE
94X-5900-F-00353	DRAWING INDEX - SHEET 1 OF 4
94X-5900-F-00277	SYMBOLS AND LEGEND SHEET
94X-5900-F-00278	HYDRAULIC WASTE RETRIEVAL AND DEWATERING
94X-5900-F-00280	OFF-GAS TREATMENT
94X-5900-F-00551	PROCESS COOLING WATER

REV.	REVISION	DRAWN	CHECKED
1	GENERAL REVISIONS		
0	APPROVED FOR CONSTRUCTION	RAZ 11-8-93	RCE 11-8-93

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. • PARSONS MAIN, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

VITRIFICATION PILOT PLANT DESIGN
CRU14 - ONE METRIC TON

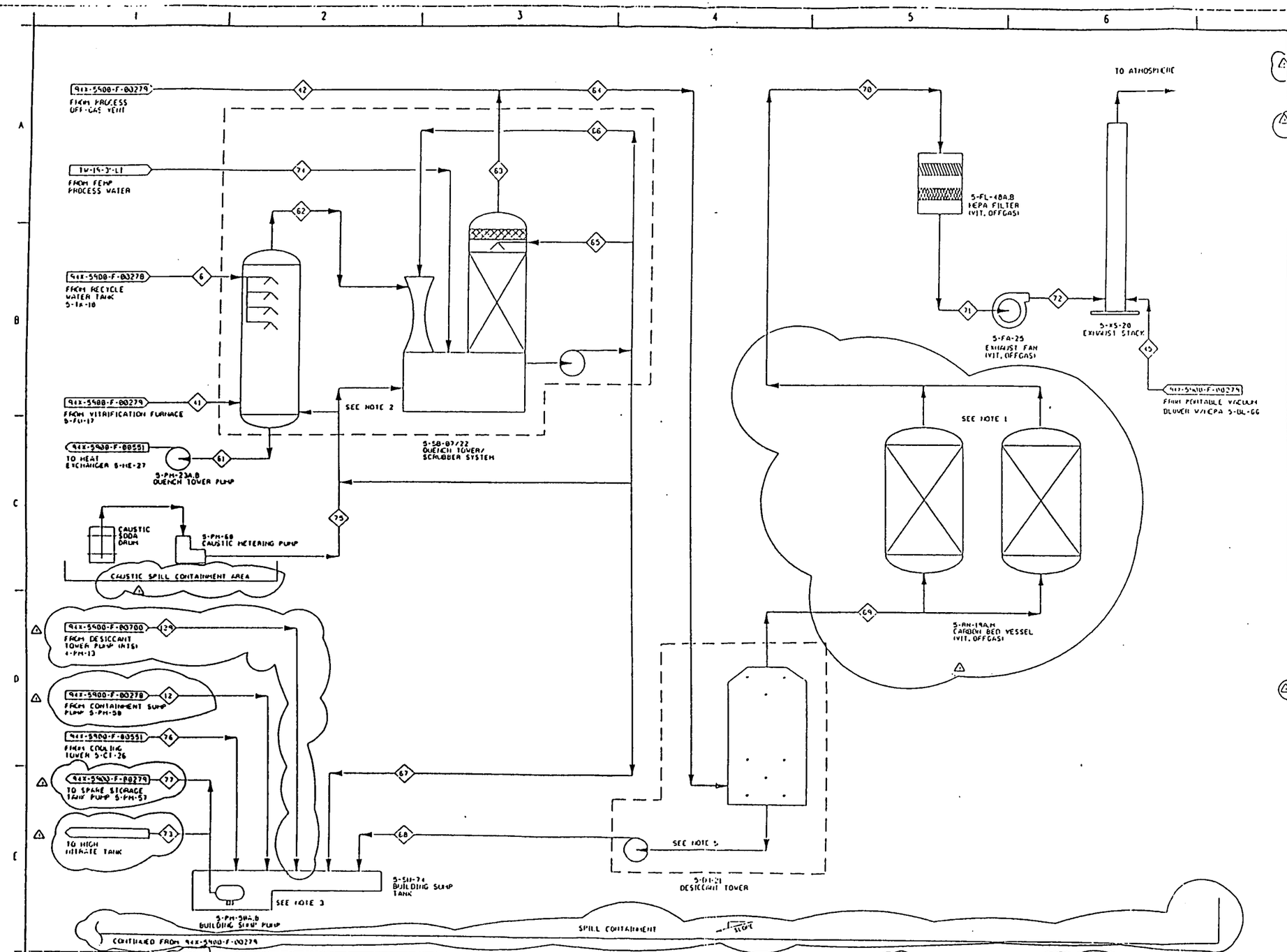
PROCESS
PROCESS FLOW DIAGRAM
FEED PREPARATION AND VITRIFICATION

DRAWN BY: J. J. WILSON 11-8-93
CHECKED BY: S.C. WALKER 11-8-93
APPROVED FOR ENGINEERING: R.C. ZIEMINSKI 11-8-93
APPROVED FOR CONSTRUCTION: R.C. EMERION 11-8-93

CRU14/P085

94X-5900-F-00279 F0003 1

R94f00280.m(1777.ws312) pos5@ws312. Fri Mar 18 07:18:10 CST 1994



STREAM NO.	6	12	41	42	45	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	129
COMPONENT	RECYCLE WATER TO QUENCH	SUMP PUMP DISCHARGE (INTERMIT)	FURNACE OFF-GAS	VENT TO DESICCANT	BLOWER EXHAUST TO STACK (INTERMIT)	QUENCH TOWER DISCHARGE	OFF-GAS TO VENTURI	OFF-GAS FROM SCRUBBER	COMBINED OFF-GAS	PACKED SCRUBBER RECYCLE	VENTURI RECYCLE	SCRUBBER TO SUMP (INTERMIT)	TOTAL COND. TO SUMP (NOTE 5)	OFF-GAS TO CARBON	OFF-GAS TO HEPA	OFF-GAS TO FAN	OFF-GAS TO STACK	TO HIGH NITRATE TANK (INTERMIT)	PROCESS WATER MAKE-UP (INTERMIT)	CAUSTIC SODA ADDITION (INTERMIT)	COOLING TOWER BLOWDOWN (INTERMIT)	SUMP TO STORAGE PUMP (INTERMIT)	RIS CONCENTRATE TO SUMP (INTERMIT)
OPERATING HR (DAY)	24		24	24			24	24	24	24	24		24	24	24	24	24						
SOLIDS LB/HR						RECYCLE																	
WATER LB/HR	2000.0		15.5	10.4		2000.0	2.1	2.1	2.1				2.1	2.0	2.0	2.0	2.0						
AIR LB/HR			500	503			500	500	1003					100.7	100.7	100.7	100.7						
CO_2 LB/HR			12.6				12.6	12.6	12.6					12.6	12.6	12.6	12.6						
SO_2 LB/HR			4.5				4.5	0.05	0.05					0.05	0.05	0.05	0.05						
NO_x LB/HR			1.5				1.5	1.5	1.5					1.5	1.5	1.5	1.5						
TOTAL LB/HR	2000.0		533.6	513.4		2000.0	533.7	516.3	1019.3				2.1	103.2	103.2	103.2	103.2						
SPECIFIC GRAVITY	1.0	1.0				1.0				1.0	1.0	1.0	1.0					1.0				1.0	1.0
LIQUID FLOW GPM	40	20				40.1				17	5	0.1						20				20	5
GAS FLOW SCFM			153.6	111.7	350		130.2	125.5	248.3					25.7	25.7	25.7	25.7						
TEMPERATURE DEG F	90		800	7	200	97	97	97	88				88	88	88	88	88				85		80
PRESSURE INCHES H2O			-0.5	-0.5	0		-1.0	-1.0	-1.0					-1.0	-1.0	-1.0	-1.0						
NOTES							6	6	6					5	6	5	6					7	

NOTES

1. THE CARBON BED VESSEL TRAIN (6 VESSELS IN SERIES) WILL NORMALLY BE OPERATED AT A TIME. IN CASE OF HIGH HAZOX ALARM, BOTH TRAINS WILL BE OPERATED IN PARALLEL TO EACH OTHER.
2. CAUSTIC SODA WILL BE ADDED TO THE QUENCH TOWER TO CONTROL ACIDITY AS NEEDED. IT WILL ALSO BE ADDED TO THE SCRUBBER SOLUTION AS NEEDED FOR SULFUR DIOXIDE REMOVAL.
3. THE BUILDING SUMP MAY REQUIRE A SMALL OFF-GAS VENT LINE.
4. P&ID SYMBOLS AND LEGEND SHEET SEE 94X-5900-F-00277. FOR DRAWING INDEX SEE 94X-5900-F-00353.
5. STREAM 68 MATERIAL BALANCE IS FOR INFORMATION ONLY. ACTUAL FLOW RATE WILL BE INTERMITTENT AT 5 GALLONS PER MINUTE.
6. STANDARD CONDITIONS = 70 DEGREES F AND 407.3 INCHES WATER ABSOLUTE AT SEA LEVEL. THE RELATIVE PRESSURES SHOWN IN THE MATERIAL BALANCE INCLUDE ASSUMED DROPS ACROSS EQUIPMENT.

REF DWG NO.	DRAWING TITLE
94X-5900-F-00353	DRAWING INDEX - SHEET 1 OF 4
94X-5900-F-00277	SYMBOLS AND LEGEND SHEET
94X-5900-F-00278	HYDRAULIC WASTE RETRIEVAL AND DEWATERING
94X-5900-F-00279	FEED PREPARATION AND VITRIFICATION
94X-5900-F-00551	PROCESS COOLING WATER
94X-5900-F-00700	SILO RADON TREATMENT SYSTEM - TITLE II

1	GENERAL REVISIONS			
0	APPROVED FOR CONSTRUCTION	RAZ 11-8-93	RCE 11-8-93	

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. • PARSONS MAIN, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

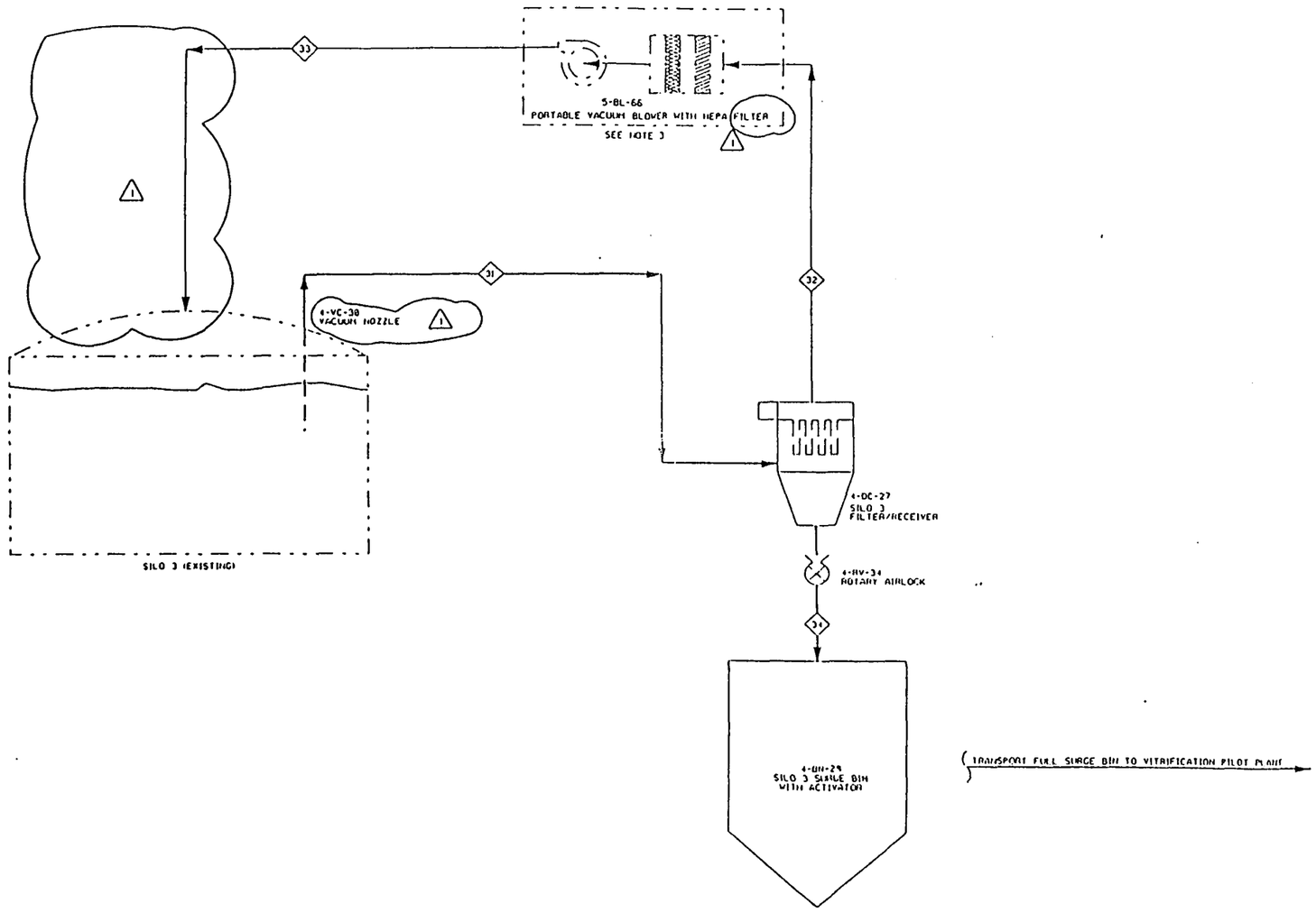
VITRIFICATION PILOT PLANT DESIGN
CRUD - ONE METRIC TON

PROCESS
PROCESS FLOW DIAGRAM
OFF-GAS TREATMENT

CRU4/P085

94X-5900-F-00280 F0004 1

R94000493.m(1430.ws426) p092@ws426. Tue Mar 22 13:47:48 EST 1994



STREAM NO.	31	32	33	34
COMPONENT	SILO 3 TO FILTER	OFF-GAS TO BLOWER	EXHAUST RECIRC TO SILO	SILO 3 MATERIAL TO BIN
OPERATING HR/DAY	INTERMIT	INTERMIT	INTERMIT	INTERMIT
SOLIDS (LBS/HR)	6000			6000
WATER (MOISTURE) (LBS/HR)	383			383
DRY AIR (LBS/HR)				
TOTAL (LBS/HR)	6383			6383
SPECIFIC GRAVITY - DRY SOLIDS	2.41			2.41
BULK DENSITY (LBS/CU FT)				60
SOLIDS FLOW (CFM)				1.77
AIR FLOW (SCFM)	350	350	350	
TEMPERATURE (DEG F)	AMBIENT	AMBIENT	3 AMB	
PRESSURE (INCHES W.G.)	-118	-124	- ATM	
NOTES	2	2		

NOTES

1. FOR SYMBOLS AND LEGEND SHEET SEE 94X-5900-F-00491. FOR DRAWING INDEX SEE 94X-5900-X-00504.
2. STANDARD CONDITIONS = 70 DEGREES F AND 407.2 INCHES WATER AT SEA LEVEL. NEGATIVE PRESSURES SHOWN IN THE MATERIAL BALANCE ONLY INCLUDES ASSUMED PRESSURE DROPS ACROSS EQUIPMENT.
3. THE EQUIPMENT ON THIS DRAWING MAY BE EXISTING AND AVAILABLE ON SITE SUBJECT TO CONFIRMATION BY FERMCO. THE VACUUM BLOWER WILL BE USED FOR THE VITRIFICATION PILOT PLANT "COLD" TEST FIRST, THEN BE MOVED FOR USE AT SILO 3. ONCE THE 10 TONS OF SILO 3 MATERIALS ARE EXTRACTED, THE VACUUM BLOWER, FILTER/RECEIVER, AND SURGE BIN WILL BE MOVED TO THE PILOT PLANT FACILITY FOR USE DURING THE "HOT" OPERATION, MEANING THAT THE PNEUMATIC SYSTEM TO REMOVE SILO 3 MATERIAL AND THE PNEUMATIC SYSTEM TO HANDLE MATERIAL LOADING AT THE PILOT PLANT ARE ESSENTIALLY THE SAME. PARSONS WILL SPECIFY ALL EQUIPMENT SO THAT CROSS REFERENCING WITH EXISTING ON-SITE EQUIPMENT CAN BE ATTEMPTED.

REF DWG NO.	DRAWING TITLE
94X-5900-X-00504	DRAWING INDEX - SHEET 1 OF 2
94X-5900-F-00491	SYMBOLS AND LEGEND SHEET

1	REVISED REFERENCE DRAWING NUMBER REVISED NOTE 1		
-	REVISED NOTES OF 4-VC-30, 5-BL-66 REVISED LOCATION OF RECIRCULATION LINE		
0	APPROVED FOR CONSTRUCTION	RAZ 11-01-93	RCE 11-01-93
REV NO	REV DESCRIPTION	DRAWN	CHECKED

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. • PARSONS HAWLINE INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

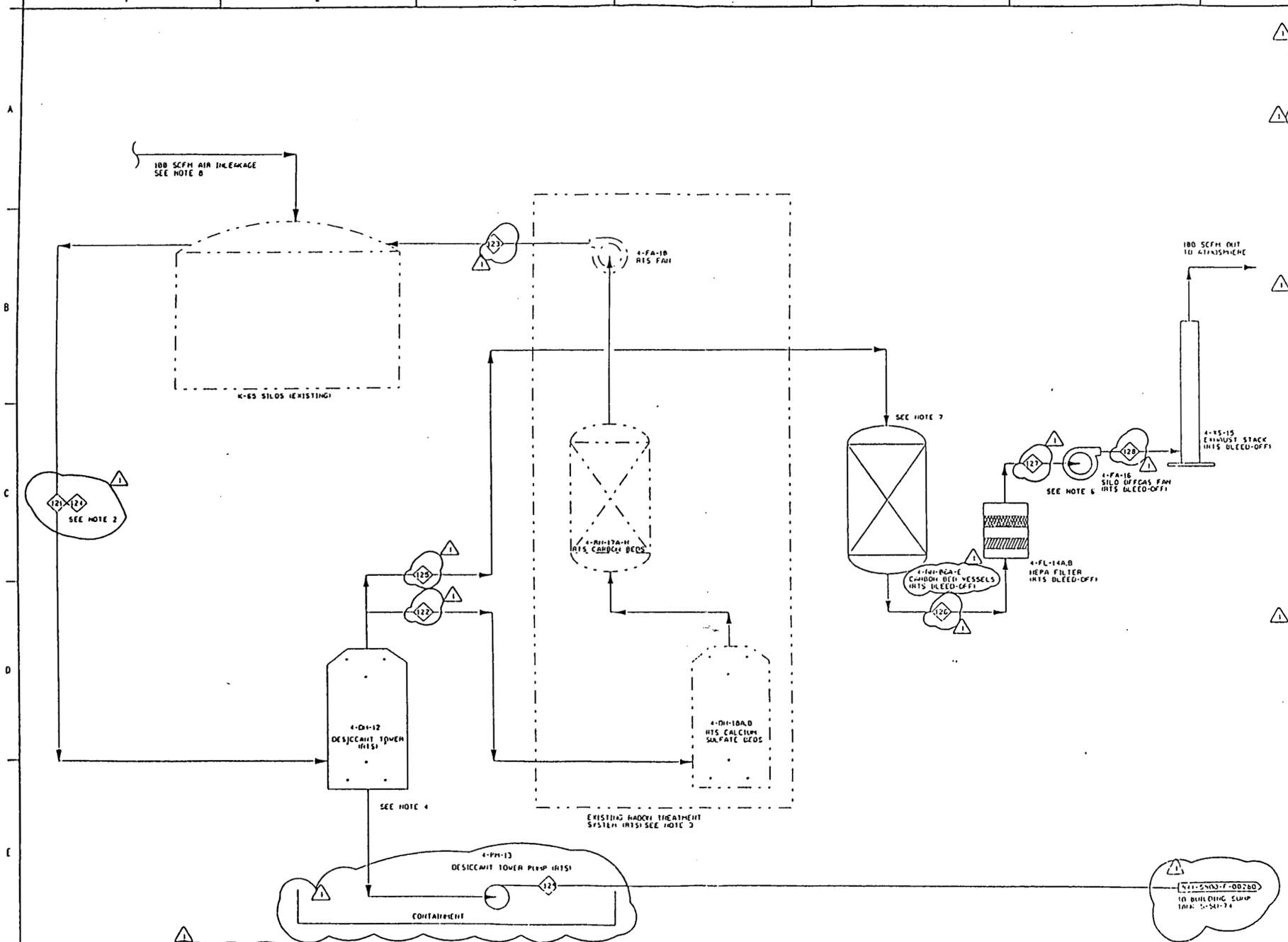
PROJECT NAME
SILO 4 WASTE REMOVAL & TRANSPORTING SYS
CRU4

DRAWING TITLE
PROCESS
PROCESS FLOW DIAGRAM
SILO 3 PNEUMATIC WASTE REMOVAL

DRAWN BY	DATE	ENGINEERED	DATE	DESIGNED BY	DATE
J. LAWSON	09-17-93	RCE / A.J. FERRIE	11-01-93	S.C. VAGER	10-05-93
REVISED BY		REVIEWED		DATE	SCALE
				NONE	
DRAWING MANAGER		TECHNICAL MANAGER		CERTIFIED FOR CONSTRUCTION	
R.A. ZIEMINSKI 11-01-93		R.C. EMERICH 11-01-93			
A/E PROJECT MGR	DATE	CRU4 PROJECT MGR	DATE	CRU4 DIRECTOR	DATE

PROJECT DWG NO.	DRAWING NO.	SHEET NO.	REV NO.
CRU4/P092	VBS 1.1.1.1.0.1.1 00-90701	94X-5900-F-00493	F0003	1

R94000700.m(1778,ws312) po85@ws312. Fri Mar 18 07:24:45 CST 1994



STREAM NO.	121	122	123	124	125	126	127	128	129
COMPONENT	OFF-GAS FROM SILO	OFF-GAS FROM DESICCANT	OFF-GAS RETURN TO SILO	PARALLEL OFF-GAS FR SILO	RTS BLEED TO ATMOS	RTS BLEED TO HEPA	RTS BLEED TO FAN	RTS BLEED TO CARBONS	DESICCANT BOTTOMS TO SUMP
OPERATING MODE	INTERMIT	INTERMIT	INTERMIT	NOTE 2	24	24	24	24	INTERMIT
SOLIDS (LBS/HR)									
WATER (LBS/HR)	110.6	15.8	15.8	10.1	1.6	1.6	1.6	1.6	
GAS (LBS/HR)	450	450	450	450	450	450	450	450	
TOTAL (LBS/HR)	560.6	465.8	465.8	460.1	451.6	451.6	451.6	451.6	
SPECIFIC GRAVITY (SOLIDS)									
SPECIFIC GRAVITY (SLURRIES)									
BULK DENSITY (LBS/CF)									
SOLIDS FLOW (CFM)									
LIQUID FLOW (GPM)									
GAS FLOW (ACFM)	1140.6	1006.5	1006.5	1006.7	100.7	100.7	100.7	100.7	
TEMPERATURE (DEG F)	60	60	60	60	60	60	60	60	60
PRESSURE (INCHES W.G.)	-0	-7	-0	-10	-7	11	-10	-10	
NOTES		5		7	5	5	5		

NOTES

1. FOR DRAWING INDEX SEE 944-5400-F-00353. FOR SYMBOLS AND LEGEND SHEET SEE 944-5400-F-00277.
2. STREAM 124 WILL OPERATE CONTINUOUSLY AT 100 SCFM TO CONTROL RADON EMISSIONS AFTER DOME MODIFICATIONS.
3. THE EXISTING RTS CONSISTING OF TWO CALCIUM SULFATE BEDS, FOUR PAIRS OF CARBON BEDS, AND THE 1000 SCFM FAN WILL BE REUSED WITH NEW PIPING FOR BOTH SILOS 1 AND 2. SILO 4 WILL NOT BE HOOKED UP TO THE EXISTING RTS.
4. THE NEW DESICCANT TOWER WILL BE SIZED TO REDUCE A NOMINAL 1100 SCFM OF 80 DEGREES F AIR AND 100% RELATIVE HUMIDITY (AH) DOWN TO 15% RH. THE EXISTING CALCIUM SULFATE BEDS WERE NOT TAKEN INTO ACCOUNT FOR THE MATERIAL BALANCE. STREAM 129 WAS ALSO NOT TAKEN INTO ACCOUNT.
5. STANDARD CONDITIONS ARE 70 DEGREES F AND 407.2 INCHES OF WATER ABSOLUTE AT SEA LEVEL. THE PRESSURES SHOWN IN THE MATERIAL BALANCE REFLECT ASSUMED PRESSURE DROPS ACROSS EQUIPMENT.
6. THE SILO OFF-GAS FAN WILL HAVE 200 SCFM CAPACITY WITH INLET VANES FOR VARYING FROM 100-200 SCFM FOR TEST PURPOSES. THE MATERIAL BALANCE REFLECTS 100 SCFM FOR CALCULATIONS.
7. THE NEW CARBON BED VESSELS WILL BE SIZED AND SPECIFIED BY FERMCO.
8. AIR BALANCE IN THE SILO WILL BE MAINTAINED BY INFILTRATION THROUGH THE EXISTING CRACKS DUE TO THE SLIGHT NEGATIVE PRESSURE CAUSED BY THE 100 SCFM BLEED-OFF SYSTEM. AS A PRECAUTION, A GRAVITY INTAKE DAMPER WILL BE INSTALLED ON THE SILO TO GUARD AGAINST EXCESSIVE NEGATIVE PRESSURE.
9. FOR TITLE I DESIGN SEE DRAWING 944-5400-F-00000494 UNDER PARSONS PROJECT ORDER 52.

REF DWG NO.	DRAWING TITLE
944-5400-F-00353	DRAWING INDEX - SHEET 1 OF 4
944-5400-F-00277	SYMBOLS AND LEGEND SHEET
944-5400-F-00280	OFF-GAS TREATMENT
944-5400-F-00494	SILO RADON TREATMENT SYSTEM

1	GENERAL REVISIONS		
0	APPROVED FOR CONSTRUCTION	RAZ 11-8-93	RCE 11-8-93

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. • FLUOR DANIEL, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

VITRIFICATION PILOT PLANT DESIGN
CRUM - ONE METRIC TON

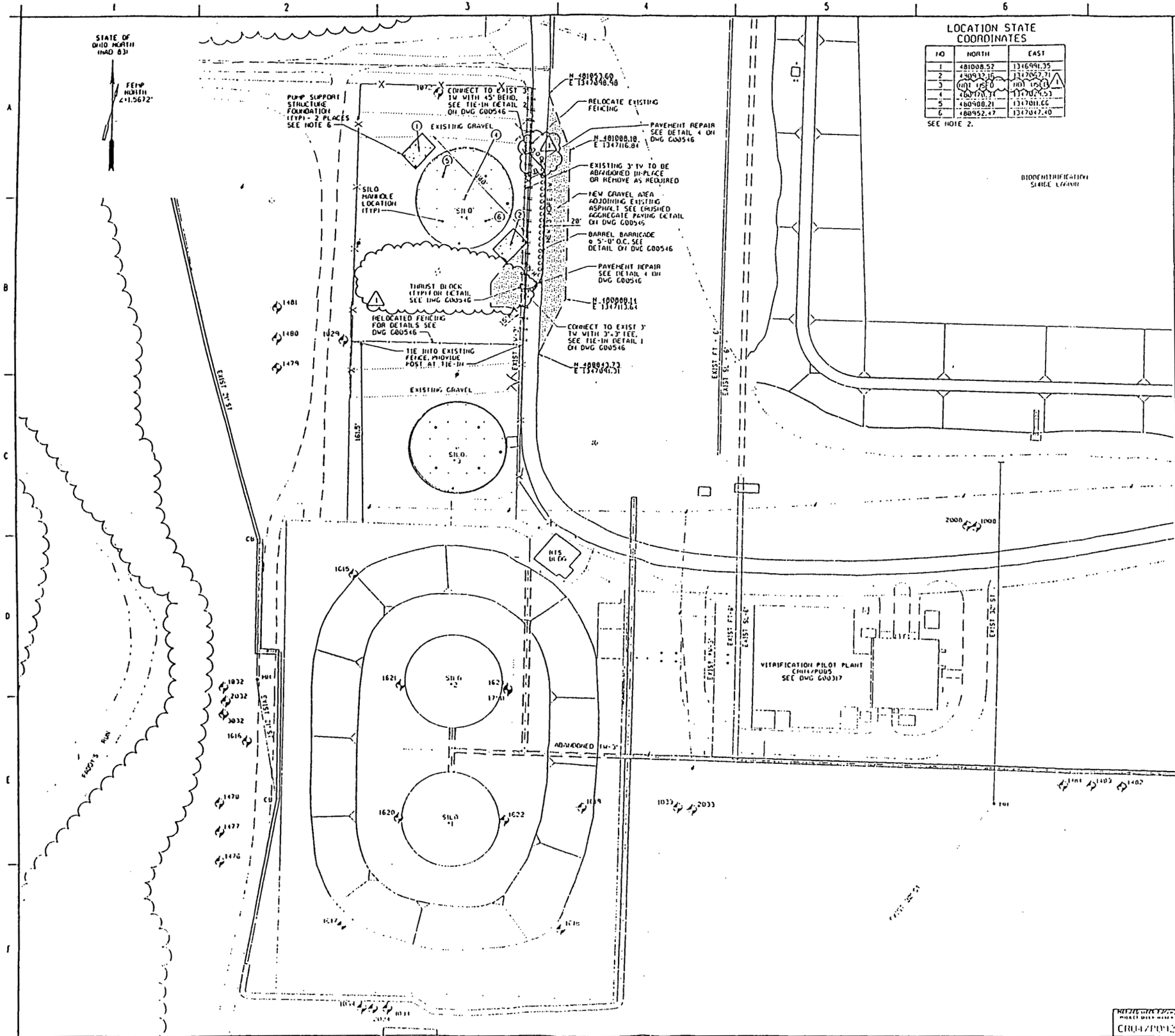
PROCESS
PROCESS FLOW DIAGRAM
SILO RADON TREATMENT SYSTEM - TITLE II

CRUM/P085

000270

944-5400-F-00700 F00061 1

R94g00544.m(5151.ws317) p092(@.ws317. Tue Mar 15 13:54:38 CST 1994



NOTES

1. INFORMATION ON THE LOCATIONS AND ELEVATIONS OF EXISTING FEATURES SHOWN ON THIS PLAN WERE OBTAINED FROM SEVERAL DIFFERENT SOURCES FROM FERNCO INCLUDING THE GRID 31 UTILITY DRAWINGS AND FIELD RUN SURVEY CONDUCTED BY FERNCO (12/93).
2. THE SUBCONTRACTOR SHALL VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS BEFORE STARTING CONSTRUCTION AND/OR FABRICATION. ANY DEVIATIONS FROM INFORMATION SHOWN SHALL BE PRESENTED IN WRITING TO THE FERNCO CONSTRUCTION CONTRACTS MANAGER IMMEDIATELY AND BE RESOLVED BEFORE CONTINUING.
3. ALL EXCAVATION SHALL BE PERFORMED WITH EXTREME CARE. SUBCONTRACTOR IS RESPONSIBLE FOR IMMEDIATELY INFORMING THE FERNCO CONSTRUCTION CONTRACTS MANAGER AND REPAIRING ANY UTILITY DAMAGE BY THE SUBCONTRACTOR TO THE SATISFACTION OF THE FERNCO CONSTRUCTION CONTRACTS MANAGER.
4. FOR DRAWING INDEX, SEE DRAWING 94X-5900-X-00504.
5. FOR LEGEND AND SYMBOLS, SEE DRAWING 94X-5900-X-00506.
6. FOR DESIGN OF STRUCTURAL FOUNDATIONS, SEE DRAWING 94X-5900-S-00507. (1)
7. CONSTRUCTION LAYOUT CONTROL TO BE PROVIDED BY FERNCO.
8. SITE WATER LINES SHALL BE HIGH DENSITY POLYETHYLENE ROPE PIPE EXCEPT AT TRANSITIONS OF DUCTILE MATERIALS AND FITTINGS. THIS MATERIAL SHALL BE DUCTILE IRON IDR.
9. FOR LOCATIONS AND DETAILS OF ELECTRICAL UTILITIES, SEE DRAWING 94X-5900-E-00608. (1)

LEGEND

- PROPOSED CRUSHED AGGREGATE SURFACING
- PROPOSED CONCRETE PAD/FOUNDATION
- BARREL BARRICADE

REF DWG NO.	DRAWING TITLE
94X-5900-X-00504	DRAWING INDEX - SHEET 1 OF 2
94X-5900-X-00506	LEGEND AND SYMBOLS
94X-5900-G-00317	SITE PLAN
94X-5900-G-00546	DETAILS
94X-5900-S-00507	FOUNDATION PLAN
94X-5900-S-00501	EQUIPMENT PAD PLAN, SECTIONS, AND DETAILS
94X-5900-E-00608	480V OVERHEAD POWER (1)

1	REMOVED EQUIPMENT PAD, PIV VALVES, 2" HDPE TW LINE, COORDINATE 3, PART OF GRAVEL DRIVE CHANGED NOTE 6 AND ADDED NOTE 9, REVISED PER FERNCO SCOPE CHANGE ON 2/25/94.			
0	APPROVED FOR CONSTRUCTION	RAZ	RCE	12/16/94

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

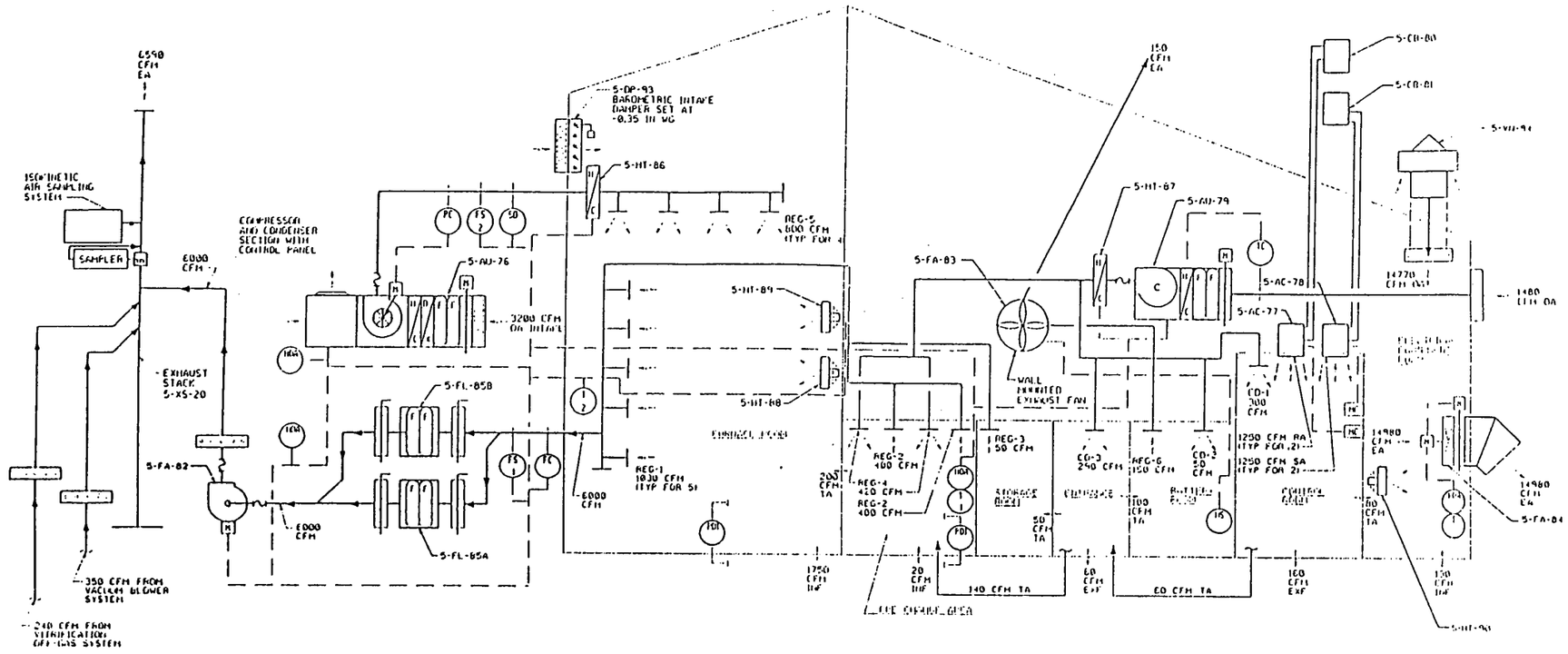
THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. • PARSONS HGM, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

PROJECT NAME
SILO 4 WASTE REMOVAL & TRANSPORTING SYS
CRUH

DRAWING TITLE
CIVIL
SITE PLAN

00-00701	94X-5900-G-00544	G0001	1

R94h00511.m(15h0.ws424) p085@ws424. Fri Apr 15 13:34:07 EDT 1994



AIR FLOW AND CONTROL DIAGRAM

SEQUENCE OF OPERATION

1.0 FURNACE ROOM

EXHAUST FAN S-FA-82, WITH FILTER ASSEMBLIES S-FL-85A AND S-FL-85B (ONE STANDBY), AND MAKE-UP AIR UNIT S-AU-76 WILL PROVIDE SPACE VENTILATION, COOLING, MAKE-UP AIR PRE-HEATING, AND NEGATIVE PRESSURIZATION CONTROL.

THE SPACE TEMPERATURE IS TO BE MAINTAINED AT 100 DEGREES F (MAXIMUM) AND 50 DEGREES F (MINIMUM) WHEN SPACE IS UNOCCUPIED.

THE AIR CONDITIONING UNIT S-AU-76 SUPPLY AIR BLOWER MOTOR SHALL BE INTERLOCKED WITH EXHAUST FAN S-FA-82 MOTOR SO THAT BOTH OPERATE SIMULTANEOUSLY.

SEQUENCE OF OPERATION

1) EXHAUST FAN S-FA-82 AND PACKAGED AIR CONDITIONING UNIT S-AU-76 SHALL BE STARTED MANUALLY FROM A LOCAL CONTROL SWITCHES OR AUTOMATICALLY IN THE EVENT OF THE ROOM GAS ALARM. THE S-AU-76 OUTSIDE AIR INTAKE CONTROL DAMPER (NORMALLY CLOSED) SHALL OPEN TO THE FULLY OPEN POSITION. FLOW SWITCHES IN THE SUPPLY AND EXHAUST SYSTEMS SHALL CONFIRM ESTABLISHMENT OF THE AIR FLOW. IN CASE OF FLOW FAILURE AFTER A 60 SECOND DELAY, THE SYSTEMS SHALL BE AUTOMATICALLY SHUT DOWN AND AN ALARM SHALL SOUND. THE FLOW FAILURE TIME DELAY SHALL BE ADJUSTABLE FROM 30 TO 120 SECONDS.

2) WHEN THE OUTSIDE AIR TEMPERATURE FALLS BELOW 60 DEGREES F, THE BUILT-IN OUTSIDE AIR TEMPERATURE CONTROLLER, SET AT 60 DEGREES F, WILL ALLOW THE UNIT HEATER IN THE PACKAGED AIR CONDITIONING UNIT S-AU-76 TO OPERATE AS FIRST STAGE HEATING AS REQUIRED BY THE ROOM THERMOSTAT. PROGRAMMABLE ROOM THERMOSTAT SHALL BE PROVIDED WITH THREE STAGE, DUAL TEMPERATURE CONTROL FOR OCCUPIED AND UNOCCUPIED MODES.

IN UNOCCUPIED MODE, THE PRE-HEATING COIL IN THE PACKAGED AIR CONDITIONING UNIT WILL BE ENERGIZED AS THE FIRST STAGE, THEN THE ELECTRIC DUCT HEATER S-HT-86 WILL BE ENERGIZED AS THE SECOND STAGE TO MAINTAIN 50 DEGREES F SPACE TEMPERATURE.

IN OCCUPIED MODE, THE SPACE UNIT HEATERS S-HT-88 AND S-HT-89 WILL BE ENERGIZED AS THE THIRD STAGE TO MAINTAIN 65 DEGREES F SPACE TEMPERATURE. AN AUTOMATIC TIMED SWITCHOVER FROM OCCUPIED TEMPERATURE SETTING TO UNOCCUPIED TEMPERATURE SETTING SHALL BE PROVIDED.

WHEN THE SPACE TEMPERATURE RISES ABOVE 90 DEGREES F, THE THERMOSTAT, SET AT 90 DEGREES F, WILL ENERGIZE THE FIRST COMPRESSOR AS THE FIRST STAGE OF COOLING. IF FURTHER COOLING WILL BE REQUIRED THE SECOND COMPRESSOR WILL BE ENERGIZED AS THE SECOND STAGE OF COOLING.

3) NEGATIVE PRESSURIZATION CONTROL IN THE FURNACE ROOM SHALL BE ACHIEVED BY MAINTAINING THE CONSTANT FLOW CONTROL OF THE EXHAUST AIR SYSTEM AND CONSTANT PRESSURE CONTROL OF THE SUPPLY AIR SYSTEM TO MAINTAIN 3,200 CFM SUPPLY AIR TO THE SPACE. DUCT MOUNTED AIR FLOW AND PRESSURE CONTROLLERS FC AND PC WILL MODULATE THE INLET AIR VANES IN THE EXHAUST FAN S-FA-82 AND IN THE PACKAGED AIR CONDITIONING UNIT S-AU-76 SUPPLY AIR BLOWER, RESPECTIVELY.

4) THE SYSTEMS SHALL BE AUTOMATICALLY SHUT DOWN IN THE EVENT OF EITHER A SMOKE DETECTION IN THE SUPPLY AIR DUCT OR A FIRE ALARM CONDITIONS.

2.0 CONTROL ROOM

HEATING AND COOLING WILL BE PROVIDED WITH THE FACTORY ASSEMBLED CONSTANT VOLUME, RECIRCULATING TYPE, AIR CONDITIONING UNITS S-AC-77 AND S-AC-78, TOGETHER WITH AIR COOLED CONDENSING UNITS S-CU-80 AND S-CU-81. REQUIRED OUTSIDE AIR WILL BE SUPPLIED BY THE HEATING AND VENTILATION UNIT S-AU-79.

THE SPACE TEMPERATURE WILL BE MAINTAINED AT 72 DEGREES.

THE AIR CONDITIONING UNITS SHALL BE STARTED FROM A MICROPROCESSOR-BASED CONTROLLER PROVIDED BY THE AIR CONDITIONING UNIT MANUFACTURER. THE MICROPROCESSOR-BASED CONTROLLER PROVIDES ON/OFF CONTROL AND AUTOMATIC TEMPERATURE CONTROL +/- 2 DEGREES F.

ALL AIR SUPPLY UNITS SHALL BE AUTOMATICALLY SHUT DOWN IN THE EVENT OF FIRE ALARM CONDITIONS.

3.0 ELECTRICAL EQUIPMENT ROOM

EXHAUST FAN S-FA-84 IS PROVIDED FOR OPERATION WHEN THE ROOM TEMPERATURE RISES TO 80 DEGREES F. MAKE-UP AIR WILL BE DRAWN INTO THE SPACE THROUGH THE GRAVITY INTAKE VENTILATOR GV-1 WITH BACKDRAFT DAMPER.

THE EXHAUST FAN S-FA-84 SHALL START MANUALLY FROM A LOCAL CONTROL SWITCH OR AUTOMATICALLY BY THE ROOM THERMOSTAT.

ELECTRIC UNIT HEATER S-HT-90 WITH A BUILT-IN THERMOSTAT, SHALL OPERATE WHEN THE SPACE TEMPERATURE DROPS BELOW 50 DEGREES F.

THE EXHAUST FAN S-FA-84 AND UNIT HEATER SHALL BE AUTOMATICALLY SHUT DOWN IN THE EVENT OF FIRE ALARM CONDITIONS.

4.0 PERSONNEL PROTECTIVE EQUIPMENT DRYING AREA AND STORAGE

EXHAUST FAN S-FA-82 AND HEATING AND VENTILATION UNIT S-AU-79 WILL PROVIDE SPACE VENTILATION, SUPPLY AIR PRE-HEATING, AND NEGATIVE PRESSURIZATION CONTROL.

THE AIR HANDLING UNIT S-AU-79 BLOWER MOTOR SHALL BE INTERLOCKED WITH THE S-FA-82 EXHAUST FAN MOTOR SO THAT BOTH OPERATE SIMULTANEOUSLY.

SEQUENCE OF OPERATION

1) HEATING AND VENTILATION UNIT S-AU-79 SHALL BE STARTED MANUALLY FROM A LOCAL CONTROL SWITCH OR AUTOMATICALLY WHEN EXHAUST FAN S-FA-82 STARTS.

2) THE BUILT-IN OUTSIDE AIR TEMPERATURE CONTROLLER, SET AT 60 DEGREES F, WILL ENERGIZE THE PRE-HEATING COIL.

3) THE SPACE THERMOSTAT WILL ENERGIZE DUCT HEATER S-HT-87 TO MAINTAIN THE SPACE TEMPERATURE AT 72 DEGREES F (MINIMUM, WINTER).

4) THE SYSTEMS SHALL BE AUTOMATICALLY SHUT DOWN IN THE EVENT OF FIRE ALARM CONDITIONS.

5.0 BATTERY ROOM

EXHAUST FAN S-FA-83, AIR HANDLING UNIT S-AU-79, AND DUCT HEATER S-HT-87 WILL PROVIDE SPACE HEATING AND VENTILATION.

EXHAUST FAN S-FA-83 SHALL BE STARTED MANUALLY FROM A LOCAL CONTROL SWITCH AND RUN CONTINUOUSLY.

THE EXHAUST FAN S-FA-83 SHALL BE AUTOMATICALLY SHUT DOWN IN THE EVENT OF FIRE ALARM CONDITIONS.

NOTES

1. FOR DRAWING INDEX, SEE DRAWING 94X-5900-H-00353.
2. FOR SYMBOLS, LEGENDS AND GENERAL NOTES, SEE DRAWING 94X-5900-H-00333.
3. FOR WIRING, RELAYS, TIME DELAYS, HAND-OFF-AUTO SWITCHES, EXHAUST FANS, MOTOR STARTERS AND ALARMS, SEE ELECTRICAL DRAWING 94X-5900-E-00424 AND SPECIFICATION SECTION 16050.
4. SUPPLY AND EXHAUST AIR SYSTEM SHALL BE BALANCED TO MAINTAIN 0.3 INCH WG NEGATIVE PRESSURE IN THE FURNACE ROOM, WHICH WILL BE MEASURED BY THE PRESSURE DIFFERENTIAL INDICATOR (PDI).
5. SUPPLY AND EXHAUST AIR SYSTEM SHALL BE BALANCED TO MAINTAIN 0.1 INCH WG NEGATIVE PRESSURE IN THE PRE CHANGE AREA, WHICH WILL BE MEASURED BY THE PRESSURE DIFFERENTIAL INDICATOR (PDI).

REF DWG NO.	DRAWING TITLE
94X-5900-H-00353	DRAWING INDEX SHEET 1 OF 4
94X-5900-H-00333	SYMBOLS, LEGEND AND GENERAL NOTES
94X-5900-E-00424	ELEMENTARY DIAGRAMS - HVAC EQUIPMENT

REV NO.	REVISION DESCRIPTION	BY	REVIEW	DATE
0	APPROVED FOR CONSTRUCTION			

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. • PARSONS RCHI, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

PROJECT TITLE
VITRIFICATION PILOT PLANT DESIGN
CRU4 - ONE METRIC TON

DRAWING TITLE
MECHANICAL UTILITIES
AIR FLOW AND CONTROL DIAGRAM
PILOT PLANT

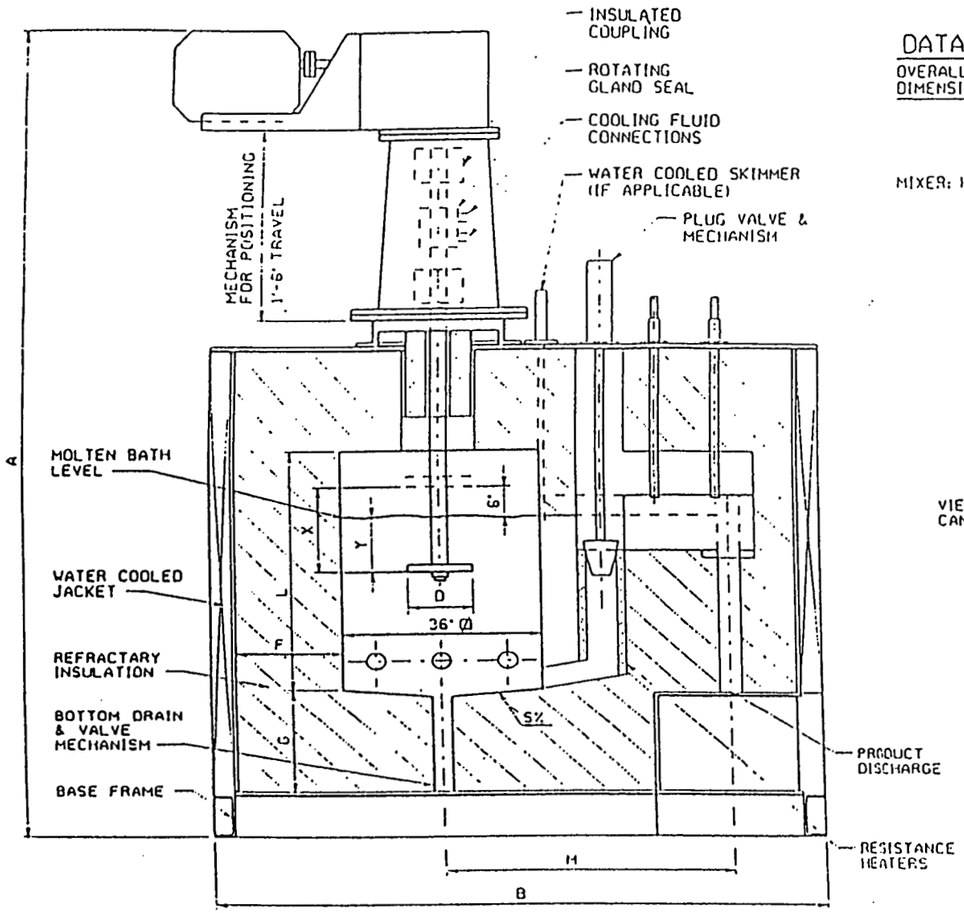
DRAWN BY: P. BUCKN. DATE: 03/22/94
DESIGNED BY: J. SILVER DATE: 03/22/94
SCALE: NO SCALE

CRU4/P085

VRS 11.11.0.31
00-50701

94X-5900-H-00511 | H0002 | 0

skm02041.in(1247.ws104) (demo@ws104. Wed Jul 21 14:46:02 CDT 1993

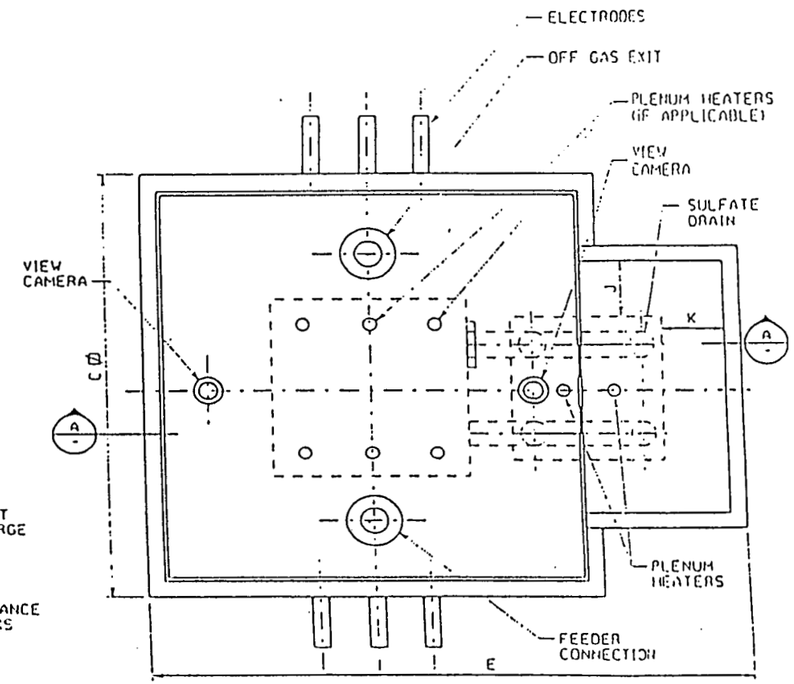


SECTION (A)

DATA TO BE SUPPIED IN PROPOSAL

OVERALL DIMENSIONS	A	B	C	X	Y	D	E	F	G	J	K	L	M	5%

MIXER: HP, RPM, IMPELLER, DIAMETER & CONFIGURATION
DRIVE TRAIN COMPONENTS



PLAN

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
PARSONS
THE RALPH M. PARSONS CO. • CHAS. T. MAIN, INC. • ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

CONFIGURATION SKETCH
AGITATED JOULE HEATED
VITRIFICATION FURNACE

DESIGNED BY:	DRAWN BY:	DATE:
L. FEKETE	D. THOMPSON	7-16-93

SKM02041

APPENDIX C

RISK ASSESSMENT REPORT
RAR-93-0012-A-O

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 1 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Internal Radiation Exposure to the Worker	Potential to exceed site dose limits resulting in facility shutdown, personnel injury, and DOE censure	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Inhalation/ingestion of radionuclide bearing dust residues B) Radiation Work Permit (RWP) is not updated as work progresses C) Silo material exposed to atmosphere D) Inhalation of radon gas	A) 2 B) 3 C) 3 D) 2	A) 3 B) 2 C) 2 D) 3

Controls and Mitigators	Residual Risk/Comments
A,C&D1) Project Engineer shall ensure that the project design includes a ventilation system that samples and removes contaminants A,C&D2) Supervisor shall ensure proper usage of personal protective equipment A,C&D3) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A,C&D4) Project Engineer shall ensure that the project design includes an adequate environmental isolation enclosure A,C&D5) Facility Owner shall ensure successful completion of training and qualification on radiation exposure for "site worker" category A&C6) Project Engineer shall ensure that the project design includes an adequate contaminated dust control system A&C7) Project Engineer shall ensure that adequate bag-in/bag-out procedures are in place prior to work initiation B1) Project Engineer shall ensure that the Architect/Engineer (A/E) design meets standards in RM-0009, "Radiological Controls Manual" and DOE Orders 6430.1A and 5480.28 B2) Supervisor shall ensure that the RWP is updated as work progresses D6) Project Engineer shall ensure that the project design includes an adequate radon collection system	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

000275

89

Risk Assessment Report (RAR)	RAR Number: RAR-93-0012-A-0	
RAR Type: A	Initiator: D. Jacoboski	Date: 10/05/93
Project Title: Operable Unit 4 Vitrification Project	Page: 2 of 28	Revised:

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Excessive External Radiation Exposure to the Worker	Potential to exceed site dose limits resulting in facility shutdown, personnel injury, and DOE censure	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Presence of higher-than-expected penetrating radiation	A) 4	A) 2
B) Radon daughters build up in head space above equipment or tanks increasing dose levels	B) 3	B) 2
C) High level of radon, radium daughter, or thorium products in the final waste form leading to greater than anticipated dose rates	C) 5	C) 1
D) Failure of shield walls	D) 3	D) 2
E) Failure of protective clothing leads to excessive skin dose	E) 4	E) 2
F) RWP is not updated as work progresses	F) 2	F) 3

Controls and Mitigators	Residual Risk/Comments
A-F1) Facility Owner shall ensure successful completion of training and qualification on radiation exposure for "site worker" category and system operation A-F2) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-E3) Project Engineer shall ensure that the A/E design applies As Low As Reasonably Achievable (ALARA) principles A-D4) Project Engineer shall ensure that the A/E design meets standards in RM-0009, "Radiological Controls Manual" and DOE Orders 6430.1A and 5480.28 A-D5) Project Engineer shall ensure that the project design includes adequate shielding and shall ensure adequate design review of the shielding B&C6) Project Engineer shall ensure that the project design includes an adequate radon collection system and shall ensure adequate design review of the radon collection system E4) Supervisor shall ensure proper usage of personal protective equipment F3) Supervisor shall ensure that the RWP is updated as work progresses	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 3 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Operational Releases of Contaminated Dust or Radon in Excess of Allowed Limits	Adverse environmental impact or release exceeding standard DOE/EPA Censure	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Work in the area disturbs excessive amounts of contaminated material	A) 4	A) 2
B) Excavation of contaminated soil	B) 4	B) 2
C) Handling of contaminated soil	C) 4	C) 2
D) Failure of dust collection or radon collection systems	D) 4	D) 2
E) Drilling, cutting, and sawing of contaminated concrete	E) 4	E) 2

Controls and Mitigators	Residual Risk/Comments
A-E1) Project Engineer shall ensure that the project design includes an adequate contaminated dust control system A-E2) Project Engineer shall ensure that the A/E design meets the use standard for HEPA filters/dust collectors D3) Facility Owner shall ensure proper maintenance and inspection of filtration equipment	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000277

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 4 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Fire/Explosion	Possible serious personnel injury/death Potential release of airborne contaminants Possible equipment damage Loss of material and equipment Local fire	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Spill during local refueling with sparking	A) 4	A) 2
B) Spill of stored fuels with sparking	B) 4	B) 2
C) Vehicle Fire	C) 4	C) 2
D) Motor fire	D) 4	D) 2
E) Electrical fire	E) 4	E) 2

Controls and Mitigators	Residual Risk/Comments
A-E1) CRU-4 Safety Engineer shall ensure that the project operations require minimal flammable material A-E2) CRU-4 Safety Engineer shall ensure that an adequate fire protection program is in place prior to work initiation A-E3) CRU-4 Safety Engineer shall ensure that the project design includes an adequate fire protection system A-E4) Facility Owner shall ensure that the FEMP 24-hour Emergency Response Team (ERT) is trained on the project requirements and the project requirements are sent to the Emergency Preparedness Team prior to work initiation A-E5) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation A&B6) Project Engineer shall ensure that the A/E design includes adequate flammable material storage that complies with NFPA and OSHA codes and DOE Order 6430.1A C-E6) Project Engineer shall ensure that adequate maintenance procedures are in place prior to work initiation C-E7) Quality Assurance (QA)/Quality Control (QC) Engineer shall ensure adequate equipment inspection prior to installation	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000278

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 5 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Personnel Injury - Construction Related (Industrial)	Possible serious personnel injury/death Adverse impact to schedule	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Improper use of electrical supply, equipment, safety devices due to human error during construction	A) 4	A) 2
B) Equipment energized during installation/testing activities	B) 4	B) 2
C) Slip, trip and fall accidents	C) 4	C) 2
D) Material handling equipment is less-than-adequate	D) 4	D) 2
E) Vehicle impact	E) 4	E) 2
F) Trench or excavation failure	F) 4	F) 2
G) Eye injury	G) 4	G) 2
H) Ear injury - excessive noise	H) 4	H) 2

Controls and Mitigators	Residual Risk/Comments
A-H1) Facility Owner shall verify and ensure that workers have received general site worker training in addition to task specific training as listed in the Project Specific Health and Safety Plan A-H2) Facility Owner shall ensure successful completion of training on project procedures A-H3) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-H4) QA/QC Engineer shall ensure adequate equipment inspection and testing prior to work initiation B&F5) Facility Owner shall ensure that procedures for Excavation Penetration Permits and Facility Outage Permits are properly followed F6) Construction Engineer shall ensure the proper use of trench boxes, shoring, sloping, etc.	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000279

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 6 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Personnel Falling into Silo	External and possible internal contamination Possible serious personnel injury/death Adverse impact to schedule	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Poor workmanship while repositioning the removal equipment and associated supports B) Improper dome removal methods	A) 3 B) 3	A) 2 B) 2

Controls and Mitigators	Residual Risk/Comments
A&B1) Facility Owner shall ensure the proper use of personnel safety restraints A&B2) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A&B3) Supervisor shall ensure that the RWP is updated as work progresses A&B4) Safety Engineer shall ensure the proper use of safety nets and barriers A&B5) Project Engineer shall ensure that the project design for silo material removal includes minimal access to the silo dome	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 7 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Silo Containment Breached	Possible serious personnel injury/death Equipment damage/loss Spread of airborne contamination Internal/external exposure Loss of containment Adverse schedule impact	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Tornado	A) 2	A) 3
B) Rigging failure	B) 4	B) 2
C) Earthquake	C) 2	C) 3
D) Failure of Environmental Isolation Enclosure	D) 4	D) 2
E) Violation of Operational Safety Requirement for Silos 1 and 2	E) 4	E) 2

Controls and Mitigators	Residual Risk/Comments
A-E1) Facility Owner shall ensure that the FEMP Emergency Response Plan is current A2) AEDO Manager shall ensure that the site tornado warning system functions properly B2) Construction Engineer shall ensure proper use of the rigging plan D2) Project Engineer shall ensure that A/E design meets DOE Orders 6430.1A and 5480.28 E2) Trades Supervisor shall ensure successful completion of training and qualification on heavy equipment use	Implementation of these controls and mitigators will reduce the probability of occurrence to negligible (1), thus reducing the quality level codes to 4.

000281

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 8 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Facility

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Electrical Shock Hazard	Possible serious personnel injury/death Impact on site safety function Loss of power for production, schedule impact Local fire Airborne release Solidification in vitrifier	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Shorts in electrical cables	A) 4	A) 2
B) Overhead lines in work area resulting in construction equipment accident	B) 3	B) 2
C) Lock and tag failures or procedures not followed	C) 4	C) 2
D) Underground line in area not known	D) 4	D) 2

Controls and Mitigators	Residual Risk/Comments
A-D1) Electrician Supervisor shall ensure proper review of all electrical interfaces prior to implementation A-D2) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-D3) Construction Engineer shall ensure an adequate Construction Environmental Health and Safety Work Survey A4) Project Engineer shall ensure that the A/E design includes a process shutdown to safe condition upon electrical failure A5) Project Engineer shall ensure that the A/E design includes Ground Fault Interrupter (GFI) equipment D4) Facility Owner shall ensure the proper implementation of SSOP-719 energy control lock and tag procedure	Implementation of these controls and mitigators will reduce the probability of occurrence to negligible (1), thus reducing the quality level codes to 4.

000282

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 9 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Vehicle Traffic Incident	Possible serious personnel injury/death Equipment damage Possible release of radioactive or hazardous contaminants	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Poor traffic patterns used by operations B) Operator error	A) 2 B) 4	A) 3 B) 2

Controls and Mitigators	Residual Risk/Comments
A&B1) Trades Supervisor shall ensure successful completion of qualification training for vehicle operators A&B2) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A&B3) Human Factors Engineer shall ensure that the project design includes adequate designated personnel walkways A4) Safety Engineer shall ensure that the project design restricts traffic in controlled areas B4) Facility Owner shall ensure that the project design includes necessary traffic barriers and controls	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

000283

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 10 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Hoisting and Rigging Failure	Possible serious personnel injury/death Equipment failure/damage Possible release of radioactive or hazardous contaminants	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Equipment failure B) Operator error due to inadequate training C) Lack of maintenance of lifting equipment D) Inadequate rigging design	A) 2 B) 4 C) 2 D) 2	A) 3 B) 2 C) 3 D) 3

Controls and Mitigators	Residual Risk/Comments
A-D1) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses B2) Trades Supervisor shall ensure successful completion of training and qualification on hoisting and rigging A&C2) Project Engineer shall ensure adequate equipment maintenance prior to initiation of work B3) Construction Engineer shall ensure that a complete sitewide hoisting and rigging plan (SSOP) is available prior to initiation of work	Implementation of these controls and mitigators will reduce the probability of occurrence to negligible (1), thus reducing the quality level codes to 4.

000284

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 11 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
General Lighting Failure/Poor Lighting	Possible personnel injury Equipment damage	1 2 (3) 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Inadequate lighting design B) Power failure C) Lighting fixture failure	A) 3 B) 4 C) 3	A) 3 B) 3 C) 3

Controls and Mitigators	Residual Risk/Comments
A1) Project Engineer shall ensure that the A/E design includes adequate lighting B1) Project Engineer shall ensure that the A/E design includes adequate emergency lighting B2) Project Engineer shall ensure that the project design includes an emergency power supply (emergency generator) C1) Project Engineer shall ensure that vendor submittals comply with lighting equipment specifications	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 4.

000285

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 12 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Loss of Primary Electrical Distribution Power	Loss of electrically-operated equipment and instrumentation Equipment damage causing monetary loss Possible personnel injury	1 2 (3) 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Equipment failure B) Human error C) Natural catastrophe	A) 3 B) 4 C) 2	A) 3 B) 3 C) 4

Controls and Mitigators	Residual Risk/Comments
A-C1) Project Engineer shall ensure that the project design includes backup power for critical functions including melter heating A-C2) Project Engineer shall ensure that the project design includes redundant power supplies for critical systems A3) Facility Owner shall ensure routine preventive maintenance B3) Trades Supervisor shall ensure operators are trained and qualified on equipment operation and proper shutdown procedures C3) CRU-4 Safety Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 4.

000286

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 13 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Loss of Containment on High-Pressure Water Line	Release of water which contains radionuclides Possible personnel injury Equipment damage causing monetary loss Adverse impact to project schedule	1 2 3 (4) 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Overpressurization of line B) Weld or seam failure C) Material defect	A) 4 B) 4 C) 4	A) 2 B) 2 C) 2

Controls and Mitigators	Residual Risk/Comments
A-C1) Construction Engineer shall ensure adequate pre-operational testing A-C2) Project Engineer shall ensure that the A/E design locates contaminated pipes in controlled areas A3) Trades Supervisor shall ensure successful completion of training and qualification on system operation A4) Project Engineer shall ensure that the project design includes adequate overpressure protection A5) Project Engineer shall ensure that the A/E design includes double walled pipe where appropriate B3) Project Engineer shall ensure that the project design includes an adequate Leak Detection System B4) QA/QC Engineer shall ensure adequate inspection of all welds	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 4.

000287

89

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 14 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Heat Stress Leading up to Heat Stroke	Adverse schedule impact if worker stay time limited based on temperature Personnel injury	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Elevated worker temperatures from working in Personnel Protective Equipment (PPE) B) Heat buildup from vitrification system C) Inadequate rest periods D) Worker failure to recognize symptoms of heat distress	A) 5 B) 5 C) 3 D) 4	A) 1 B) 1 C) 2 D) 2

Controls and Mitigators	Residual Risk/Comments
A-D1) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-D2) Safety Engineer shall ensure the use of short-term work cycle as required by Industrial Hygiene A&B3) Project Engineer shall ensure that the A/E design includes an adequate ventilation system A&B4) Safety Engineer shall ensure working conditions monitored and controlled A&B5) Safety Engineer shall ensure that the project design includes adequate cooling apparatus A6) Supervisor shall ensure air lines supplied to PPE as necessary C&D3) Trades Supervisor shall ensure adequate use of buddy system among workers D4) Trades Supervisor shall ensure successful completion of training in first aid and the symptoms of heat stress	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000288

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 15 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Loss of Containment (Building)	Release of dust and radium-bearing residues Potential internal exposure Adverse schedule impact DOE/EPA Censure	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Natural phenomena B) Crane accident C) Vehicle accident	A) 2 B) 3 C) 3	A) 3 B) 2 C) 2

Controls and Mitigators	Residual Risk/Comments
A-C1) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-C2) Project Engineer shall ensure that the A/E design complies with DOE Orders 6430.1A and 5480.28 B&C3) Trades Supervisor shall ensure successful completion of training and qualification on equipment maintenance and system operation B&C4) Facility Owner shall ensure that the project design includes adequate traffic controls and restricts traffic in controlled areas B5) Construction Engineer shall ensure successful completion of training and qualification for hoisting and rigging equipment B6) Construction Engineer shall ensure that a complete sitewide hoisting and rigging plan (SSOP) is available prior to initiation of work C5) Trades Supervisor shall ensure successful completion of training and qualification for vehicle operators	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

000289

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 16 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Contaminated Dust Released to the Air from Preparation Activities	Personnel exposure to contaminated dust Possible DOE censure	1 (2) 3 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Work in the area B) Excavation and handling of contaminated soil	A) 6 B) 6	A) 3 B) 3

Controls and Mitigators	Residual Risk/Comments
A&B1) Project Engineer shall ensure that the project design includes an adequate dust suppression system A&B2) Supervisor shall ensure proper use of PPE to prevent personnel contamination and exposure A&B3) Supervisor shall ensure prior process knowledge is used to identify hot spots	Implementation of these controls and mitigators will reduce the probability of occurrence to moderate (3), thus reducing the quality level codes to 4.

000290

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 17 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Slurry Line from the Silos Fails	Release of slurry with K-65 residues causing spread of contamination Possible personnel exposure Possible equipment damage	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Material defect	A) 4	A) 2
B) Operator error connecting slurry line	B) 4	B) 2
C) Slurry line overpressurized	C) 2	C) 3
D) Freeze/thaw action on slurry line	D) 2	D) 3
E) Weld or seam failure	E) 4	E) 2
F) Vehicle accident pulls slurry line from silo	F) 2	F) 3
G) Crane accident pulls slurry line from silo	G) 2	G) 3
H) Natural phenomena	H) 2	H) 3

Controls and Mitigators	Residual Risk/Comments
A-H1) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-H2) Project Engineer shall ensure that the project design includes use of double wall pipe in outdoor areas and an adequate Leak Detection System A-H3) Project Engineer shall ensure that the A/E design locates the contaminated pipes in controlled areas A-H4) Project Engineer shall ensure that the A/E design openly drains the slurry line into the thickener B-D&F-G5) Trades Supervisor shall ensure successful completion of training and qualification on vehicle operations, crane operation, and process operation for workers conducting those activities A&E5/B&C6) Construction Engineer shall ensure adequate pre-operational testing of slurry line C7) Project Engineer shall ensure that the A/E design includes adequate overpressurization protection D6) Project Engineer shall ensure that the A/E design includes adequate freeze protection for the slurry line E6) QA/QC Engineer shall ensure adequate inspection of all welds	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

000291

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 18 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Explosion in Furnace	Glass lava spills out of furnace causing schedule delay Failure of adjacent equipment, piping, or support structure Possible death/serious injury to on-site personnel Spread of contamination	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Overpressurization due to steam buildup B) Operator error due to lack of training	A) 3 B) 4	A) 2 B) 2

Controls and Mitigators	Residual Risk/Comments
A1) Project Engineer shall ensure that the furnace design includes overpressurization protection such as engineered means of relief and measures to prevent liquid entering containment basins for molten glass A2) Project Engineer shall ensure that the project design includes an adequate ventilation/off-gas system A3) Project Engineer shall ensure that the project design includes adequate electrical temperature controls/interlocks A4) Project Engineer shall ensure that the A/E designs the melter with double containment and spill control B1) Trades Supervisor shall ensure successful completion of operator training and qualification on furnace operation	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000292

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 19 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Leak or Spill of Molten Glass or Heavy Metals from Furnace	Fire due to molten glass release Potential worker death/serious injury Adverse impact to schedule	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Loss of containment due to material defect B) Loss of containment due to worker error during installation from lack of inspection C) Loss of containment due to worker error from lack of training on system operation D) Loss of containment due to fire in furnace area	A) 3 B) 4 C) 4 D) 3	A) 2 B) 2 C) 2 D) 2

Controls and Mitigators	Residual Risk/Comments
A-D1) Project Engineer shall ensure that the A/E design includes adequate containment dikes and spill barriers A-D2) Facility Owner shall ensure that the work area minimizes the storage of combustible materials in the vitrifier area C3) Supervisor shall ensure successful completion of operator training and qualification on the vitrification system operation	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000293

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 20 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Damage to the Furnace	Molten glass would solidify in place causing irreparable damage to the melter/furnace Adverse impact to project schedule	1 2 (3) 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Loss of electricity to the melter	A) 3	A) 3

Controls and Mitigators	Residual Risk/Comments
A1) Facility Owner shall ensure that operation is restricted when stand-by power is not available A2) Project Engineer shall ensure that the melter design includes adequate insulation A3) Project Engineer shall ensure that the melter design includes emergency power	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level code to 4.

000294

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 21 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
External Dose Hazard from the vitrified product	Difficulty in handling material causes schedule delay Possible exposure to personnel	1 (2) 3 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) High radium content in the vitrified product	A) 3	A) 4

Controls and Mitigators	Residual Risk/Comments
A1) Test Engineer shall ensure optimum mix of feed material and additives are used to reduce dose rate as low as practical A2) Safety Engineer shall ensure that ALARA principles are followed	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus ensuring a quality level code of 4.

000295

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 22 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
High Radon Emanation from the Product	Difficulty in storage and handling of the glass blocks causes schedule delay Possible exposure to personnel	1 (2) 3 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Failure of the glass matrix to contain radon	A) 3	A) 4

Controls and Mitigators	Residual Risk/Comments
A1) Supervisor shall ensure that radon flux is measured and surface contamination is checked prior to transport to the storage facility	Implementation of this control/mitigator will reduce the probability of occurrence to low (2), thus ensuring a quality level code of 4.

000296

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 23 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
High Radon Levels in the Process Building	Internal exposure hazard to personnel working in the building	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Higher than expected radon emanation from equipment B) Loss of off-gas system to the building	A) 3 B) 3	A) 2 B) 2

Controls and Mitigators	Residual Risk/Comments
A&B1) Project Engineer shall ensure that the A/E design includes a high airborne contamination alarm A&B2) Facility Owner shall ensure that adequate evacuation alarms and procedures are in place prior to work initiation A3) Project Engineer shall ensure the use of charcoal canisters in off-gas system to filter radon from building air	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000297

89

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 24 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
RTS Carbon Canisters Catch Fire	Fire and rupture of the canisters causes large radon release Potential hazard to on- and off-site persons	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Off-gas temperature which enters the carbon canisters is above the ignition temperature of the carbon due to quench tower failure (350-450 degrees C)	A) 3	A) 2

Controls and Mitigators	Residual Risk/Comments
A1) Safety Engineer shall ensure that the project design includes an adequate fire protection system A2) Safety Engineer shall ensure that the project procedures include an adequate fire protection program A3) Project Engineer shall ensure that the A/E design includes adequate controls and interlocks A4) Project Engineer shall ensure that the A/E design includes adequate temperature controls to shut down the canister inlet	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level code to 3.

000298

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 25 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Equipment Failure Due to Cold Weather	Monetary loss due to equipment damage Adverse schedule impact Possible injury to personnel	1 2 (3) 4 5 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Inadequate or failed freeze protection	A) 3	A) 3

Controls and Mitigators	Residual Risk/Comments
A1) Project Engineer shall ensure that the A/E design meets the cold protection provisions in DOE Order 6430.1A A2) Facility Owner shall ensure that an adequate cold weather emergency plan is in place prior to work initiation	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level code to 4.

000299

68

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 26 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Labor Dispute	Unsafe operating conditions could result in possible personnel injury Unsafe operating conditions could result in possible equipment damage Adverse schedule impact	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Failure of management and union to agree B) Improper industrial relations	A) 3 B) 3	A) 2 B) 2

Controls and Mitigators	Residual Risk/Comments
A&B1) Industrial Relations Representative shall ensure that formal industrial relations policies are followed A&B2) Trades Supervisor shall ensure that formal industrial relations policies are followed	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000300

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 27 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Facility

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Contamination of Heavy Machinery or Equipment	Possible exposure to personnel Adverse impact to schedule for decontamination procedure implementation Monetary loss	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Contamination through routine use B) Personnel contamination transfers to equipment C) Material handling accident transfers contamination to equipment	A) 4 B) 4 C) 4	A) 2 B) 2 C) 2

Controls and Mitigators	Residual Risk/Comments
A-C1) Project Engineer shall ensure that procedures are in place to minimize the transfer of contamination to equipment A-C2) Project Engineer shall ensure that adequate decontamination procedures are in place prior to work initiation A-C3) Project Engineer shall ensure that the A/E design includes an adequate decontamination system A-C4) Facility Owner shall ensure that bag-in/bag-out procedures are properly applied A-C5) Trades Supervisor shall ensure successful completion of training and qualification on material handling and decontamination procedures as outlined in the Project Specific Health and Safety Plan	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2), thus reducing the quality level codes to 3.

000301

68

Fernald Site

RISK ASSESSMENT REPORT (RAR) CONCURRENCE/APPROVAL

RAR Number: RAR-93-0012-A-0	Project Title: Operable Unit 4 Vitrification Project		Page 28 of 28
	Name	Job Title	Date
Initiator	Signature:		
	Print: D. Jacoboski		
Initiator's Section Manager	Signature:		
	Print: W. Pickles		
Manager NF&SS	Signature:		
	Print: R. Schmidt		
Manager SQA	Signature:		
	Print:		
	Signature:		
	Print:		
	Signature:		
	Print:		
	Signature:		
	Print:		
Final Approval			
Author's Department Manager	Signature:		
	Print:		

000302

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 1 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Internal Radiation Exposure to the Worker	Potential to exceed site dose limits resulting in facility shutdown, personnel injury, and DOE censure	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Inhalation/ingestion of radionuclide bearing dust residues	A) 2	A) 3
B) Radiation Work Permit (RWP) is not updated as work progresses	B) 3	B) 2
C) Silo material exposed to atmosphere	C) 3	C) 2
D) Inhalation of radon gas	D) 2	D) 3

Controls and Mitigators	Residual Risk/Comments
A,C&D1) Project Engineer shall ensure that the project design includes a ventilation system that samples and removes contaminants A,C&D2) Supervisor shall ensure proper usage of personal protective equipment A,C&D3) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A,C&D4) Project Engineer shall ensure that the project design includes an adequate environmental isolation enclosure A,C&D5) Facility Owner shall ensure successful completion of training and qualification on radiation exposure for "site worker" category A&C6) Project Engineer shall ensure that the project design includes an adequate contaminated dust control system A&C7) Project Engineer shall ensure that adequate bag-in/bag-out procedures are in place prior to work initiation B1) Project Engineer shall ensure that the Architect/Engineer (A/E) design meets standards in RM-0009, "Radiological Controls Manual" and DOE Orders 6430.1A and 5480.28 B2) Supervisor shall ensure that the RWP is updated as work progresses D6) Project Engineer shall ensure that the project design includes an adequate radon collection system	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

000303

89

Risk Assessment Report (RAR)

RAR Type: A

RAR Number: RAR-93-0012-A-0	
Initiator: D. Jacoboski	Date: 10/05/93
Page: 2 of 28	Revised:

Project Title: Operable Unit 4 Vitrification Project

Possible Failure/Concern/Hazard	Consequences	Seriousness Code
Excessive External Radiation Exposure to the Worker	Potential to exceed site dose limits resulting in facility shutdown, personnel injury, and DOE censure	1 2 3 4 (5) 6

Possible Cause(s) of Failure/Concern/Hazard	Probability of Occurrence Code (1-6)	Quality/Risk Level Code (1-4)
A) Presence of higher-than-expected penetrating radiation	A) 4	A) 2
B) Radon daughters build up in head space above equipment or tanks increasing dose levels	B) 3	B) 2
C) High level of radon, radium daughter, or thorium products in the final waste form leading to greater than anticipated dose rates	C) 5	C) 1
D) Failure of shield walls	D) 3	D) 2
E) Failure of protective clothing leads to excessive skin dose	E) 4	E) 2
F) RWP is not updated as work progresses	F) 2	F) 3

Controls and Mitigators	Residual Risk/Comments
A-F1) Facility Owner shall ensure successful completion of training and qualification on radiation exposure for "site worker" category and system operation A-F2) Project Engineer shall ensure that the Project Specific Health and Safety Plan is approved prior to work initiation and followed as work progresses A-E3) Project Engineer shall ensure that the A/E design applies As Low As Reasonably Achievable (ALARA) principles A-D4) Project Engineer shall ensure that the A/E design meets standards in RM-0009, "Radiological Controls Manual" and DOE Orders 6430.1A and 5480.28 A-D5) Project Engineer shall ensure that the project design includes adequate shielding and shall ensure adequate design review of the shielding B&C6) Project Engineer shall ensure that the project design includes an adequate radon collection system and shall ensure adequate design review of the radon collection system E4) Supervisor shall ensure proper usage of personal protective equipment F3) Supervisor shall ensure that the RWP is updated as work progresses	Implementation of these controls and mitigators will reduce the probability of occurrence to low (2) for all causes, thus reducing all of the quality level codes to 3.

000304