This document was too large to scan as a single document; therefore, it has been divided into smaller sections.

Section 1 of 2

Document Information			
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1	1	Cog. Mgr. GA Glover	GA Glover		T4-20	DL McKinnis	DL McKinnis		T4-20	1	1
1	1	QA DR Groth	DR Groth	6/24/96	T4-15	~~GM Kronvall~~ P.E. Roege			T5-15	3	
3		Safety ~~DM Wyatt~~ C. Sadanaga			T5-11	RD Redekopp			T5-15	3	
		Env. NA				CP Christenson			A5-55	3	
1		EC Vogt, Plant Manager			T5-50	~~BW Templeton~~ W.D. Seaborg			R3-79	3	
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	" "		0	T.A.Brown T5-15	" "	3		
	" "		0	J.R. Bell G1-15	" "	3		
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	" "		0	L.J. Olquin N1-26	" "	3		
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	" "		0	T.E. Huber T5-50	SQD	3		

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FIRE HAZARD ANALYSIS FOR PLUTONIUM FINISHING PLANT PROJECT

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B&W Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract: This document performed a fire hazards analysis for the Plutonium Finishing Plant (PFP) in accordance with DOE Directive RLID 5480.7, DOE Order 5480.7A and complies with WHC-CM-4-41 and WHC-SD-GN-FHA-30001.

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FIRE HAZARD ANALYSIS

FOR

PLUTONIUM FINISHING PLANT PROJECT

HNF-SD-CP-FHA-004

REVISION 0

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FIRE HAZARD ANALYSIS

FOR

PLUTONIUM FINISHING PLANT COMPLEX

WHC-SD-CP-FHA-004

REVISION 0

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ACRONYMS

AISG	American Insurance Services Group
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BLEVE	Boiling Liquid Expanding Vapor Cloud Explosion
CFAST	Consolidated Model of Fire Growth and Smoke Transport
D&D	Decontamination and Decommissioning
DCG	Design Concentration Guide
DETACT-QS	Detector Actuation Model
DGFPS	Draft Glovebox Fire Protection Standard
DNFSB	Defence Nuclear Facilities Safety Board
DOE	Department of Energy
DOT	Department of Transportation
FHA	Fire Hazard Analysis
FIRES-T3	3-D Finite Element Heat Transfer Model
FM	Factory Mutual
FPETOOL	Fire Protection Computer Model
FSAR	Final Safety Analysis Report
HEPA	High Efficiency Particulate Air
HFD	Hanford Fire Department
HVAC	Heating, Ventilation, Air Conditioning
LFL	Lower Flammable Limit
LLNL	Lawrence Livermore National Laboratory
LLWTF	Low-level Waste Treatment Facility
LPG	Liquid Propane Gas
LWBS	Limited Water Bottle Station
MCFL	Maximum Credible Fire Loss
MPFL	Maximum Possible Fire Loss
MT	Miscellaneous Treatment
NBS	National Bureau of Standards (now National Institute of Standards and Technology (NIST))
NDA	Non-Destructive Analysis
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology (formerly National Bureau of Standards (NBS))
PFP	Plutonium Finishing Plant
PMF	Probable Maximum Flood
PMMA	Polymethylmethacrylate
PRF	Plutonium Reclamation Facility

ACRONYMS (Continued)

RL	Richland
RMA	Remote Mechanical-A (gloveboxes)
RMC	Remote Mechanical-C (gloveboxes)
RTI	Response Time Index
SFPE	Society of Fire Protection Engineers
SNM	Special Nuclear Material
SRV	Safety Relief Valve
STAR*CD	3-D Finite Element Heat Transfer Package
TBP	Tributyl Phosphate
TRU	Transuranic Waste
UBC	Uniform Building Code
WHC	Westinghouse Hanford Company

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EXECUTIVE SUMMARY

1. Introduction

A fire hazards analysis (FHA) was performed for the Plutonium Finishing Plant (PFP) Complex at the Department of Energy (DOE) Hanford site. The scope of the FHA focusses on the nuclear facilities/structures in the Complex. The analysis was conducted in accordance with RLID 5480.7, [DOE Directive RLID 5480.7, 1/17/94] and DOE Order 5480.7A, *Fire Protection* [DOE Order 5480.7A, 2/17/93] and addresses each of the sixteen principle elements outlined in paragraph 9.a(3) of the Order. The elements are addressed in terms of the fire protection objectives stated in paragraph 4 of DOE 5480.7A. In addition, the FHA also complies with WHC-CM-4-41, Fire Protection Program Manual, Section 3.4 [1994] and WHC-SD-GN-FHA-30001, Rev. 0 [WHC, 1994].

Objectives of this FHA are to determine: (1) the fire hazards that expose the PFP facilities, or that are inherent in the building operations, (2) the adequacy of the fire safety features currently located in the PFP Complex, and (3) the degree of compliance of the facility with specific fire safety provisions in DOE orders, related engineering codes, and standards. The scope of this FHA includes the building construction, the process hazards, existing building fire protection, and the site wide fire protection for the following PFP facilities:

(1) Building 234-5Z
(2) Building 242-Z
(3) Building 236-Z
(4) Building 291-Z
(5) Building 2736-ZB
(6) Building 2736-Z
(7) Building 2721-Z
(8) Building 232-Z
(9) Building 241-Z
(10) Building 243-Z
(11) Compressed Gas Storage Areas
(12) Hazardous Product and Waste Exterior Lay Down Areas

The approach for the development of this FHA included several tasks. Several site visits were conducted to document the buildings, processes, and fire protection features as well as to obtain general site information. The site visits included a walkthrough of the PFP facilities, discussions with fire protection and facility personnel, and review of drawings and site plans/documents.

An analysis was then performed to establish candidate fire scenarios, evaluate the damage potential associated with these fires, and determine compliance with DOE fire protection requirements. The analyses involved reviewing existing requirements, modeling, and analytical analyses in order to quantify the potential impact of plausible fire scenarios on process operations, facility operations, and safety.

Each of the FHA elements identified in DOE 5480.7A are addressed in this FHA. Also, at the request of PFP facility staff, an additional section relating to glovebox fire protection features and requirements is included.

Requirements in DOE Order 6430.1A, General Design Criteria [DOE Order 6430.1A, 1989], applicable National Fire Protection Association (NFPA) standards, DOE Draft Glovebox Fire Protection Standard [WHC, 1993], and the Uniform Building Code (UBC) are addressed in the context of the FHA elements. DOE Order 6430.1A and UBC criteria apply to new construction and are referenced in the FHA for guidance purposes only. In addition, where deemed appropriate, quantitative analyses are performed to estimate the potential impact of credible fire scenarios. The scenarios are based on an engineering analysis of the PFP facilities and the processes.

2. Summary and Conclusions

The analyses presented in this report are based on the assumption that the types and quantities of combustibles observed during the site visit are representative of the existing and potential fire hazards in the PFP Complex. It is further assumed that the information provided in the site documents, drawings and plans are accurate and there are no plans to change the primary use of the facility.

The facility operation poses some unique fire hazards that are unusual for a typical industrial structure. Issues addressed include hydrogen generation from stored radioactive materials and gloveboxes. However, the principle fire hazards, propane and ordinary combustibles, are not unique to this facility.

A detailed evaluation of the fire potentials of the hazards identified was performed. The following conclusions are based on the analyses documented in this report:

1. The fire safety features within the PFP Complex provide adequate protection for the structures based on the majority of the fire scenarios identified.

2. The automatic sprinkler systems are a critical element in the fire protection for the facilities. The systems should be properly maintained and tested. Sprinkler protection throughout the majority of the operating facilities limits the damage potential from most of the fire scenarios.

3. The provisions for life safety throughout the Complex are in compliance with NFPA 101 and are adequate for the number of workers anticipated to occupy the building.

4. Important elements of the fire safety provided within Building 234-5Z include:

   a. Automatic sprinkler protection throughout the facility;

   b. Protection of the structural elements of the first floor with a plaster membrane; and

   c. Masonry walls separating the first floor into zones.

5. The fuel loads in Building 234-5Z at the time of the survey are limited by good housekeeping and operational procedures. The maximum fuel load anticipated in a typical office, laboratory or storage area on the first floor is estimated. Based on a maximum possible fire exposure on the first floor of Building 234-5Z, the proposed fire scenario is not of sufficient duration to cause structural failure. However, clogging of the HEPA filter system could be possible. Clogging of HEPA filters could result in the loss of negative pressure in the building. Therefore, leakage of fire products, including radiological materials, to the exterior is possible through cracks or other passive methods.

6. Hydrogen generation from stored plutonium solutions in 55-gallon drums is shown to not present a significant fire hazard due to a deflagration or detonation. In order to prevent hydrogen buildup within the storage containers, vented type containers should be used.

7. In Building 234-5Z, fire scenarios are provided that cause structural failure of the second floor roof and fire spread throughout the areas containing combustibles. Based on the structural failure, it is postulated that the release of radiological materials from the filter rooms is possible.

8. Building 242-Z was not accessible. Concerns regarding the interior finish within the facility have been raised. Sufficient data is not available to evaluate the hazard posed by the finish. However, based on the facility being unoccupied, sprinkler protection being provided, and the fuel load specified by facility staff, the interior finish is not a concern.

9. A fire involving the plastics stored in the annex (i.e., TC-66) to Building 242-Z would be controlled by the sprinkler system. However, if sprinklers fail a fire could result in the loss of contents in TC-66 and 242-Z.

10. The fuel load in Building 236-Z is limited. In addition, the fire resistive construction and automatic sprinkler protection provided throughout will limit the effects of a fire.

11. Fire scenarios in Building 2736-ZB result from the ordinary combustibles in the office and laboratory spaces. The fires are expected to be controlled by the automatic sprinkler system. However, if the automatic sprinkler system fails, the fire resistive construction will limit the area of fire damage.

12. The limited fuel load in the vaults and the fire resistive construction of Building 2736-Z results in bounded effects of a fire. The maximum scenario results from a fire causing damage to the security system.

13. A diesel fuel spill fire in Building 2721-Z creates the maximum concerns associated with a fire. The automatic dry pipe sprinkler system will limit the effects of the fire. If the automatic sprinkler system fails, damage to all the equipment and the structure is possible.

14. The fire scenario within Buildings 241-Z and 243-Z are limited because there were no fuel loads identified during the site visit. Assuming a transient combustible fire, damage to the contents and structure are expected to be limited.

15. Fire spread associated with the compressed gas storage area and the hazardous product and waste exterior product lay down areas are limited to the contents of the area only. A fire in the compressed gases will result solely in the loss of the gas, equipment and storage shed. A fire in the lay down areas could cause the release of contamination.

With the incorporation of the recommendations in the FHA, the PFP Facility Complex will meet the objective of Paragraph 4 of DOE 5480.7A.

3. Description of Construction

This section provides a general description of construction for the facilities addressed in this study. Construction details are based on information provided in the PFP Final Safety Analysis Report (FSAR) [WHC, 1995] and individual building, architectural, and structural drawings.

4. Facility Description and Operations

The Plutonium Finishing Plant (PFP) is located on the DOE Hanford site in south central Washington State. PFP was operated by Westinghouse Hanford Company (WHC) during the development of the FHA. The Project Hanford Management Contractor is now issues to Fluor Daniel Hanford and major subcontractor, B&W Hanford Company (BWHC) for the operations of PFP and DOE Richland Operations Office. Since 1991, the mission of the PFP has changed from special nuclear material (SNM) processing to preparation for decontamination and decommissioning (D&D). The PFP is in transition between its previous mission and the proposed D&D mission. The objective of the transition is to place the facility into a stable state for long-term storage of SNM prior to final disposition of the facility. In this section, an overview of the current operations in the PFP facilities is provided. The facility descriptions and operations are based on information found in the PFP Final Safety Analysis Report (FSAR) [WHC, 1995].

5. Fire Protection Features

This section provides a general description of the active fire protection features at the PFP. An overview of the water supply and demand required by the installed automatic sprinkler systems is included.

The Sanitary Water System serving the 200 West Area is a shared system providing water for sanitary, process, and fire protection uses. The Fire Protection Water Supply Analysis [WHC-SD-SQA-ANAL-30001, Rev.0, August 18, 1995] provides recommendations which if implemented will increase the reserve fire protection water supply and the reliability of the water supply system. The water supply analysis states that the 200 Area water systems are considered to be in fair condition, however, the systems are not in compliance with DOE 5480.7A and RLID

5480.7. Project B-604 is intended to bring the systems into full compliance with DOE Orders 5480.7A, 6430.1A, and RLID 5480.7. The project scope is to upgrade the 200 West water supply in three phases. Phase I and II are estimated by the project engineer to be completed by April 30, 1997 and Phase III was canceled via DOE approved Baseline Change Request LPM-096-050, Site Control Number W96-358 [McKinnis, 1996]. Although completion of Phase III may not directly affect the PFP Facility, there will be a continued reliability issue associated with the 200 West Area water distribution system. The "Improved Risk" level of fire protection as required for 200 West Area by DOE Order 6430.1A and 5480.7A is not addressed within this facility specific FHA.

The water supply system for fire protection service for the PFP Complex satisfies the requirements contained in NFPA 13 for Ordinary Hazard Group I in terms of required pressure and fire flow for the sprinkler systems.

The automatic sprinkler system coverage in the PFP facilities meet the requirements of DOE 5480.7A, Section 9.b(3)(b) and DOE 6430.1A, paragraph 1530-2.3.2 regarding provision of automatic suppression systems for facilities where the maximum possible fire loss could exceed $1 million. In Building 234-5Z, automatic sprinkler coverage is not provided in all areas. Automatic sprinklers are not recommended in the filter rooms and the storage vaults based on the limited fuel load and criticality concerns in these areas. However, other areas of the building, which do not currently have sprinklers, should be provided with automatic sprinkler protection (e.g., Rooms 194, 334, and 335).

For the buildings not provided with automatic sprinkler protection, the Maximum Possible Fire Loss (MPFL) does not exceed $1 million. Therefore, automatic fire suppression is not required in these facilities (see Section 12).

6. Fire Hazards

6.1 GENERAL

This section describes the existing fuel loading and potential fire hazards in the PFP facilities. The fuel arrays selected for fire hazard impact analysis are chosen based on the results of a walk down of each of the PFP facilities and discussions with facility plant personnel regarding support operations and transient activities in the Complex. The following "plausible" fire scenarios are included in this analysis:

1. Building 234-5Z - Office, laboratory, and process area fires,
2. Building 234-5Z - Hydraulic oil spill fire in room 321 (supply fan room),
3. Building 234-5Z - Potential hydrogen generation hazard in plutonium solution storage rooms,
4. Building 234-5Z - Propane cylinder release and deflagration hazard (Appendix B),
5. Building 242-Z - Plastic fire in TC-66,
6. Building 236-Z - Transient combustibles fire in room 41 (MT glovebox room),
7. Building 291-Z - Transformer oil spill fire in room 500,

8. Building 2736-ZB - Office/lab equipment fire in room 637 (NDA Lab),
9. Building 2721-Z - Diesel oil fire resulting from leak in emergency generator reservoir,
10. Building 232-Z - Transient combustibles fire in process area,
11. Building 243-Z - Transient combustibles fire in process area,
12. Compressed Gas Storage Area - Potential propane cylinder explosion hazard,
13. Hazardous Product and Waste Exterior Laydown Area - Exposure hazard resulting from a vehicle fuel tank rupture which spills, ignites and exposes stored 55-gallon TRU waste drums.

These scenarios do not include all possible fires; however, they are expected to bound the fire scenarios that exist within the facilities.

6.2 APPROACH

The approach for the analyses includes several tasks. A site visit was conducted to gather information relating to the building layout, structural components, process operations, and actual fire loading. The site visit included a building walk down, discussions with facility staff, and documentation/drawing reviews.

Based on the information gathered during the site survey, candidate fire scenarios are developed for the PFP facilities. The scenarios generally include worst case fire events. In some areas where multiple hazards exist, other credible fire events are also considered. The damage potential associated with the various fire scenarios was determined quantitatively using well documented, state-of-the-art fire protection models and equations or qualitatively using information in literature.

For each of the PFP facilities, the Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) were determined in accordance with DOE Order 5480.7A based on evaluation of the identified fire scenarios. For the MPFL, automatic and manual suppression systems are assumed to be unavailable. For the MCFL, consideration is given to any automatic suppression systems in the facility or fire area. Based on the MPFL and MCFL, compliance with DOE and WHC fire protection requirements was reviewed.

6.3 SUMMARY OF FIRE HAZARDS

Based on the fire scenarios examined throughout Section 6, Table EX-1 summarizes the potential maximum effects.

Table EX-1. Summary of Fire Scenario Effects

Building	Fire Scenario	Potential Impact with Automatic Sprinkler Protection	Potential Impact Without Automatic Sprinkler Potential
234-5Z	Office/Lab/Process Area Fire First Floor	- Damage to fuel package and equipment - Contamination within facility	- Damage to Sections of building - Contamination of various levels of facility - Clogging of HEPA filters
	Office Fire/Combustible Liquid Fire Second Floor	- Damage to equipment	- Structural failure of second floor roof - Damage to equipment - Release of materials outside structure
	Hydrogen Generation Hazard	- Damage to drums	- Damage to drums
242-Z	Plastic Fire in TC-66	- Damage to fuel of origin	- Loss of building contents - Structural failure of 242-Z
236-Z	Transient Combustibles in MT Glovebox Room	- Damage to glovebox and equipment - Contamination in facility	- Damage to glovebox and equipment - Contamination in facility
291-Z	Transformer Oil Fire	- Damage to transformers - Damage to equipment in Room 501	- Damage to transformers - Damage to equipment in Room 501
2736-ZB	Office/Lab Fire	- Damage to fuel of origin - Contamination in facility	- Damage to equipment/contents - Contamination in facility
2721-Z	Diesel Oil Fire	- Loss of equipment	- Loss of equipment - Damage to structure

Table EX-1. Summary of Fire Scenario Effects (continued)

Building	Fire Scenario	Potential Impact with Automatic Sprinkler Protection	Potential Impact Without Automatic Sprinkler Potential
232-Z	Transient Combustible Fire	N/A	- Damage to contents - Contamination
241-Z	Transient Combustible Fire	N/A	- Damage to contents
243-Z	Transient Combustible Fire	- Damage to equipment	- Damage to equipment
Compressed Gas Storage Areas	Propane Cylinder Leak	N/A	- Loss of storage structure - Damage to cylinders
Hazardous Product and Wastes Exterior Laydown Areas	Vehicle Fuel Exposure Fire	N/A	- Contamination release

N/A - Not applicable; sprinklers not provided in facility

7. Glovebox Fire Protection Analysis

As requested by Westinghouse Hanford Company (WHC), the fire safety features within the gloveboxes used in the Plutonium Finishing Plant (PFP) were assessed. The fire safety approach for gloveboxes includes analysis of existing active gloveboxes and existing gloveboxes which have been removed from service. In this analysis, the existing active gloveboxes used for the 94-1 Thermal Stabilization Process are specifically addressed for compliance with the Draft Glovebox Fire Protection Standard (DGFPS) [WHC, 1993] prepared for the U.S. Department of Energy (DOE) by WHC. In addition, the fire hazards and potential fire spread for existing PFP gloveboxes is assessed based on the anticipated fuel loading. Recommended fire protection features are presented as a general guide; however, other alternatives are available for specific applications based on a risk/cost analysis of the protection method versus overall hazard. The recommended glovebox fire protection features are proposed to be applicable to all existing gloveboxes used in PFP.

7.1 RECOMMENDED FIRE PROTECTION FEATURES

Based on the analysis of the existing PFP gloveboxes, in particular those used for the 94-1 Thermal Stabilization Process, recommendations with respect to glovebox fire protection are provided for both active gloveboxes and gloveboxes removed from service (i.e., inactive gloveboxes).

It is recognized that the facility staff wishes to comply with the intent of the DGFPS and other applicable codes. However, it does not appear cost effective to retrofit all of the gloveboxes to comply with the DGFPS. Given the condition of the existing gloveboxes and extensive modifications necessary to comply with all of the applicable criteria, more practical methods of protection are considered. In this section, alternatives are presented which provide a specific level of fire protection for the gloveboxes consistent with the intent of the DGFPS. The alternative fire safety features presented in this section are intended to be applicable to all existing PFP gloveboxes.

Tables EX-2 and EX-3 provide a summary of the recommended fire protection features for *existing* active and inactive gloveboxes which are part of process lines in addition to those which are isolated from other gloveboxes.

The overall goal of the recommended protection strategies is to control the extent of burning from a fire to a single glovebox. Where contamination or operational concerns do not allow for the loss of a particular glovebox, including the loss of integrity of the glovebox and the spread of contamination to other gloveboxes or the room, additional fire protection features may be required.

Table EX-2. Process Line Gloveboxes — Recommended Fire Protection

Status	Plastic Windows (polycarbonate or acrylic)	Glass Windows
Inactive	• Automatic suppression or inerting system or • Separation; and remove all combustibles; and provide automatic detection or • Separation; and remove all combustibles; and remove ignition sources; and cap gloves	• Automatic suppression or inerting system or • Separation; and contents limited to ordinary combustibles; and provide automatic detection or • Remove all combustible contents; and remove ignition sources; and provide automatic detection or • Separation; and remove all combustibles; and remove ignition sources; and cap gloves
Active	• Automatic suppression or inerting system	• Automatic suppression or inerting system or • No flammable liquids; storage of combustible materials less than that required to activate suppression system; and combustible materials transported during supervised operation only; and provide automatic detection
Containing combustible or pyrophoric metals	• Gas inerting system or • Apply inactive/active glovebox criteria for oxidation processes	• Gas inerting system or • Apply inactive/active glovebox criteria for oxidation processes

Table EX-3. Stand Alone Glovebox - Recommended Fire Protection

Status	Plastic (polycarbonate or acrylic) and/or Glass Windows
Separated greater than 10 feet from other gloveboxes	• Automatic suppression or inerting system or • Automatic detection or • Remove all combustible contents; and remove ignition sources; and cap gloves
Separated less than 10 feet from other gloveboxes	• Must comply with Table EX-2 criteria; Physical separation complies with separation criteria specified in Table EX-3 or • Analysis demonstrates that the fire exposure to other gloveboxes within 10 feet does not cause fire spread

8. Protection of Essential Safety Class Equipment

"An engineered safety feature is a system, component, or structure that prevents and/or mitigates the consequences of all potential accidents including the design basis accidents" [DOE Order 5480.7A, 1993]. A Westinghouse Hanford Safety Class item is comparable to a DOE Order 6430.1A "safety class" item and provides protection of the offsite public and environment. Westinghouse Hanford also provides criteria for Safety Significant Items; however, these are not addressed as essential Safety Class systems.

In general, Safety Class systems in the PFP are protected by one or more of the following: (1) automatic suppression systems, (2) automatic fire detection, (3) compartmentation/separation of hazards, (4) redundant safety systems, and (5) scheduled maintenance and testing. Potential damage of Safety Class systems is described in Section 6 for the applicable MPFL fire scenarios.

If the suppression systems in the building fail, scenarios exist that can cause damage to Safety Class Systems. For example, equipment on the second floor (e.g., fan room) or Zone 1, Zone 3a, or Zone 3 can be damaged by fire. Based on input from PFP staff, total failure of Safety Class systems is not possible as a result of any of the MPFL scenarios. Total failure of Safety Class equipment and subsequent consequences of their failure is addressed in the FSAR and bounds all possible scenarios in the FHA.

9. Life Safety Considerations

For the purposes of this Fire Hazard Analysis, each of the structures evaluated is classified according to a specific occupancy type as defined by NFPA 101 *Life Safety Code* [NFPA, 1994]. The buildings addressed fall into one or more of the following occupancy classifications: business, general and special purpose industrial, storage, and mixed use occupancy. A mixed use occupancy classification covers structures whose primary functions include more than one occupancy type.

The specific occupancy type of each structure is presented in Table EX-4.

Table EX-4. Building Occupancy Classifications

Building	Occupancy Classification
232-Z Building	Special Purpose and General Industrial
234-5Z Complex	Mixed Use - Business, Storage, Special Purpose and General Industrial
236-Z Building	Special Purpose and General Industrial
241-Z Building	Mixed Use - Storage, Special Purpose and General Industrial
242-Z Building	Mixed Use - Storage, Special Purpose and General Industrial
243-Z Building	Special Purpose and General Industrial
291-Z Building	Special Purpose and General Industrial
2721-Z Building	Special Purpose and General Industrial
2736-Z Complex	Storage

In general, the buildings are in compliance with NFPA 101 criteria.

10. Critical Process Equipment

Critical process equipment is not clearly defined in the applicable DOE order, DOE 5480.7A. For this Fire Hazard Analysis critical process equipment is defined as equipment that is considered necessary to the Hanford Site mission. Based on this definition and input from facility staff, there are no critical process equipment designated for the PFP facilities.

11. High Value Property

High value property for purposes of this analysis is defined as property or equipment with replacement costs estimated in excess of $1 million as identified in the RL Property system. The

RL high value property/equipment and associated replacement costs for the PFP facilities are identified in Table 11-1. Damage to some of the high value property/equipment is possible based on the postulated fire scenarios as discussed in Sections 6.0 and 12.0.

12. Damage Potential

Estimates of damage potential are based on the worst-case fire scenarios in each of the facilities. Cost estimates include loss of contents, structural damage to the buildings, and contamination cleanup. Based on facility direction, loss of production or program continuity is not a monetary concern in this analysis because operations can be relocated. Based on DOE Order 5480.7A, estimates of the MPFL assume that one automatic suppression system will malfunction. Manual firefighting efforts are also ignored for determination of the MPFL. Estimates of the MCFL are based on the assumption that the fire protection features, including automatic sprinkler systems, function as designed. Table EX-5 provides a summary of the MPFL and MCFL cost estimates for each of the PFP facilities.

Table EX-5. Summary of MPFL and MCFL Estimates for PFP Facilities

Building	MPFL	MCFL
234-5Z fire (first floor)	$14,000,000	$1,300,000
234-5Z fire (second floor)	$13,000,000	$3,000,000
242-Z	$5,300,000	$16,000
236-Z	$1,800,000	$1,800,000
291-Z	$530,000	$530,000
2736-ZB	$2,227,000	$2,227,000
2736-Z	$800,000	$800,000
2721-Z	$1,000,000	$500,000
232-Z	$100,000	$100,000
241-Z	$250,000	$250,000
243-Z	$500,000	< $500,000
Compressed Gas Storage Areas	<$1,000,000	<$1,000,000
Hazardous Product and Waste Exterior Lay Down Areas	$980,000	$980,000

Replacement costs of building contents and the structure are based on RL Property Systems cost breakdown as provided by WHC. A copy of the cost breakdown by room for each of the PFP facilities is included in Appendix E. The cost of contamination cleanup is based on

recent cleanup efforts in Building 232-Z. A fixed rate of $4.00 per square foot of surface area is used as a conservative cleanup estimate [McKinnis, 1996].

In accordance with DOE Order 5480.7A, facilities having a MPFL in excess of $1,000,000 require an automatic suppression system designed in accordance with the applicable NFPA standards. When the MPFL exceeds $50 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $50 million. When the MPFL exceeds $150 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $150 million.

13. Fire Department/Brigade Response

The Hanford Fire Department (HFD) consists of four fire stations covering the 560 square mile area of the Hanford site. These stations are strategically located across the site to ensure minimum response time to all facilities. Front-line engines are aerial device/pumpers in all stations with regular pumpers as back-up/reserve. The HFD maintains a fleet of 39 vehicles with a diversified range of capabilities. Of these, 29 are fire/emergency response apparatus. Of the 29 emergency response apparatus, 24 are considered first-line equipment. The remainder are fully maintained reserves.

The 200 area station is the closest to PFP. This station is located between the 200W and 200E areas. The estimated response time for apparatus to arrive on the scene of an incident is expected to be four to five minutes after notification from the dispatch/communications center. This estimate assumes the firefighters are in the 200 area fire station and normal road and traveling conditions.

Future changes to the HFD include closing Station 1 during the night. This will have no impact on fire department services to the PFP.

14. Recovery Potential

Table EX-6 identifies the primary consequences and recovery potential, as provided by PFP facility staff, for the fire scenarios presented in Section 6.0 which involve active PFP facilities.

Table EX-6. Effects of Fire Scenarios on PFP Operations

Scenario Description	Recovery Potential and Consequences
Loss of 234-5Z from propane deflagration and resulting fire spread.	The loss of the structure would have a major impact on the facility. The 234-5Z would be closed down and not replaced. The impact on the various projects for DOE would result in review and re-assignment on an as needed basis of projects to other facilities within Hanford or other DOE sites. Clean-up of contamination, ensuring containment and eliminating contamination spread to other areas would become PFP's mission. Staffing, as needed, would be assigned to other facilities to assist in that effort. With Hanford's once defense mission changing to a clean-up mission, there would not be a threat to the nation's defense in any way.
Building 234-5Z: First floor fire including loss of analytical labs, offices and other lab areas, and storage rooms.	The PFP would utilize the R&D Lab and redirect the overflow of work to one of the other labs located on the Hanford site. Additional equipment could be purchased for the R&D labs to handle the additional work. Operations would be delayed, but not greatly impacted, because of job priorities at other labs.
Building 234-5Z: First floor fire including loss of entire 94-1 Thermal Stabilization Process Line	The 94-1 Stabilization project would be temporarily shut down. Process line equipment and gloveboxes would be required to be relocated to a different part of the facility to allow 94-1 project to continue its efforts. This would cause a delay of approximately 6 months for some 94-1 project operations.
Building 234-5Z: Second floor fire including complete loss of supply fans and equipment	Loss of the supply fans would have an impact on the facility causing all radiological work to stop until the supply system could be replaced. PFP could maintain negative confined pressure in the facility by continued use of the exhaust fans. This would cause a down time of about one month before temporary supply fans could be installed and one year before permanent supply fan replacement.
Building 291-Z: Including loss of transformers, compressor, dryers and vacuum pumps	Loss of the transformers would be a temporary power loss until the power could be switched to a different power source. Loss of the compressor, dryer and reservoir would be temporary until portable equipment, which is on site, could be setup. There would be a down time of approximately two weeks. Loss of the exhaust fans would have a major impact on the facility causing all radiological work to stop until the exhaust system could be replaced. However, there are no credible fire scenarios which could potentially damage all of the exhaust fans simultaneously.
Building 2721-Z: Loss of emergency generators	The generators are not emergency generators but are considered standby generators. If these generators were lost due to fire, uninterrupted power supplies (UPS) are in place to support the needed areas of concern. Loss of operations would not be effected because of the UPS and emergency generators that would start up. Needed power feeds would be re-routed to other generators. The damaged generators would not be replaced.
Building 2736-ZB: Including complete loss of the NDA Lab	The PFP would utilize the analytical, R&D, or any of the other labs located on the Hanford site to process any needed tests or materials. Their would be no operational loss to the PFP.

Table EX-6. Effects of Fire Scenarios on PFP Operations (Continued)

Scenario Description	Recovery Potential and Consequences
Building 2736-Z: Fire involving loss of security equipment in storage vaults	Patrol would man security stations as they currently do. Only limited access would be allowed into the vaults. Each vault being entered would have a security guard stationed outside the vault door to survey everyone leaving the vault until the security systems were brought back on line. Loss of operations would be minimal since administrative procedures would be put in place to secure the area until new systems could be purchased and installed. Equipment would be purchased and installed within three weeks.

15. Potential for a Toxicological, Biological, and/or Radiological Incident Due to a Fire

This section addresses special fire hazards that result from chemicals, radioactive materials, and toxic materials and the potential for their release to the site or the public. A release to the environment can pose a health hazard and can also result in contamination of onsite and offsite areas. The health hazards associated with toxicological, biological, and/or radiological materials are addressed in the FSAR [WHC, 1995]. In this section, the analysis focuses on the extent of contamination and maximum cleanup costs resulting from the MPFL fire scenarios developed in Section 6.0. Although a toxicological incident due to fire can also occur in some of the PFP facilities (e.g., 236-Z Chem Prep Room 40), the FHA addresses worst case events, and involving a toxicological incident rather than radiological does not change that MPFL scenario results.

Contamination within the PFP facilities occurs for several of the fire scenarios considered in this analysis. Since the buildings are maintained at a negative pressure with respect to the outside, most of the fire scenarios do not result in a release to the environment. A release from the building to the outside can occur if any of the following occur:

(1) The building is intentionally vented;

(2) The building is exposed to an abnormal event such as an earthquake which could lead to loss of building perimeter integrity;

(3) An explosion occurs which violates the integrity of the exterior walls;

(4) Fire products escape through building openings (e.g., roof or door); or

(5) Fire products escape through building openings created by structural collapse due to fire.

There are two MPFL fire scenarios which can potentially result in a release to the outside: (1) second floor hydraulic oil spill fire; and (2) exterior, transuranic (TRU) drum storage fire. The fire damage resulting from these scenarios is discussed in Section 6.0. In Section 15, the maximum on and off site contamination was determined.

16. Emergency Planning

Several prefire plans have been developed by the fire department and PFP staff for the Complex. The primary tactic selected for manual firefighting is a direct interior attack unless conditions prevent such a strategy. The PFP Complex does not maintain a fire brigade. In most situations, the personnel are instructed to activate the building fire alarm system, and notify personnel within the immediate area. In some cases, there are plant operating procedures which address specific responses to fire.

The PFP Complex is included in the site-wide emergency plan and WHC-CM-5-8. Fire incidents are reported to the fire department by the fire alarm system or use of the phone. Water flow alarm from the sprinkler system is also transmitted to the fire department. A local fire alarm bell is installed outside the building to provide notification of a fire incident.

17. Security and Safeguards Considerations Related to Fire Protection

Access to the PFP facility is restricted to authorized or escorted personnel. There are no special security considerations identified in the PFP Complex that were judged to impact the fire hazard analysis. Most doors are operable for egress, without lockout or cipher locks. In addition, site security plans do not inhibit access to the building for fire department personnel and apparatus.

18. Natural Hazards Impact on Fire Safety

The impact of floods, tornadoes, and earthquakes on the PFP Complex have been previously analyzed in the FSAR and are summarized in Section 18.

19. Exposure Fire Potential

Piloted ignition of adjacent structures can occur due to flame radiation from fully developed fires. Minimum separation distances between structures were determined based on the construction and dimensions of the perimeter walls, building heights, potential fire severity, and the number of unprotected openings.

Minimum separation distances for adjacent structures were estimated based on procedures provided in NFPA 80A, *Recommended Practice for Fire Protection of Buildings from Exterior Fire Exposures* [NFPA 80A]. NFPA 80A was used to determine the minimum separation distance required between the main facility (including 234-5Z, 242-Z, and 236-Z) and other buildings which pose a potential exposure hazard.

All of the PFP facilities meet the requirements of NFPA 80A with respect to required separation distances.

20. Recommendations

20.1 GENERAL RECOMMENDATIONS

- Maintain all existing automatic sprinkler systems installed in the PFP facilities.
- Maintain existing housekeeping efforts in the PFP facilities.
- Provide automatic fire suppression and fire detection in gloveboxes in accordance with the recommendations presented in Section 7.0 or, based on glovebox specific evaluation, provide cost effective protection.
- Document fire resistance rating of fire barriers on facility drawings.

20.2 BUILDING 234-5Z

- Limit the combustible loading in offices, labs, storage rooms, and process areas to existing levels with a maximum fuel load as discussed in Section 6. Increased fuel loads will result in longer fire durations and can potentially increase the MPFL for the building.
- Do not allow the storage of combustible materials in the duct level. The floor/ceiling assembly for the first floor may not prevent fire spread to the duct level if combustibles materials are stored on the duct level floor. Fire spread to the duct level will increase the MPFL for the building.
- Do not store combustible materials in the corridors except in designated storage areas (e.g., second floor near elevator). During the site survey, corridors were generally free of combustibles; however, in some areas, the corridors were used for temporary storage (e.g., laundry bags, cardboard boxes). Combustible materials in the corridor provide a means for fire spread throughout the facility and could result in a greater MPFL for the building.
- Maintain the integrity of the first floor ceiling assembly. The plaster ceiling is heavily relied upon to maintain structural integrity of the building. Existing penetrations and unprotected openings do not violate the passive fire resistance of the plaster ceiling for the design basis fire scenarios. Future unprotected penetrations or openings should not be permitted.
- Maintain a minimum 1-hour fire resistance rating for the fire barrier separating 234-5Z and 234-5ZA. The 2-hour fire resistance rating of the 234-5ZA roof assembly is not required and should not be maintained.

- Deactivate or abandon in place the manual fire alarm station located in the corridor 4B airlock (i.e., no. 27-50) and provide a sign indicating that the device is not or may not be operational.

- Deactivate or abandon in place the heat detector located in the corridor 4B airlock (i.e., no. 27-49) and provide a sign indicating that the device is not or may not be operational.

- Continue to store combustible and flammable liquids in approved flammable liquid cabinets.

- Conduct a complete evaluation of the emergency lighting system. If deficiencies are found, they should be addressed with work packages or corrective actions.

- Automatic sprinkler protection is not required in the filter rooms or plutonium storage vaults based on the limited fuel load and criticality concerns. However, all other areas of the building which do not have sprinklers should be provided with automatic sprinkler protection (e.g., Rooms 194, 334, and 335).

- Provide a diked area around the hydraulic elevator pump in room no. 321 (i.e., fan room) in accordance with NFPA 30, *Flammable and Combustible Liquids Code*. The automatic sprinkler system on the second floor is expected to control and limit damage resulting from a fire involving ordinary combustibles. However, a combustible liquid fire may not be controlled by the sprinkler system; therefore, the exposed structural steel members on the second floor may be exposed to such a fire and result in structural failure of the roof assembly. As such, limiting the maximum fire size of a hydraulic oil spill will minimize the potential damage to the facility.

- Maintain the water spray deluge system protecting the oil filled transformers (i.e., Station 252-ZI). The water spray system is required since the transformers provide an exposure hazard to the 234-5Z facility.

20.3 BUILDING 242-Z

- Deactivate or abandon in place the fire alarm equipment that cannot be accessed for testing and is not necessary based on this analysis. In addition, post a sign upon entering the facility indicating that the fire alarm equipment is not or may not be operational.

- Remove the plastic rolls from TC-66 or enclose them in noncombustible containers.

20.4 BUILDING 236-Z

- There are no recommendations for this facility.

20.5 BUILDING 291-Z

- Maintain the water spray deluge system protecting the oil filled transformers in Room 500.
- Fill all penetrations and maintain a minimum 3-hour fire resistance rating for the wall separating Room 500 and the fan room.
- Fill all penetrations and maintain a minimum 1-hour fire resistance rating for the wall separating Rooms 500 and 501.

20.6 BUILDING 2736-ZB

- Relocate the designated fire wall to along the south wall of the NDA Lab. This will allow the door serving the NDA Lab to remain open while maintaining adequate separation between the office and lab/storage areas.

20.7 BUILDING 2736-Z

- Provide door no. 8, which serves as an exit, with a knob, handle, panic bar, or other simple type of releasing device which opens with no more than one releasing operation. Currently, this door requires multiple actions to open.

20.8 BUILDING 2721-Z

- There are no recommendations for this facility.

20.9 BUILDING 232-Z

- There are no recommendations for this facility.

20.10 BUILDING 241-Z

- There are no recommendations for this facility.

20.11 BUILDING 243-Z

- There are no recommendations for this facility.

20.12 COMPRESSED GAS STORAGE AREAS

- Replace the combustible wood storage shed with a structure constructed of noncombustible materials in accordance with NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders.*

20.13 HAZARDOUS PRODUCT AND WASTE EXTERIOR LAY DOWN AREAS

- There are no recommendations for this facility.

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SECTION 1.— INTRODUCTION

1.1 SCOPE AND OBJECTIVES

A fire hazards analysis (FHA) was performed for the Plutonium Finishing Plant (PFP) Complex at the Department of Energy (DOE) Hanford site. The scope of the FHA focusses on the nuclear facilities/structures in the Complex. The analysis was conducted in accordance with RLID 5480.7, [DOE Directive RLID 5480.7, 1/17/94] and DOE Order 5480.7A, *Fire Protection* [DOE Order 5480.7A, 2/17/93] and addresses each of the sixteen principle elements outlined in paragraph 9.a(3) of the Order. The elements are addressed in terms of the fire protection objectives stated in paragraph 4 of DOE 5480.7A. In addition, the FHA also complies with WHC-CM-4-41, Fire Protection Program Manual, Section 3.4 [1994] and WHC-SD-GN-FHA-30001, Rev. 0 [WHC, 1994].

This analysis was developed under contract with WHC and has been accepted by B&W Hanford Company (BWHC). Reference to WHC personnel is found throughout this analysis because interviews were performed while personnel were employed by WHC. Personnel are now employed under the Project Hanford Management Contractor by various contractors throughout the site.

Objectives of this FHA are to determine: (1) the fire hazards that expose the PFP facilities, or that are inherent in the building operations, (2) the adequacy of the fire safety features currently located in the PFP Complex, and (3) the degree of compliance of the facility with specific fire safety provisions in DOE orders, related engineering codes, and standards. The scope of this FHA includes the building construction, the process hazards, existing building fire protection, and the site wide fire protection for the following PFP facilities:

(1)	Building 234-5Z	(7)	Building 2721-Z
(2)	Building 242-Z	(8)	Building 232-Z
(3)	Building 236-Z	(9)	Building 241-Z
(4)	Building 291-Z	(10)	Building 243-Z
(5)	Building 2736-ZB	(11)	Compressed Gas Storage Areas
(6)	Building 2736-Z	(12)	Hazardous Product and Waste Exterior Lay Down Areas

Figures 1-1, 1-2, 1-3, 1-4, 1-5, and 1-6 depict the general layout of the PFP buildings and the floor plans for the individual facilities.

The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, the impact on employee and public safety, and the impact of the facility's fire protection.

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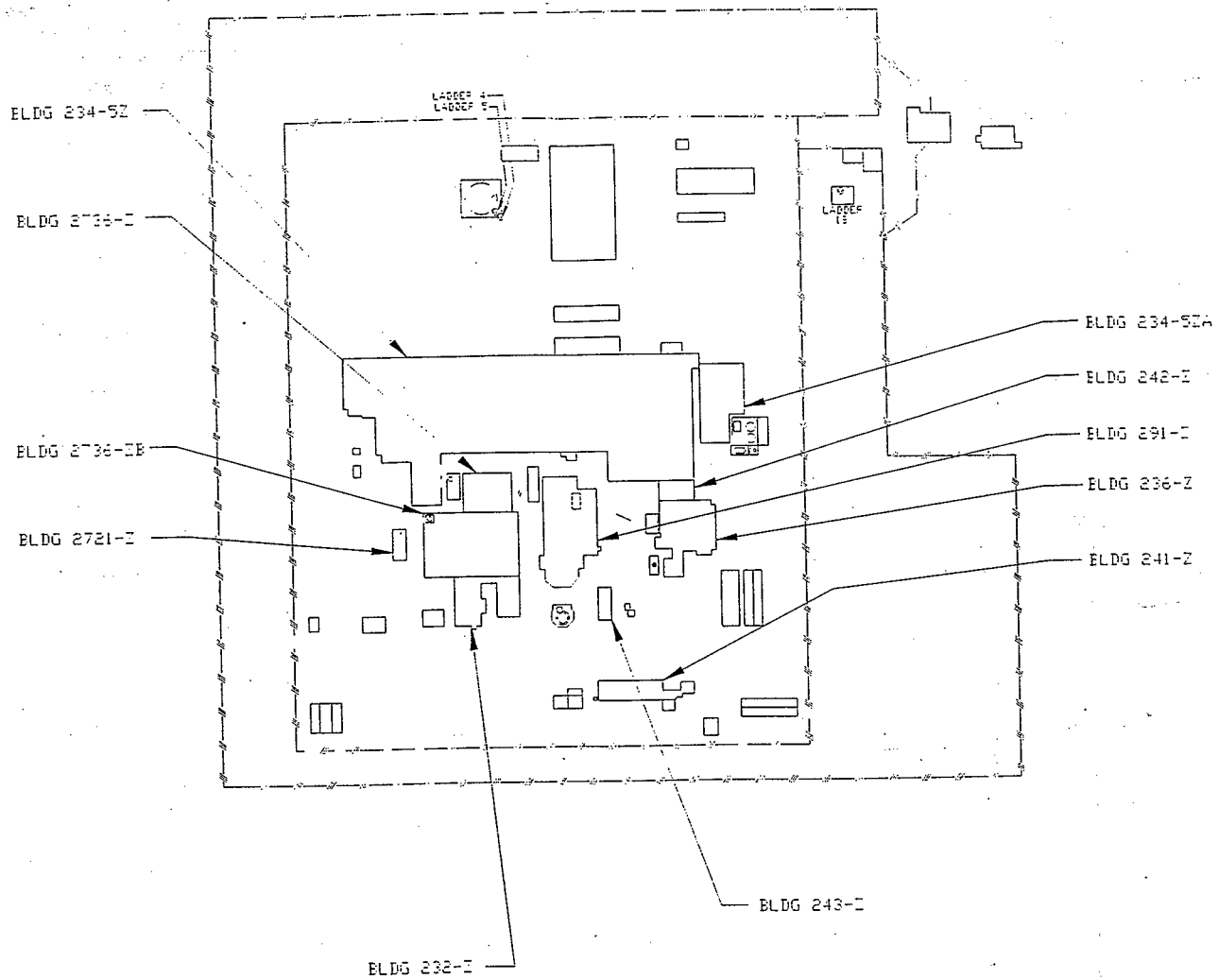

Figure 1-1 PFP facilities - General layout

VICINITY MAP, KEY PLAN

0 50' 100' 150 250

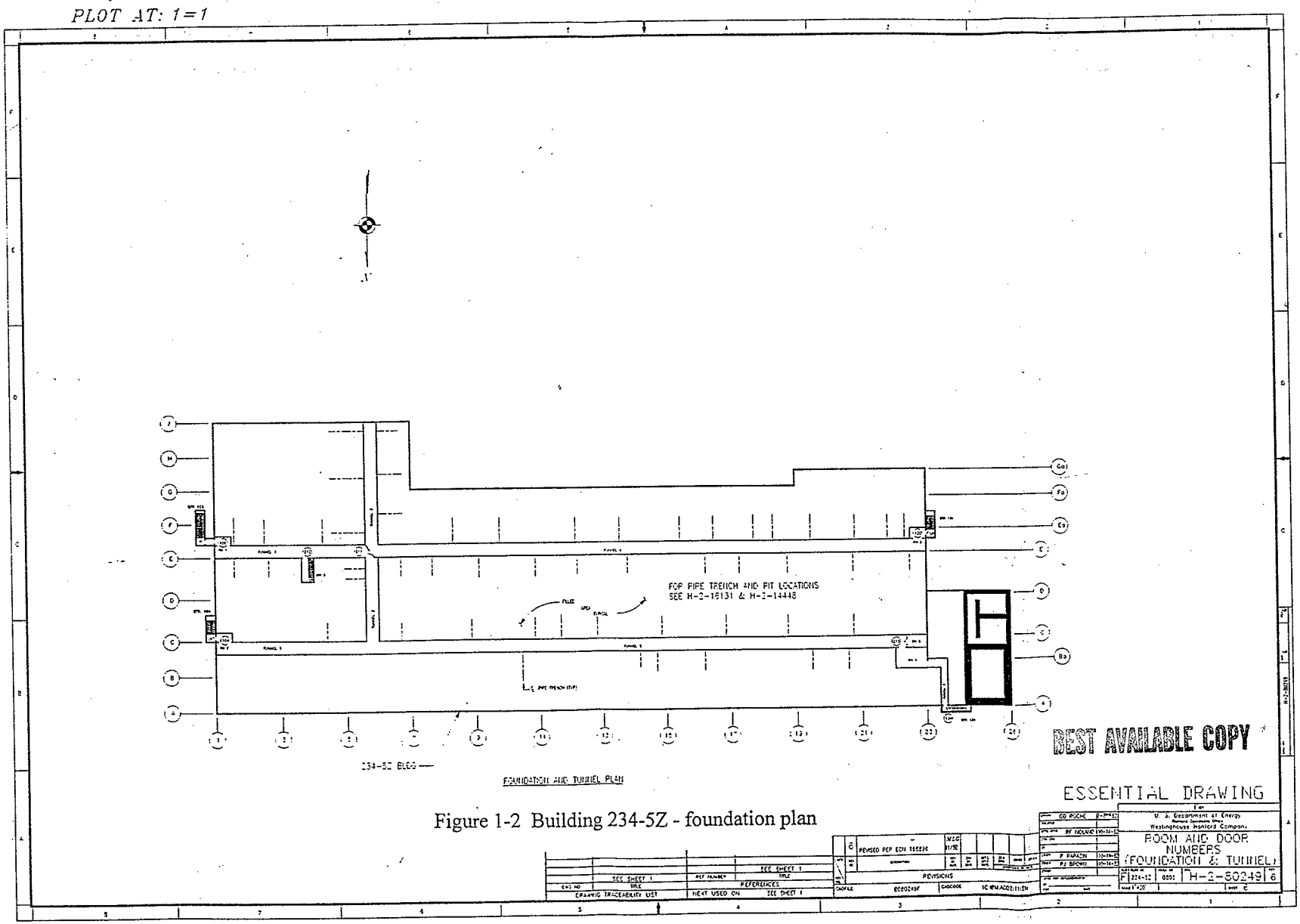

Figure 1-2 Building 234-5Z - foundation plan

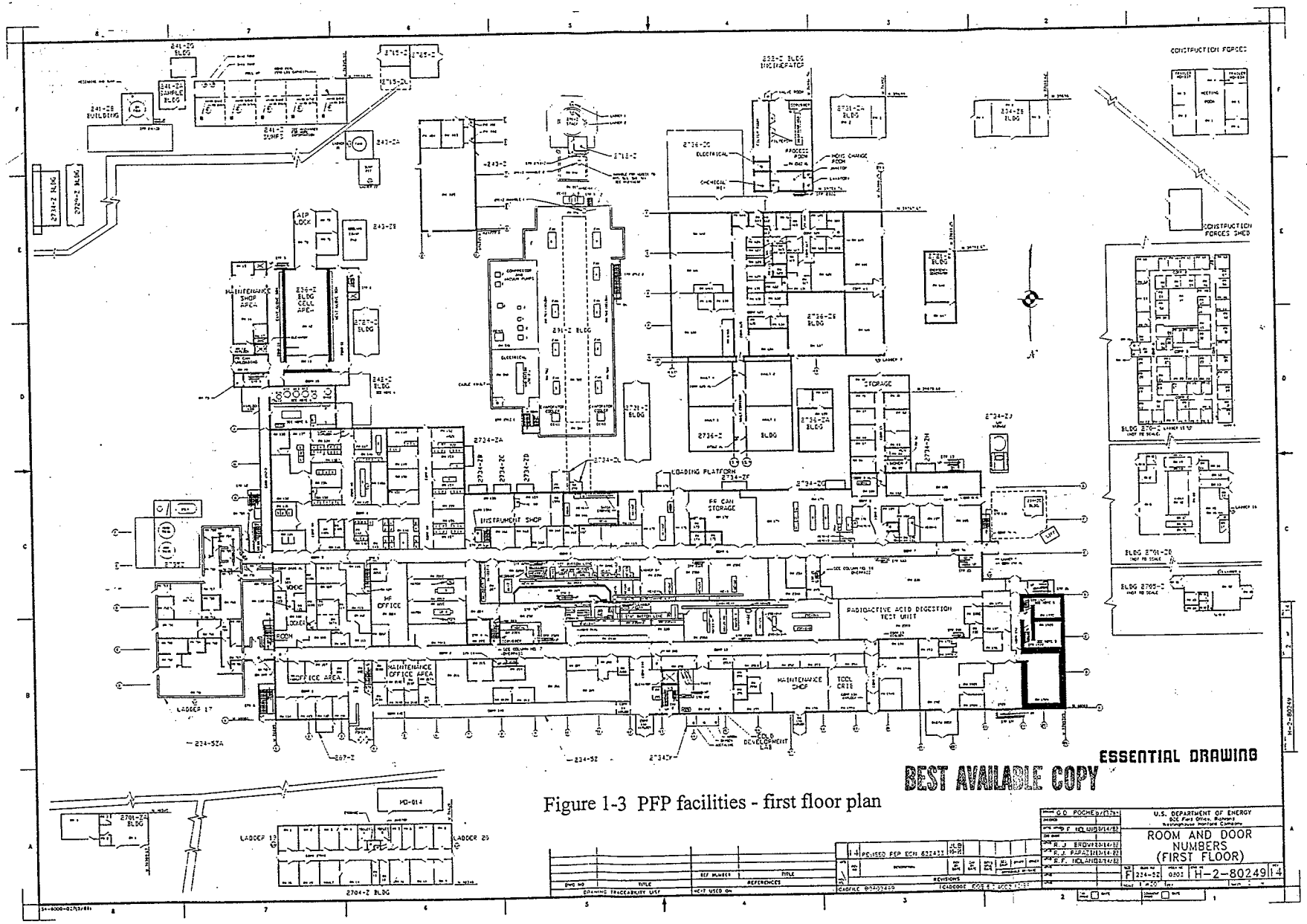

Figure 1-3 PFP facilities - first floor plan

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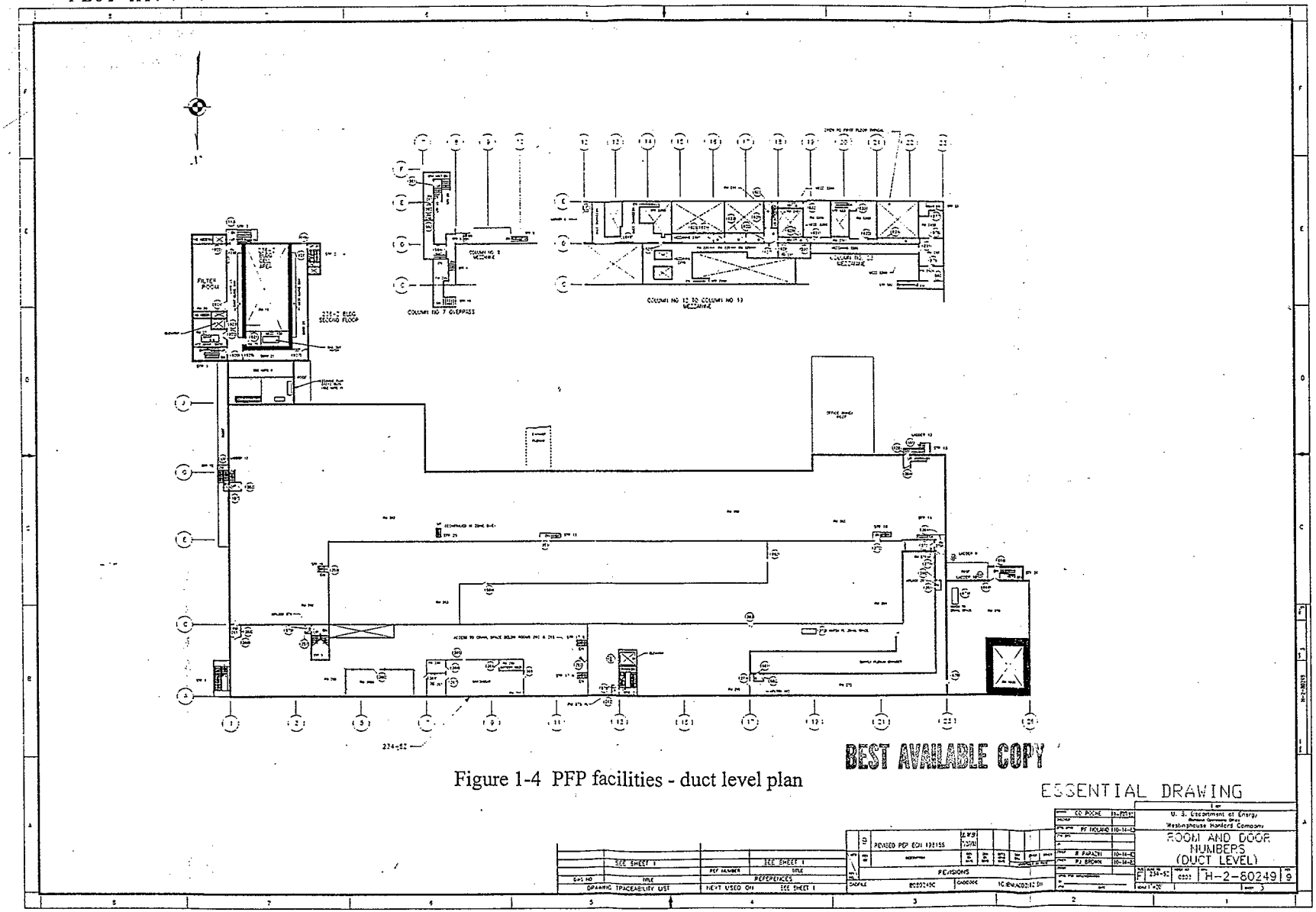

Figure 1-4 PFP facilities - duct level plan

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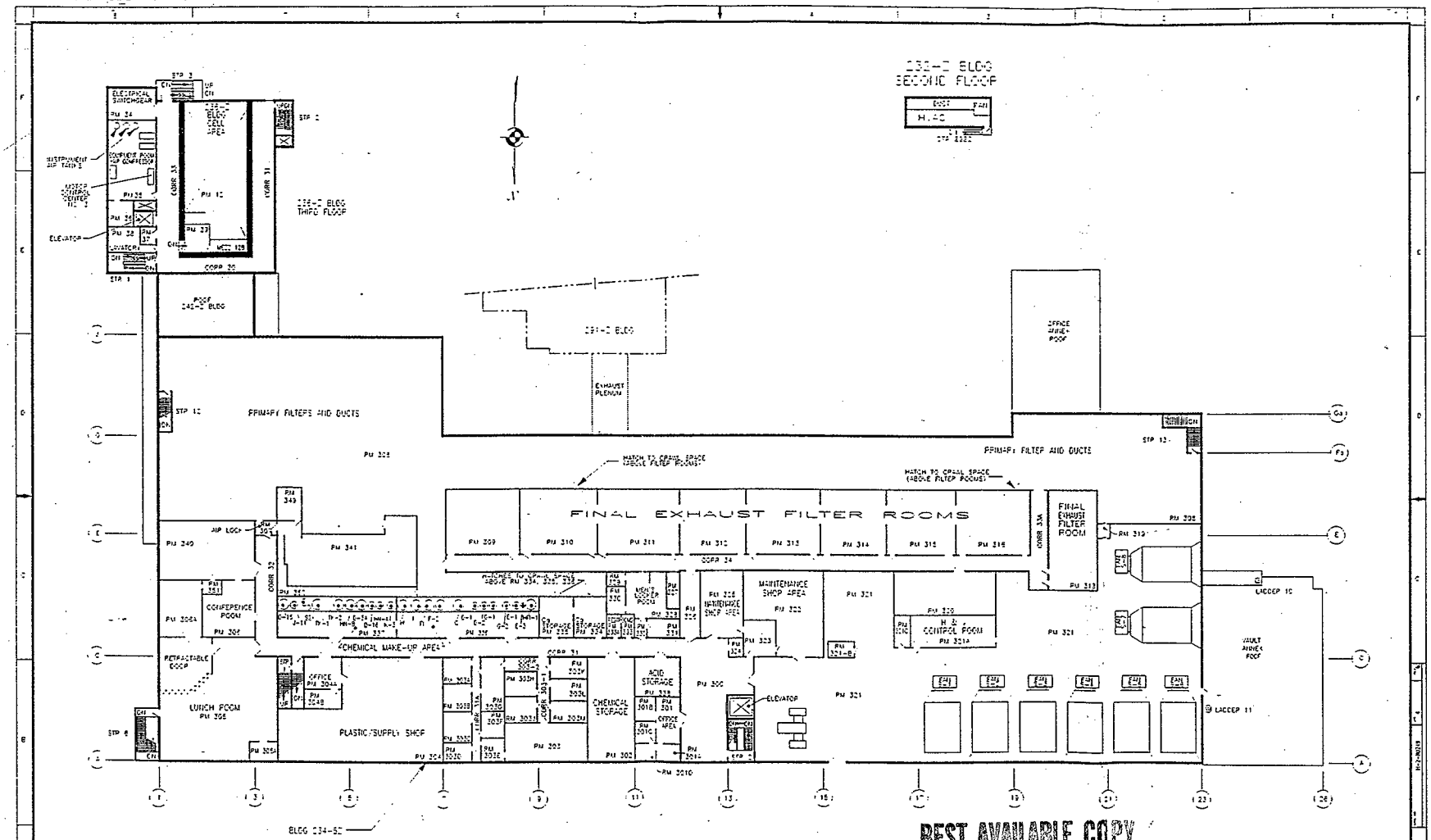

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Figure 1-5 PFP facilities - second floor plan

ESSENTIAL DRAWING

REVISED PER ECN 197045
REVISED PER ECN

U. S. Department of Energy
Richland Operations Office
Westinghouse Hanford Company

ROOM AND DOOR NUMBERS (SEC0ND FLOOR)

H-2-80249 8

PLOT AT: 1=1

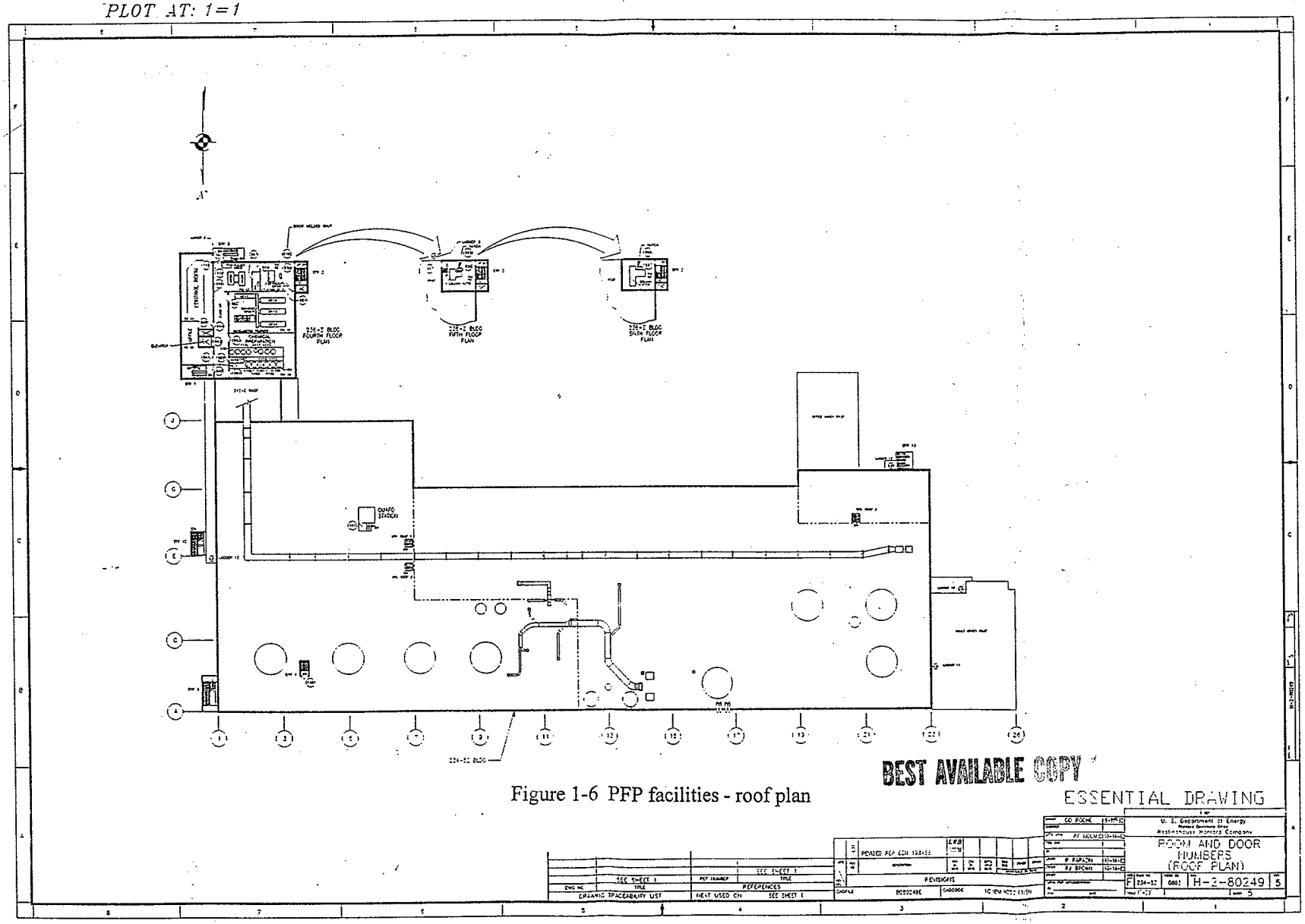


Figure 1-6 PFP facilities - roof plan

1.2 APPROACH

The approach for the development of this FHA included several tasks. Several site visits were conducted to document the buildings, processes, and fire protection features as well as to obtain general site information. The site visits included a walkthrough of the PFP facilities, discussions with fire protection and facility personnel, and review of drawings and site plans/documents.

An analysis was then performed to establish candidate fire scenarios based on the existing fire hazards, evaluate the damage potential associated with these fires, and determine compliance with DOE fire protection requirements. The analyses involved reviewing existing requirements, modeling, and analytical analyses in order to quantify the potential impact of plausible fire scenarios on process operations, facility operations, and safety.

1.3 ASSUMPTIONS AND LIMITATIONS

The results of this study are based on the assumption that the types and quantities of combustibles observed during the walkthrough and identified by building staff are representative of the potential fire hazards in the PFP Complex. Quantities of combustible materials significantly greater than that discussed in Section 6 may invalidate the basis for determining the candidate fire scenarios and the potential impact presented in this study. Although worst case conditions are generally considered in the FHA, the MPFL fire scenarios evaluate a maximum quantity of combustibles which should not be exceeded without evaluation.

It is further assumed that the information provided in various site documents, drawings, and plans are accurate. This includes information provided in the *Final Safety Analysis Report (FSAR)* [WHC, 1995], prior test results on fire protection systems, hydraulic data from water supply analyses, and construction features. An independent hydraulic analysis of the most remote sprinkler systems is performed as part of this study.

The fire hazards identified in this report include all of the fire related explosion hazards possible based on document reviews and discussions with facility staff. The facility staff were more familiar with the buildings' use and contents; therefore, input from staff was relied upon to identify the hazards present, especially explosion hazards. This fire hazard analysis relied upon the staff to identify chemicals used at various locations. Through the review process, no other specific chemical, flammable or combustible explosion hazards were identified other than those specified in the FHA or supporting its documentation.

In keeping with sound engineering practice, in the absence of technical information, conservative "worst case" assumptions are made regarding fuel loading, fuel package burning rates, fire spread, and thermophysical effects. In the event that such an analysis demonstrates minimal or no impact on fire hazard potential, no further analysis is performed. It is recommended that the results presented in this report not be readily applied to other "apparently" similar problems without careful review and consideration of the assumptions and procedures documented in this report.

1.4 DOE FHA BASIS

Each of the FHA elements identified in DOE 5480.7A are addressed in this FHA. Also, at the request of PFP facility staff, an additional section relating to glovebox fire protection features and requirements is included. The elements of the FHA are identified in Table 1-1.

Requirements in DOE Order 6430.1A, General Design Criteria [DOE Order 6430.1A, 1989], applicable National Fire Protection Association (NFPA) standards, DOE Draft Glovebox Fire Protection Standard [WHC, 1993], and the Uniform Building Code (UBC) are addressed in the context of the FHA elements. DOE Order 6430.1A and UBC criteria apply to new construction and are referenced for guidance purposes only. In addition, where deemed appropriate, quantitative analyses are performed to estimate the potential impact of credible fire scenarios. The scenarios are based on an engineering analysis of the PFP facilities and the processes.

Table 1-1. FHA Elements

Element (from DOE 5480.7A and facility staff)	FHA Report Section
Description of Construction	3.0
Facility Description and Operations	4.0
Fire Protection Features	5.0
Description of Fire Hazards	6.0
Glovebox Fire Protection Analysis	7.0
Protection of Essential Safety Class Equipment	8.0
Life Safety Considerations	9.0
Critical Process Equipment	10.0
High Value Property	11.0
Damage Potential MPFL MCFL	12.0 12.1 12.2
Fire Department/Brigade Response	13.0
Recovery Potential	14.0
Potential for a Toxicological, Biological, and/or Radiological Incident Due to a Fire	15.0
Emergency Planning	16.0
Security and Safeguards Considerations Related to Fire Protection	17.0
Natural Hazards Impact on Fire Safety	18.0
Exposure Fire Potential	19.0

SECTION 2 — SUMMARY AND CONCLUSIONS

The analyses presented in this report are based on the assumption that the types and quantities of combustibles observed during the site visit, as documented in Section 6, are representative of the existing and potential fire hazards in the PFP Complex. It is further assumed that the information provided in the site documents, drawings and plans are accurate and there are no plans to change the primary use of the facility.

The facility operation poses some unique fire hazards that are unusual for a typical industrial structure. Issues addressed include hydrogen generation from stored radioactive materials and gloveboxes. However, the principle fire hazards, propane and ordinary combustibles, are not unique to this facility.

A detailed evaluation of the fire potentials of the hazards identified was performed. The following conclusions are based on the analyses documented in this report:

1. The fire safety features within the PFP Complex provide adequate protection for the structures based on the majority of the fire scenarios identified.

2. The automatic sprinkler systems are a critical element in the fire protection for the facilities. The systems should be properly maintained and tested. Sprinkler protection throughout the majority of the operating facilities limits the damage potential from most of the fire scenarios.

3. The provisions for life safety throughout the Complex are in compliance with NFPA 101 and are adequate for the number of workers anticipated to occupy the building.

4. Important elements of the fire safety provided within Building 234-5Z include:

   a. Automatic sprinkler protection throughout the facility;

   b. Protection of the structural elements of the first floor with a plaster membrane; and

   c. Masonry walls separating the first floor into zones.

5. The fuel loads in Building 234-5Z at the time of the survey are limited by good housekeeping and operational procedures. The maximum fuel load anticipated in a typical office, laboratory or storage area on the first floor is estimated. Based on a conservative maximum possible fire exposure on the first floor of Building 234-5Z, a fire is not of sufficient duration to cause structural failure. However, clogging of the HEPA filter system could be possible. Clogging of HEPA filters could result in the loss of negative pressure in the building. Therefore, leakage of fire products, including radiological materials, to the exterior is possible through cracks or other passive methods.

6. Hydrogen generation from stored plutonium solutions in 55-gallon drums is shown to not present a significant fire hazard due to a deflagration or detonation. In order to prevent hydrogen buildup within the storage containers, vents must be used on all drums.

7. In Building 234-5Z, fire scenarios are provided that cause structural failure of the second floor roof and fire spread throughout the areas containing combustibles. Based on the structural failure, it is postulated that the release of radiological materials from the filter rooms is possible.

8. Building 242-Z was not accessible. Concerns regarding the interior finish within the facility have been raised. Sufficient data is not available to evaluate the hazard posed by the finish. However, based on the facility being unoccupied, sprinkler protection being provided, and the fuel load specified by facility staff, the interior finish is not a concern.

9. A fire involving the plastics stored in the annex (i.e., TC-66) to Building 242-Z would be controlled by the sprinkler system. However, if sprinklers fail a fire could result in the loss of contents in TC-66 and 242-Z.

10. The fuel load in Building 236-Z is limited. In addition, the fire resistive construction and automatic sprinkler protection provided throughout will limit the effects of a fire.

11. Fire scenarios in Building 2736-ZB result from the ordinary combustibles in the office and laboratory spaces. The fires are expected to be controlled by the automatic sprinkler system. However, if the automatic sprinkler system fails, the fire resistive construction will limit the area of fire damage.

12. The limited fuel load in the vaults and the fire resistive construction of Building 2736-Z results in bounded effects of a fire. The maximum scenario results from a fire causing damage to the security system.

13. A diesel fuel spill fire in Building 2721-Z creates the maximum concerns associated with a fire. The automatic dry pipe sprinkler system will limit the effects of the fire. If the automatic sprinkler system fails, damage to all the equipment and the structure is possible.

14. The fire scenarios within Buildings 241-Z and 243-Z are limited because there were no fuel loads identified during the site visit. Assuming a transient combustible fire, damage to the contents and structure are expected to be limited.

15. Fire spread associated with the compressed gas storage area and the hazardous product and waste exterior product lay down areas are limited to the contents of the area only. A fire in the compressed gases will result solely in the loss of the gas, equipment and storage shed. A fire in the lay down areas could cause the release of contamination.

With the incorporation of the recommendations in the FHA, the PFP Facility Complex will meet the objective of Paragraph 4 of DOE 5480.7A.

SECTION 3 – DESCRIPTION OF CONSTRUCTION

This section provides a general description of construction for the facilities addressed in this study. Construction details are based on information provided in the FSAR [WHC, 1995] and individual building architectural and structural drawings. Table 3-1 provides a summary of the PFP facility construction classification.

Table 3-1. PFP Construction Type Summary

Building	UBC Classification	NFPA Classification
234-5Z	Type II-N	Type II (000)
242-Z	Type II-N	Type II (000)
236-Z	Type I Fire Resistive	Type I (443)
291-Z	Type I Fire Resistive	Type I (443)
2736-ZB	Type II Fire Resistive	Type II (222)
2736-Z	Type I Fire Resistive	Type I (443)
2721-Z	Type II Fire Resistive	Type II (222)
232-Z	Type II-N	Type II (000)
241-Z	Type II-N	Type II (000)
243-Z	Type II-N	Type II (000)

3.1 BUILDING 234-5Z

3.1.1 Fire Resistance/Construction Type

The 234-5Z Building is generally constructed of unprotected noncombustible materials. The frame is constructed of braced structural steel with corrugated metal exterior walls and a built up insulated metal deck roof. The interior walls are constructed of reinforced concrete, steel structure, metal studs, metal lath, and plaster. The first floor is a concrete slab, the duct level floor is sheet metal roof decking, and the second floor is a concrete slab. The building has a minimum construction type classification of Type II-N in accordance with the Uniform Building Code (UBC) [1994 ed., Chapter 6]. This type of construction is classified as Type II (000) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.1.2 Fire Areas/Separations

Building 234-5Z is provided with fire rated partitions (WHC Drawing No. H-2-81011). Maintained fire rated assemblies in the building include the interior stairwells, the elevator shaft, the plastic shop on the second floor, and a fire wall separating the 234-5ZA facility. In addition, several of the noncombustible interior walls and ceiling assemblies provide some passive resistance to fire spread. For example, a 20 cm (8 in.) concrete wall extends the length of the facility approximately along column line C. The concrete wall extends through the duct level to the concrete slab of the second floor. The wall separates the clean front side of the facility from the back side which contains radiation and contamination areas. The concrete wall does not currently have a maintained fire resistance rating because of unprotected duct openings, miscellaneous small penetrations, and non-rated door assemblies.

A 20 cm (8 in.) thick solid concrete wall will provide at least 4 hours fire resistance rating provided that all openings and penetrations are properly protected [UBC, 1994]. The concrete walls in 234-5Z are reduced to 10 cm (4 in.) at each vertical duct chase. At this thickness, the concrete wall will have a fire resistance rating of at least 1 hour [UBC, 1994]. Although the doors in this wall assembly are not fire rated doors, they are of solid construction and are all sealed shut or monitored closed by an alarm. The process area doors along this wall are constructed of steel with combination safe-type locks. During the site visit, there were no large penetrations identified for the wall assembly.

A similar concrete wall extends the length of the building along column line E (WHC Drawing No. H-2-81011). Unlike the concrete wall discussed earlier, this wall only extends to the duct level floor. It is expected to prevent horizontal fire spread on the first floor in a similar manner to the wall at column line C.

The wall separating the 234-5ZA and 234-5Z Buildings is a 4-hour fire resistance rated barrier. The wall extends the entire length of the 234-5ZA Building and all doors are self-closing fire rated assemblies. The roof of the 234-5ZA facility also has a 2-hour fire resistance rating.

Most interior walls are constructed of 1.91 cm (3/4 in.) plaster on metal lath on both sides of 10 cm (4 in.) steel studs. Similar wall assemblies have a fire resistance rating of 1 hour [UBC, 1994]. On the second floor, a continuous wall assembly of this type separates the front and back sides of the facility. There were no unprotected openings identified in the wall during the site survey. However, door penetrations are protected by non-fire resistance rated assemblies. There were no locations where combustibles were located adjacent to doors in the partition. It is expected that this wall will provide a 1 hour fire resistance rating. Other wall assemblies in the facility provide similar levels of protection and are identified in the specific fire scenario analyses.

The first floor ceiling assembly is constructed of 1.91 cm (3/4 in.) plaster on metal lath with restrained steel bar joists supporting the steel decking floor above. In several areas, the ceiling assembly is equipped with surface-mounted lights. Similar floor/ceiling assemblies with a 5 cm (2 in.) light-weight concrete slab on the steel deck have a 2 hour fire resistance rating

[UBC, 1994]. Since the steel decking has a much higher thermal conductivity without a concrete slab, heat from a fire on the first floor will transfer through the floor assembly to the duct level more easily. This will provide a greater endurance time for the steel structural members within the ceiling assembly. However, without the concrete slab on the steel deck, the floor/ceiling assembly would likely fail the ASTM E-119 criteria for a maximum 250°C temperature rise on the unexposed surface in less than 2 hours. However, since there are limited combustibles in the duct level, a 250°C temperature rise does not present a fire hazard. For a description of fuel loading on the duct level, refer to Section 6.3.1. The 1.91 cm (3/4 in.) plaster on metal lath is anticipated to provide a 2 hour structural fire resistance rating for the steel bar joists and beams within the ceiling assembly.

In other areas, the ceiling assemblies are constructed with flush-mounted lights and have several penetrations (piping, wiring, ducts, etc.). In these areas, the structural integrity of the ceiling assembly is assessed for specific fire scenarios in Section 6.0.

The floor/ceiling assembly for the duct level and second floor is a concrete slab supported by unprotected structural steel (e.g., columns, beams, joists). The floor/ceiling assembly has no fire resistance rating.

The second floor roof/ceiling assembly is also supported by unprotected structural steel (e.g., columns, beams, joists). The ceiling assembly has no fire resistance rating.

3.2 BUILDING 242-Z

3.2.1 Fire Resistance/Construction Type

The 242-Z Building is constructed of unprotected noncombustible materials. The south wall of the building is constructed of reinforced concrete and the remainder is of structural steel frame covered with metal lath and plaster internally and insulating material wall panels externally. The roof is constructed of metal decking, covered by insulation and built-up asphalt and gravel. The building has a minimum construction type classification of Type II-N in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type II (000) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.2.2 Fire Areas/Separations

There are no fire rated partitions in Building 242-Z. A 20 cm (8 in..) solid concrete wall separates the facility from Building 236-Z. This wall has an effective fire resistance rating of at least 6 hours [UBC, 1994]. The wall separating the facility from Building 234-5Z is constructed of metal wall panels and plaster on metal lath. Similar wall assemblies having 1.91 cm (3/4 in.) plaster on metal lath have a 1-hour fire resistance rating [UBC, 1994]. Therefore, this wall is expected to provide at least 1 hour passive fire resistance.

3.3 BUILDING 236-Z

3.3.1 Fire Resistance/Construction Type

The 236-Z Building is constructed of noncombustible fire resistive materials. The exterior walls and floors of the facility are 20 cm (8 in.) reinforced concrete construction. The roof is a concrete slab over metal deck with a built up roof cover. Interior walls are constructed of concrete, concrete block, and gypsum plaster. The building has a minimum classification of Type I Fire-Resistive in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type I (443) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.3.2 Fire Areas/Separations

With the exception of the Stair 1 and Stair 2 enclosures, there are no fire rated partitions in Building 236-Z. The 20 cm (8 in.) concrete exterior walls and floor assemblies provide at least a 6 hour fire resistance rating. However, the canyon walls which extends the height of the building have many penetrations of glass, steel plates, and piping. The fourth floor roof and ceiling assembly consists of light-weight concrete on steel joists with 1.91 cm (3/4 in.) plaster suspended ceilings. Provided that all openings are protected, the roof ceiling assembly provides a 2 hour fire resistance rating [UBC, 1994].

3.4 BUILDING 291-Z

3.4.1 Fire Resistance/Construction Type

Building 291-Z is constructed of noncombustible fire resistive materials. The exterior and interior walls are constructed of concrete. The roof assembly is a concrete roof with a sealant of urethane foam for waterproofing. Beneath the urethane foam, there are sections of the roof that can be removed for large equipment placement. The building has a minimum construction type classification of Type I Fire-Resistive in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type I (443) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.4.2 Fire Areas/Separations

Based on facility drawings, a 30 cm (12 in.) concrete fire wall separates Rooms 500 and 501 from the main exhaust room (see Figure 3-1). A solid concrete wall of this thickness will have a minimum fire resistance rating of 8 hours, provided all penetrations and openings are protected [UBC, 1994]. Room 500 contains two 1000 kVA oil filled transformers which are protected by an automatic water spray deluge system. In accordance with NFPA 70, *National Electrical Code* [1993], the Room 500 enclosure must have a fire resistance rating of 1 hour. Currently, there are several penetrations in the concrete wall separating Rooms 500 and 501. These penetrations must be filled and a minimum 1-hour fire resistance rating must be maintained.

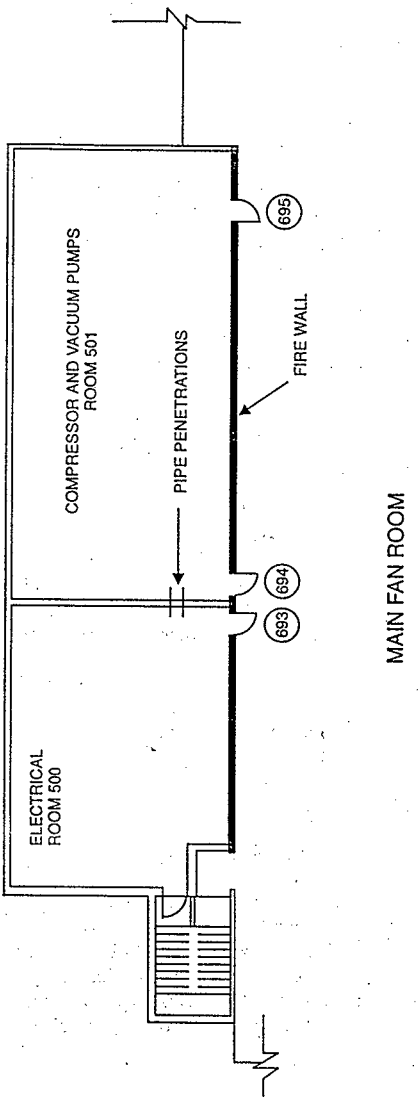


Figure 3-1 Building 291-Z - fire barrier locations

3.5 BUILDING 2736-ZB

3.5.1 Fire Resistance/Construction

Building 2736-ZB is constructed of noncombustible fire resistive materials. The framing, exterior walls, and roof are constructed of steel and concrete. Interior walls are constructed of concrete and gypsum board on metal studs. The building has a minimum classification of Type II Fire-Resistive in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type II (222) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.5.2 Fire Areas/Separations

Building 2736-ZB is divided north-south by a concrete fire barrier. Figure 3-2 shows the location of the existing fire barriers in the facility. A similar concrete wall separates the receiving, shipping, and staging rooms (e.g., room nos. 642, 641, and 638 respectively) from the remainder of the facility. Based on facility drawings, the doors to these rooms are solid steel combination type doors having a 1 hour fire resistance rating. During the site visit, there were no significant penetrations or openings identified in the wall; however, the doors are not equipped with an automatic closer. Since these doors are normally maintained closed for security purposes, this wall is expected to provide additional separation in the facility. The NDA Lab (e.g., room no. 637) is completely enclosed by similar concrete walls. Since the door serving the NDA Lab is required to be open, it is recommended that the designated fire wall be relocated to along the south wall of the NDA Lab. Relocating the designated fire wall will continue to provide adequate separation between the office and lab/storage areas.

The north wall of the facility provides a separation to the 2736-Z facility. The north wall is a 30.5 cm (12 in.) concrete wall with no identified penetrations other than the door openings. The buildings are separated by metal paneling and concrete walls in addition to an airlock which physically separates the two structures.

3.6 BUILDING 2736-Z

3.6.1 Fire Resistance/Construction Type

Building 2736-Z is constructed of noncombustible fire resistive materials. The building is constructed of 36 cm (14 in.) thick reinforced concrete walls supported by cast-in-place concrete columns. The roof is a cast-in-place concrete slab 16.5 cm (6.5 in.) thick. The building has a minimum construction type classification of Type I Fire-Resistive in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type I (443) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

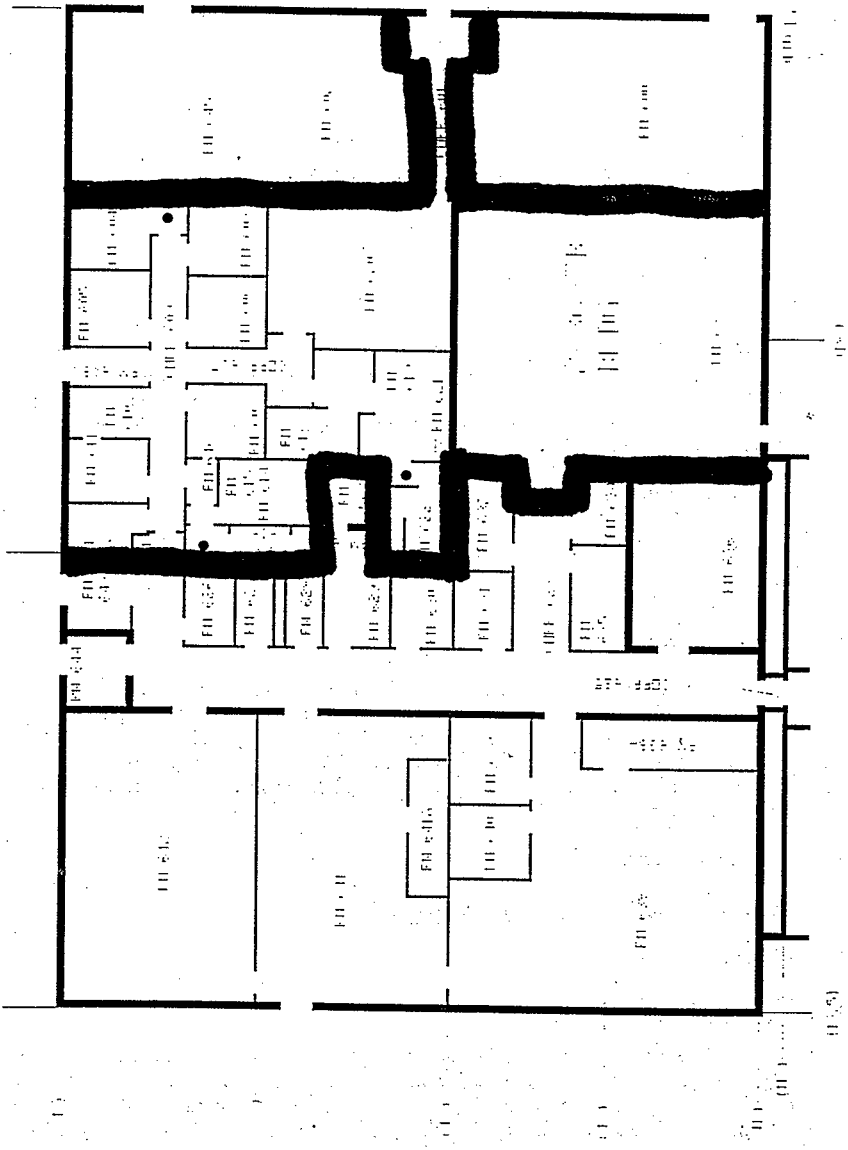


Figure 3-2 Building 2736-ZB - fire barrier locations

3.6.2 Fire Areas/Separations

Building 2736-Z is not separated into fire areas by fire rated partitions. However, each of the vaults are enclosed by solid concrete walls and concrete roof. Also, the vaults are separated by a corridor running the width of the building. There were no significant penetrations identified during the site visit. Therefore, each of the vaults can be considered a separate fire area.

3.7 BUILDING 2721-Z

3.7.1 Fire Resistance Construction

Building 2721 is constructed of noncombustible fire resistive materials. The building is constructed of reinforced concrete walls and built up concrete roof. The building has a minimum classification of Type II Fire-Resistive in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type II (222) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.7.2 Fire Areas/Separations

There are no fire rated partitions in Building 2721-Z.

3.8 BUILDING 232-Z

3.8.1 Fire Resistance/Construction Type

Building 232-Z is constructed of noncombustible fire resistive materials. The building is constructed concrete block exterior walls and concrete slab over metal deck built up roof. The interior walls are concrete block and metal partitions. The building has a minimum construction type classification of Type II-N in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type II (000) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.8.2 Fire Areas/Separations

There are no fire rated partitions in Building 232-Z.

3.9 BUILDING 241-Z

3.9.1 Fire Resistance/Construction Type

The 241-Z Building is constructed of noncombustible materials. The floor and walls of the underground portion of the structure are constructed of reinforced concrete. The roof is constructed of reinforced concrete blocks. The above ground facility is constructed of corrugated steel walls and roof. The building has a minimum construction type classification of Type II-N

in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type II (000) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.9.2 Fire Areas/Separations

There are no fire rated partitions in Building 241-Z.

3.10 BUILDING 243-Z

3.10.1 Fire Resistance/Construction Type

Building 243-Z is constructed of noncombustible materials. The structure, exterior walls and roof are constructed of steel. The building has a minimum construction type classification of Type II-N in accordance with the UBC [1994 ed., Chapter 6]. This type of construction is classified as Type II (000) noncombustible construction in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.10.2 Fire Areas/Separations

There are no fire rated partitions in Building 243-Z.

3.11 COMPRESSED GAS STORAGE AREAS

3.11.1 Fire Resistance/Construction Type

There are several storage sheds used for storing compressed gas cylinders in the PFP yard area (e.g., the 2734-Z series). While most of the storage sheds are constructed of non-combustible materials, the 2734-Z compressed gas storage shed is constructed of combustible wood materials. The storage sheds have a UBC [1994 ed., Chapter 6] classification of Type II-N for the noncombustible facilities and Type V-N for the wood shed. This type of construction is classified as Type II (000) for the noncombustible facilities and Type V (000) for the combustible shed in accordance with NFPA 220 [1992 ed., paragraph 3-2].

3.11.2 Fire Areas/Separations

Gas storage sheds 2734-ZA, 2734-ZC, and 2734-ZK are separated from 234-5Z by concrete block fire barrier walls. In addition, 2734-Z includes a 30-minute fire barrier between bays 9 and 10 for separation of flammable gases.

3.12 HAZARDOUS PRODUCT AND WASTE EXTERIOR LAY DOWN AREAS

There are no buildings associated with the Lay Down Areas.

SECTION 4 — FACILITY DESCRIPTION AND OPERATIONS

The Plutonium Finishing Plant (PFP) is located on the DOE Hanford site in south central Washington State. PFP is operated by Westinghouse Hanford Company (WHC), which is the Hanford Operations and Engineering contractor for the DOE Richland Operations Office. Since 1991, the mission of the PFP has changed from special nuclear material (SNM) processing to preparation for decontamination and decommissioning (D&D). The PFP is in transition between its previous mission and the proposed D&D mission. The objective of the transition is to place the facility into a stable state for long-term storage of SNM prior to final disposition of the facility. In this section, an overview of the current operations in the PFP facilities is provided. The facility descriptions and operations are based on information found in the PFP Final Safety Analysis Report (FSAR) [WHC, 1995].

4.1 BUILDING 234-5Z

The 234-5Z Building was constructed in 1949 and is the main PFP facility. Floor levels are designated as the basement, first floor, duct level, second floor, and roof level. The building is approximately 55 m wide by 152 m long and extends from 2.9 m below grade to 14.3 m above grade. The basement level primarily consists of pipe tunnels containing drain piping to sumps. The first floor houses the two former plutonium processing lines (RMA and RMC) and existing 94-1 Thermal Stabilization Process; reactive material stabilization gloveboxes; plutonium storage vaults; standards and analytical laboratories; maintenance shops; support labs; and office spaces. The duct level contains most of the service piping, ventilation ducts, and some filter boxes. The second floor houses additional office and storage spaces, a plastics shop, a lunchroom, exhaust air duct work including filter boxes and filter rooms, and the main fan room.

The 234-5Z Building is separated into a front (north) and back (south) side. The front side does not contain any radiation or contamination areas. The back side contains the laboratories, process rooms, and other areas which may be designated as radiation and/or contamination zones. Typically, access to the back side is provided only through the security station in the 234-5ZA facility. Other doors or passages connecting the front and back sides have been sealed or placed on alarm.

4.2 BUILDING 242-Z

The 242-Z Building was constructed in 1964. The building houses portions of the waste treatment facility and the americium facility, which are inactive. The building is approximately 12.2 m wide, 7.9 m long, and 7.0 m high. The structure lies between the southeastern corner of the 234-5Z Building and the 236-Z Building (see Figure 1-2). Along the west side is an enclosure used for outside entry into the facility. This area is primarily used for storage. The 242-Z Building is a single story structure with a mezzanine level over the northwest portion of the facility.

4.3 BUILDING 236-Z

The 236-Z Building was constructed in 1964 and is known as the Plutonium Reclamation Facility (PRF). The building has four levels surmounted by a two story penthouse. The facility is approximately 24 m wide by 22 m long. Its principal internal feature is a single process equipment cell that is 9.8 m wide by 15.8 m long. The process cell extends the height of the building and has gloveboxes along the east and west sides at each level. Currently the process cell is inactive.

The ground floor contains maintenance shop facilities located on the service (east) side of the building. The second floor of the service side contains maintenance gloveboxes and ventilation exhaust filters. The third level of the service area contains service equipment and electrical switch gear. The fourth floor areas are used for: (1) chemical preparation, (2) miscellaneous treatment, (3) an operating control room, (4) slag and crucible dissolver equipment, and (5) a column room in which two vertical sections of two liquid extraction columns, penetrating the room from below and extending through the penthouse levels, are housed in a glovebox.

4.4 BUILDING 291-Z

The 291-Z Building was constructed in 1949. The facility is known as the Exhaust Fan House, Exhaust Air Stack Building, and Compressor and Fan House. The single story building is of irregular shape (see Figure 1-2), approximately 23 m wide by 44 m long. Its overall height is approximately 7 m with only 1 m above grade. Building 291-Z is located about 16 m south of the central part of the 234-5Z Building.

Building 291-Z houses the exhaust fans, the mechanical service equipment, and an electrical substation for the PFP Complex. Auxiliary to the 291-Z Building is the 61 m (200 ft) high exhaust stack.

4.5 BUILDING 2736-ZB

Building 2736-ZB was constructed in 1982. The facility is used for shipping, receiving, staging, and repackaging of radiological materials. The single story reinforced concrete structure is approximately 40 m long by 27 m wide. The shipping and receiving areas are each provided with approximately 95 m^2 of floor space to accommodate a maximum of 100 shipping containers the size of 55-gallon drums. The facility also houses the Nondestructive Analysis (NDA) Lab for measurement of fissile material content. Other areas include office spaces, change rooms, lunch room, and mechanical spaces. Building 2736-ZB is located immediately south of the 2736-Z Building.

4.6 BUILDING 2736-Z

Building 2736-Z was constructed in 1971. The facility is the primary PFP plutonium storage area. The one-story building is approximately 17 m wide by 20 m long. There are four

vaults used for storage of Special Nuclear Materials (SNM), divided by a corridor running the width of the building (see Figure 1-2). Each storage vault is approximately 8.5 m by 8.5 m in size. Building 2736-Z is located approximately 7 m south of the 234-5Z Building.

4.7 BUILDING 2721-Z

Building 2721-Z was constructed in 1979. The building houses three 325 kW diesel driven generators which provide primary backup power to the PFP facilities. The building is approximately 14 m long by 6 m wide. The switchgear room is located on the north end of the building. Building 2721-Z is located approximately 8 m west of Building 2736-ZB.

4.8 BUILDING 232-Z

Building 232-Z was constructed in 1961. Commonly called the Incinerator Building, the facility houses the Contaminated Waste Recovery Process. The facility is approximately 11.3 m wide by 17.4 m long. The building is one story over the process and storage areas and two stories over the service areas at the north end. Currently the building is inactive and entering a Decontamination and Decommissioning (D&D) phase. Building 232-Z is located approximately 60 m south of the 234-5Z Building.

4.9 BUILDING 241-Z

Building 241-Z was constructed in 1949. The facility is used for treatment, storage, and disposal of PFP low level radioactive mixed waste. The underground portion of the structure consists of five separate ventilated cells, each containing a 20,000 liter tank. Only tanks D-5 and D-8 are currently active. A prefabricated sheet metal enclosure, 6.1 m wide, 28.0 m long, and 6.7 m high, covers the underground structure. Building 241-Z is located about 100 m south of the 234-5Z Building.

4.10 BUILDING 243-Z

Building 243-Z was constructed in 1994. Known as the Low-Level Waste Treatment Facility (LLWTF), Building 243-Z provides for treatment of the PFP effluents to remove low-level radioactive and chemical contamination. The process area makes up the majority of the single story building. This area contains tanks, pumps, filters, and the associated piping and instrumentation necessary for operation and monitoring the equipment and incoming waste streams.

4.11 COMPRESSED GAS STORAGE AREAS

The 2734-Z series compressed gas storage sheds are located in various locations in the PFP yard area (see Figure 1-3). Flammable gases are typically stored in 2734-Z, which consists of 11 individual storage bays. However, while this storage shed is undergoing renovations to meet current code criteria, the compressed flammable gases are temporarily being stored in other 2734-Z series storage sheds.

4.12 HAZARDOUS PRODUCT AND WASTE EXTERIOR LAY DOWN AREAS

There are no buildings associated with the Lay Down Areas. Designated areas within the fenced security area outside the PFP are used for temporary storage.

SECTION 5 – FIRE PROTECTION FEATURES

This section provides a general description of the active fire protection features at the PFP. An overview of the water supply and demand required by the installed automatic sprinkler systems is included.

5.1 FIRE PROTECTION WATER SUPPLY

The water supply system at the Hanford Site consists of two underground main systems, raw and sanitary water. Water for fire protection purposes is provided to the PFP facilities through the sanitary water system. The water is provided through two 12 in. lines and an 8 in. line which feed into a 10 in. looped system encompassing the PFP facilities.

The Sanitary Water System serving the 200 West Area is a shared system providing water for sanitary, process, and fire protection uses. The Fire Protection Water Supply Analysis [WHC-SD-SQA-ANAL-30001, Rev.0, August 18, 1995] provides recommendations which if implemented will increase the reserve fire protection water supply and the reliability of the water supply system.

The water supply analysis indicates that the sanitary water system is served by the existing primary sanitary clearwell system with a water storage capacity of 400,000 gallons and the secondary system with a 1,100,000 gallon reservoir for the 200 West Area. Sanitary water system pumping capabilities cited by the analysis are summarized below:

200 West:

Primary System

- three electric pumps @1,000 gpm
- one electric pump @600 gpm

Secondary System

- one electric pump @ 4,000 gpm

The water supply analysis also indicates that the current raw water system for the 200 West area is serviced by a 3,000,000 gallon reservoir in addition to the 24 in. supply line from the 100 Area. Raw water pumping capacities to 200 West facilities are summarized below:

200 West:

- one electric pump @5,000 gpm
- three electric pumps @ 3,000 gpm
- one steam pump @3,000 gpm

The water supply analysis states that the 200 Area water systems are considered to be in fair condition, however, the systems are not in compliance with DOE 5480.7A and RLID 5480.7. Project B-604 is intended to bring the systems into full compliance with DOE Orders 5480.7A, 6430.1A, and RLID 5480.7. The project scope is to upgrade the 200 West water supply in three phases. Phase I and II are estimated by the project engineer to be completed by April 30, 1997 and Phase III was canceled via DOE approved Baseline Change Request LPM-096-050, Site Control Number W96-358 [McKinnis, 1996]. The canceled portion of this project would have installed a second 24 inch export line serving 200 West. Phase I and II of the project includes upgrading the export water system, the 200 Areas raw and sanitary water systems, and related piping and reservoirs to ensure the availability of fire protection water for simultaneous process and domestic water usage. New raw water fire pumps will be installed in each of the 200 Areas. The pumps will be capable of meeting the maximum raw and sanitary water process and fire protection demand for the areas as follows:

200 West:

- Sanitary Water Capability: 1,100 gpm sanitary water plus 2,500 gpm fire flow for a total water demand of 3,600 gpm; to be supplied via one 4,000 gpm fire pump rated at 110 psi.

Although completion of Phase III may not directly affect the PFP Facility, there will be a continued reliability issue associated with the 200 West Area water distribution system. The "Improved Risk" level of fire protection as required for 200 West Area by DOE Order 6430.1A and 5480.7A is not addressed within this facility specific FHA.

Figure 5-1 shows the layout of the sanitary water supply system serving the PFP Complex. The PFP facilities are serviced by 8 hydrants which are supplied by the 10 in. general supply loop. Water flow test data for hydrant no. 10Z is summarized in Table 5-1 [WHC, 1995a].

Table 5-1. Hydrant Water Flow Test Results

Hydrant	Static Pressure (psi)	Residual Pressure (psi)	Flow (gpm)
10Z	124	80	1170

DOE Order 6430.1A applies to new construction; however, the criteria contained within can be utilized as guidance for existing water supply systems. Paragraph 0266-4 requires that the hydrant system deliver a minimum of 1000 gpm at a residual pressure of 10 psi. It also requires that:

1. Hydrants be spaced no more than 400 feet apart,
2. Fire hydrant branches be no less than 6 inches in diameter and no longer than 300 feet,

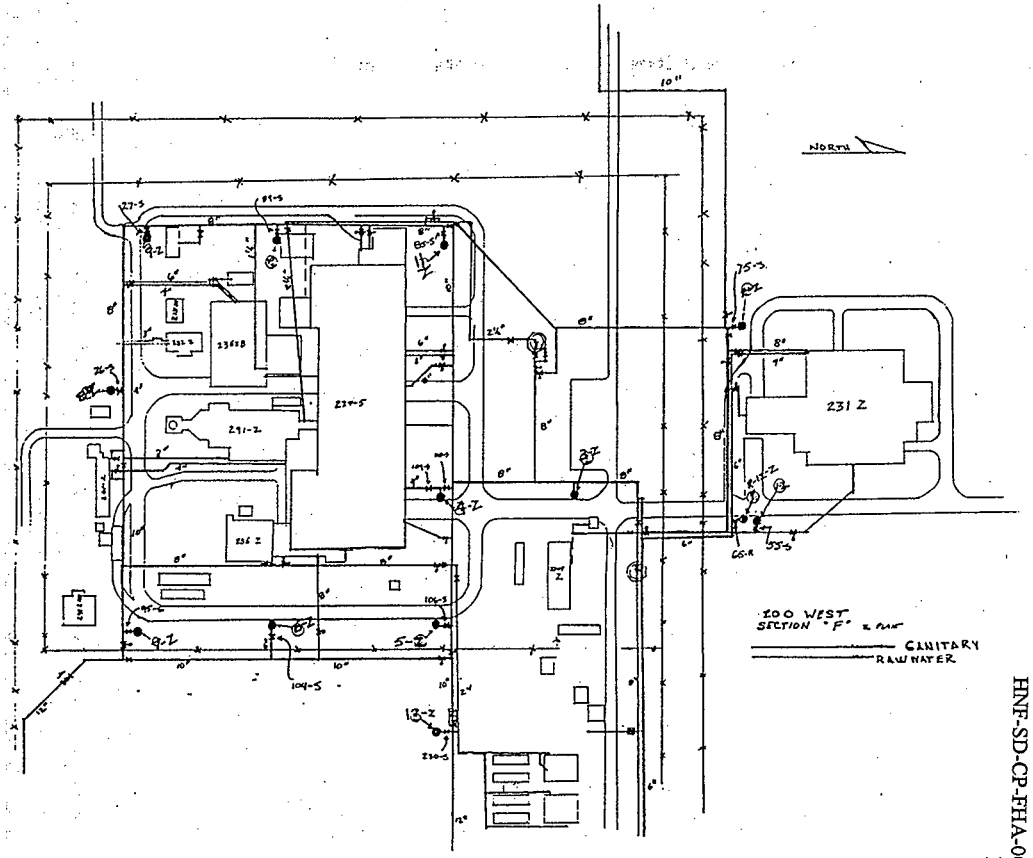


Figure 5-1 PFP water supply distribution system

3. Hydrants be no more than 300 feet from the building/facility to be protected,
4. Each building/facility is to be protected by at least two hydrants,
5. Hydrants should not be closer than 50 ft from the building, and
6. Adequate flow and pressure is provided to maintain operation of any automatic sprinkler system in the facilities.

Most areas of the PFP facilities are classified as an Ordinary Group I fire hazard in accordance with NFPA 13, *Installation of Automatic Sprinkler Systems* (1994 ed.). A scoping analysis is provided based on NFPA 13 classifications to determine if the water supply for suppression systems is adequate. Table 5-2 contains a summary of a hydraulic water demand analysis of remote areas of the sprinkler systems in Building 234-5Z and Building 236-Z (NFPA 13, Section 5-2.3). Figures 5-2 and 5-3 show the water supply vs. demand curves for the sample remote areas of the two facilities.

Table 5-2. Hydraulic Water Demand Analysis

System	Classification	Required Residual Pressure (psig)	Total Demand (gpm)	Available Pressure at Demand (psig)
234-5Z, Riser 5 - Second Floor, Primary Filter and Duct Area	Ordinary Group I	62	718	106
236-Z, Riser 7 - Fourth Floor, Rooms 41, 42, 43, and 44	Ordinary Group I	52	854	99

The water supply system for fire protection service for the PFP Complex satisfies the requirements contained in NFPA 13 in terms of required fire flow for the sprinkler systems.

5.2 FIRE SUPPRESSION SYSTEMS

5.2.1 Automatic Fire Sprinkler System

WHC Drawing No. H-2-26916 identifies the fire protection sprinkler coverage for the PFP facilities. In general, most of the systems provide total coverage protection for the buildings. However, the following areas are not provided with sprinkler protection:

(1) Building 291-Z,
(2) The storage vaults in 2736-Z,
(3) The filter rooms, several vaults, and storage rooms in the 234-5Z Building, and
(4) The Process Cell in Building 236-Z.

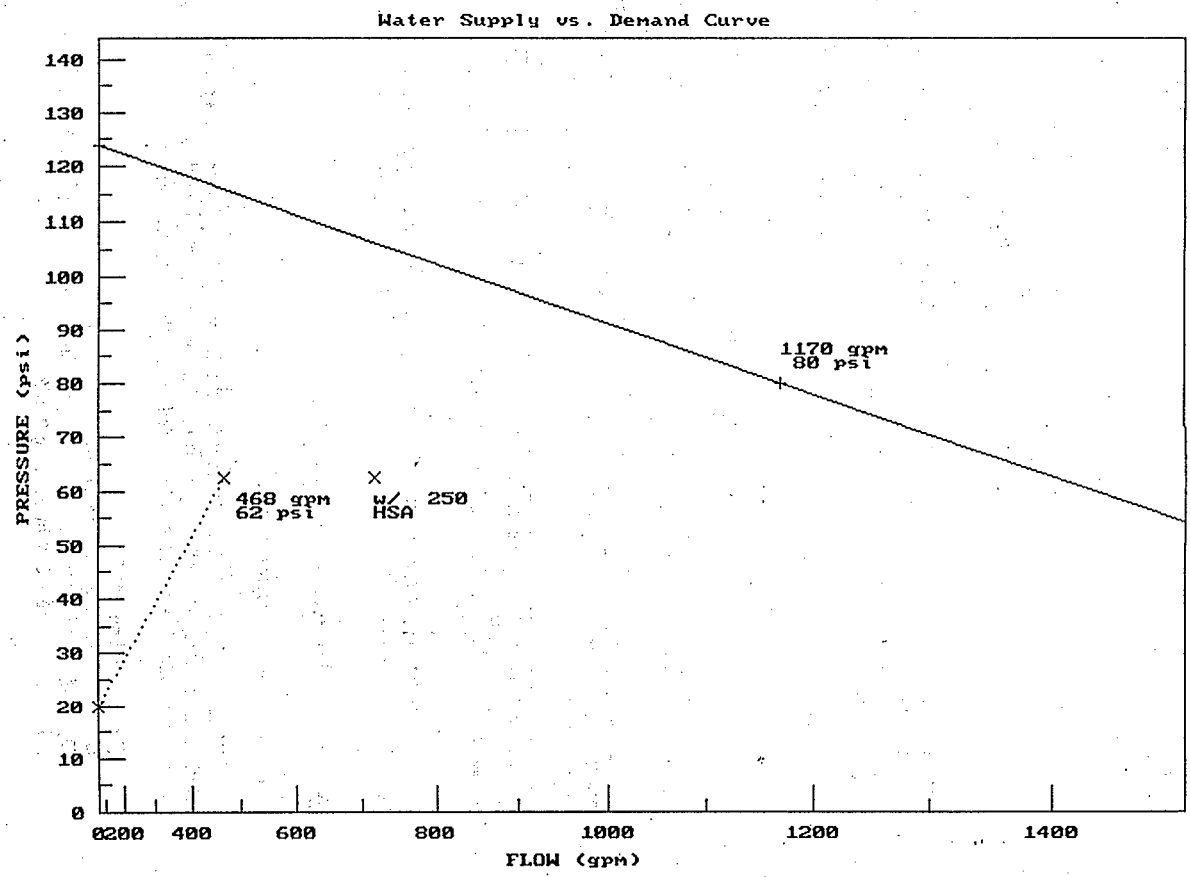


Figure 5-2 Water supply/demand for Building 234-5Z (Ordinary Hazard Group I)

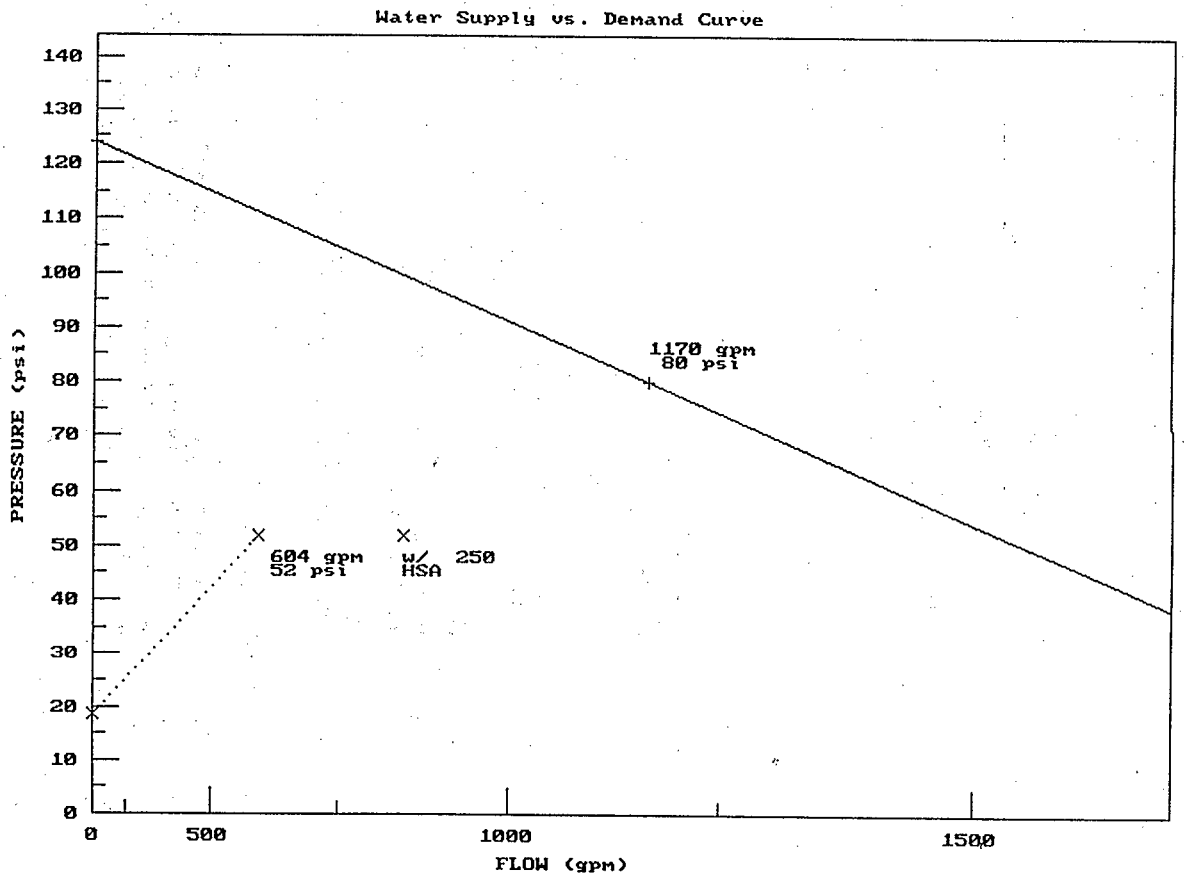


Figure 5-2. Water supply/demand for Building 236-Z (Quality Hazard Control Building)

According to facility staff, most of the automatic sprinkler systems were designed according to the pipe schedule method outlined in NFPA 13, "*Installation of Automatic Sprinkler Systems*." The results of a hydraulic analysis of sample remote areas using "The" Sprinkler Hydraulic Analysis Program [FPE Software, Inc., 1991] indicate adequate pressure and water flux (i.e., density) to meet the NFPA 13 requirements for Ordinary Group I hazard occupancies. The results of the hydraulic analysis are presented in Appendix A. A summary of the calculations for the most remote areas are provided in Section 5.1.

The supply plenum in the Duct Level is provided with a preaction sprinkler system. Preaction systems are generally used in order to prevent unwanted water damage in areas where the sprinkler system may be physically damaged by operations or freezing is a problem. Based on the site visit, the need for a preaction system rather than a wet pipe automatic sprinkler system is not apparent. However, the preaction system currently provides an acceptable level of protection in the plenum space. The decision to change the preaction system to a wet pipe system should be based on the cost of modifying or maintaining the system and the life expectancy of the building.

Based on facility staff direction, automatic sprinkler protection is provided in the elevator shaft within the pit and at the top of the shaft. NFPA 13 [1994 ed.] Section 4-5.5 requires a sidewall sprinkler located no more than 0.6 m (2 ft) above the floor of the elevator pit and a sprinkler at the top of the shaft. Sprinkler protection in the elevator shaft is in compliance with NFPA 13.

The automatic sprinkler system coverage in the PFP facilities meet the requirements of DOE 5480.7A, Section 9.b(3)(b) and DOE 6430.1A, paragraph 1530-2.3.2 regarding provision of automatic suppression systems for facilities where the maximum possible fire loss could exceed $1 million. In Building 234-5Z, automatic sprinkler coverage is not provided in all areas. Automatic sprinklers are not recommended in the filter rooms and the plutonium storage vaults based on the limited fuel load and criticality concerns in these areas. However, other areas of the building which do not currently have sprinklers should be provided with automatic sprinkler protection (i.e., Rooms 194, 334, and 335).

For the buildings not provided with automatic sprinkler protection, the MPFL does not exceed $1 million. Therefore, automatic fire suppression is not required in these facilities (see Section 12).

5.2.2 Water Spray Deluge Systems

The two oil-filled transformers located in Building 291-Z (Room 500) and the four oil-filled transformers adjacent the north wall of Building 234-5Z (Station 252-ZI) are protected by fixed water spray nozzle deluge suppression systems. Design and installation of the water spray systems should comply with NFPA 15, "Standard for Water Spray Fixed Systems for Fire Protection" [NFPA 15, 1990]. NFPA 15 Section 4-4.3.4 requires the following for transformers:

"Transformer protection shall contemplate essentially complete impingement on all exterior surfaces, except underneath surfaces that in lieu thereof may be protected by horizontal projection. The water shall be applied at a rate not less than 0.25 gpm per sq. ft (10.2 (L/min)/m^2) of projected area of rectangular prism envelope for the transformer and its appurtenances and not less than 0.15 gpm per sq. ft (6.1 (L/min)/m^2) on the expected nonabsorbing ground surface area of exposure."

Table 5-3 contains an overview of the hydraulic water demand for the PFP transformers. According to facility staff, the deluge systems were not hydraulically designed when they were installed. In order to determine the adequacy of the deluge systems, a hydraulic analysis was conducted for the two systems based on facility fire protection drawings and NFPA 15 criteria using "The" Sprinkler Hydraulic Analysis Program [FPE Software, Inc., 1991]. The results of the analyses indicate adequate pressure and water flux (i.e., density) to meet NFPA 15 criteria. The results of the hydraulic analysis are presented in Appendix A.

Table 5-3. Water Demand Requirements for PFP Fixed Water Spray System Transformer Stations

Building Area	Required Residual Pressure (psig)	Total Demand (gpm)	Available Pressure at Demand (psig)
291-Z Room 500	92	631	110
234-5Z Station Z1	52	698	107

Although the deluge systems were not originally hydraulically designed, the hydraulic analysis indicates adequate water supply for the transformers. A review of the water spray coverage areas was also conducted to determine compliance with NFPA 15 criteria. Although the coverage areas appear to be adequate, the facility drawings do not provide the level of detail needed to determine exact coverage areas. However, the level of protection provided by the fixed water spray system is sufficient based on the fire hazard and exposure potential. Therefore, system modifications and/or upgrades are not required.

5.2.3 Interior Standpipe Systems

Interior hose connections are provided throughout the building. The hose connections are 1½ in. connections without hose. The fire department will provide hoses upon arrival at the scene. Based on HFD capabilities and the lack of input from HFD requesting upgrades, the locations are adequate for interior manual firefighting to be conducted without compromising the integrity of the confinement structure.

5.2.4 Portable Fire Extinguishers

UL listed portable fire extinguishers are located throughout the PFP facilities. In some of the process areas, magnesium oxide sand is also provided. The locations and extinguisher ratings comply with NFPA 10, "Standard for Portable Fire Extinguishers" [NFPA 10, 1994], for protection of the Complex.

5.2.5 Special Hazard Suppression Systems

A total flooding Halon system, dry-chemical systems, and limited water bottle stations (LWBS) are used to protect several of the hoods and gloveboxes, including those which are part of the former RMC and RMA process lines. A description of these systems and their effectiveness in controlling glovebox fires is presented in Section 7.0.

5.3 FIRE DETECTION AND ALARM SYSTEMS

Smoke and/or heat detection systems are provided in most of the PFP facilities. In Buildings 234-5Z, 242-Z, 236-Z, and 2736-ZB, the automatic detection systems provide redundant fire protection (as defined in DOE 5480.7A) in addition to the automatic fire suppression systems. A description of the fire detection and alarm systems in the PFP Complex is provided based on the description provided in the FSAR [WHC, 1995].

The 234-5Z Building is equipped with a Gamewell Flex 500A (trademark of Gamewell Corp) fire alarm control panel which is located in corridor 14A. This panel also serves fire zones in the 236-Z, 242-Z, 2727-Z, 2729-Z, 2734-ZA, TC-66, 234-ZC, 234-5ZA, and 2734-ZC Buildings. All alarms also annunciate in room 321 or the Micon (trademark of MICON Company) Control Panel. Each fire zone is transmitted to the Hanford Fire Department (HFD) by radio fire alarm reporters (numbers 2780 and 2781) located on the wall outside the building near the airlock to Corridor 14-A of the 234-5Z Building.

Local and remote alarms are initiated by heat detectors, smoke detectors, activation of automatic fire suppression systems, and manual fire alarm stations. Activation of the panel will result in notification of the HFD and sounding a local fire alarm bell. All circuits are electrically supervised in accordance with NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems* [1993 ed.].

A single heat detector (no. 27-49) located in the corridor 4B airlock leading to the airlock along the west wall of Building 242-Z is currently inaccessible for testing and maintenance. The area served by the heat detector contains no combustibles, is provided with sprinkler protection, and is not accessible to personnel. Because of the lack of combustibles and sprinkler protection, together with the inability to test and maintain the device, the heat detector is not necessary and should be deactivated (i.e., either removed or abandoned in place), and a sign should be provided indicating that the device in the protected area may not be operational.

Heat detectors are provided in many of the PFP gloveboxes. In some gloveboxes, the detectors are used as initiating devices for automatic suppression systems (see Section 7.0). Recommended fire protection features for the PFP gloveboxes are presented in Section 7.0.

Manual fire alarm stations are provided at all exits from Buildings 234-5Z, 242-Z, 236-Z, 291-Z, 2736-Z, 2736-ZB, 2721-Z, and 243-Z. A manual fire alarm station (no. 27-50) located in the corridor 4B airlock leading to the airlock along the west wall of Building 242-Z is currently inaccessible for testing and maintenance. This airlock no longer serves as an exit from the 234-5Z Building. Because the device cannot be maintained and the manual fire alarm station is not required, it should be deactivated (i.e., either removed or abandoned in place).

SECTION 6 — FIRE HAZARDS

6.1 GENERAL

This section describes the existing fuel loading and potential fire hazards in the PFP facilities. The fuel arrays selected for fire hazard impact analysis are chosen based on the results of a walk down of each of the PFP facilities and discussions with facility plant personnel regarding support operations and transient activities in the Complex. The following "plausible" fire scenarios are included in this analysis:

1. Building 234-5Z - Office, laboratory, and process area fires,
2. Building 234-5Z - Hydraulic oil spill fire in room 321 (supply fan room),
3. Building 234-5Z - Potential hydrogen generation hazard in plutonium solution storage rooms
4. Building 234-5Z - Propane cylinder release and deflagration hazard (Appendix B),
5. Building 242-Z - Plastic fire in TC-66,
6. Building 236-Z - Transient combustibles fire in room 41 (MT glovebox room),
7. Building 291-Z - Transformer oil spill fire in room 500,
8. Building 2736-ZB - Office/lab equipment fire in room 637 (NDA Lab),
9. Building 2721-Z - Diesel oil fire resulting from leak in emergency generator reservoir,
10. Building 232-Z - Transient combustibles fire in process area,
11. Building 243-Z - Transient combustibles fire in process area,
12. Compressed Gas Storage Area - Potential propane cylinder explosion hazard,
13. Hazardous Product and Waste Exterior Laydown Area - Exposure hazard resulting from a vehicle fuel tank rupture which spills, ignites and exposes stored 55-gallon TRU waste drums.

The FHA addresses only the worst case fire scenarios to determine maximum possible fire loss. These scenarios do not include all possible fires; however, they are expected to bound the fire scenarios that exist within the facilities.

6.2 APPROACH

The approach for the analyses includes several tasks. A site visit was conducted to gather information relating to the building layout, structural components, process operations, and actual fire loading. The site visit included a building walk down, discussions with facility staff and documentation/drawing reviews.

Based on the information gathered during the site survey, candidate fire scenarios are developed for the PFP facilities. The scenarios generally include worst case fire events. In some areas where multiple hazards exist, other credible fire events are also considered. The damage potential associated with the various fire scenarios is determined quantitatively using well documented, state-of-the-art fire protection models and equations or qualitatively using information in literature.

For each of the PFP facilities, the Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) are determined in accordance with DOE Order 5480.7A based on evaluation of the design basis fire scenarios. For the MPFL, automatic and manual suppression systems are assumed to be unavailable. For the MCFL, consideration is given to any automatic suppression systems in the facility or fire area. Based on the MPFL and MCFL, compliance with DOE and WHC fire protection requirements is reviewed.

6.3 BUILDING 234-5Z

6.3.1 Fuel Loading

The fuel loading in Building 234-5Z consists primarily of ordinary combustibles located in the office and lab spaces on the first and second floors. Typical combustibles include office supplies such as desks, tables, chairs, bookcases, computer hardware, and paper goods. In the lab spaces, combustible and flammable liquids are sometimes used in limited quantities. During the site survey combustible and flammable liquids were limited to one gallon containers and, when not in use, were almost always stored in flammable liquid cabinets. The total quantity of combustible and/or flammable liquids in use in any laboratory appeared to be limited to less than 5 gallons. Other combustibles in the these areas include protective clothing and various storage containers. Although the fuel load in the office and lab spaces is generally low, the fire spread potential is assessed for office and lab areas of the facility.

The Duct Level in Building 234-5Z consists primarily of non-combustible ventilation ducts, plenums, and equipment As a result of the limited fuel load, no credible fire scenarios were identified which could potentially cause damage to the structure or spread to other areas of the facility. Based on a series of in situ NDA measurements [FSAR, WHC-SD-SAR-021, Section 7.4.2], an estimated 6 kg of crystalline form (non-dispersable) plutonium is contained in the exhaust ducting. However, since a fire in the Duct Level is not expected to damage the exhaust ducts, the potential fire and contamination hazard is considered to be less severe than for other areas of the building and therefore is not considered in the MPFL and MCFL scenarios.

Several active and inactive gloveboxes are located in the labs and process areas of Building 234-5Z. Many of the gloveboxes contain plutonium bearing and combustible materials. Glovebox combustibles may include polycarbonate/acrylic window panels, gloves, rags, plastics, paper, electrical insulation, flammable/combustible liquids, and miscellaneous organic compounds. In addition to the combustible fuel loading, contamination within the gloveboxes adds to the fire hazard. A fire which breaches a glovebox enclosure can spread contamination to other areas of the facility. In some areas, several gloveboxes are physically connected together via conveyors and other gloveboxes to form a process line. In these cases, the potential exists for fire spread from one glovebox to another. The most extensive process line in the facility is the 94-1 Thermal Stabilization gloveboxes. As such, a fire in one of the 94-1 gloveboxes is considered as the worst case glovebox fire for the 234-5Z building.

The fire hazards and fuel loading associated with the office and lab spaces and the gloveboxes are common throughout most of the facility. In addition, there are also notable fire hazards specific to certain operations and/or areas of the building. The following areas and/or operations are identified as having a fire potential:

- The hydraulic elevator pump located in Room 321. A leak or accidental discharge from the pump could potentially result in 568 liters (150 gallons) of hydraulic oil being spilled onto the floor in Room 321. The hydraulic oil used is a Class IIIB combustible liquid having a flash point of 198°C (388°F) [Unocal, 1992]. Since the oil has a high flash point, it will not readily produce flammable vapors under ambient conditions and, therefore, requires some pre-heating prior to ignition. However, once ignited, a hydraulic oil spill can present a significant fire hazard to the facility.

- Plutonium bearing materials, such as plutonium nitrate and plutonium filtrate solutions, are stored in Rooms 172 and 236. The materials are normally sealed in vented containers which are spaced according to criticality specifications. Since the stored plutonium is in the 4 valance state (PuIV), a steady production of hydrogen and oxygen takes place resulting in a potential explosion hazard. Since the storage containers are vented to the room, it possible to generate an explosive concentration of hydrogen in the room if proper ventilation is not provided. The maximum number of containers stored in Room 236, the larger of the two storage rooms, is 378 [Rodgers, 1996].

- Liquid propane gas (LPG) is used infrequently in the PFP for a variety of maintenance. The propane used is administratively restricted to nominal 465 g (16.4 oz) U.S. Department of Transportation (DOT) 39 cylinders of liquid propane gas [WHC, 1995]. The hazards associated with the propane cylinders include both slow leaking and catastrophic cylinder failures. Based on an analysis of the propane hazards by WHC, the propane scenarios are not considered credible events (i.e., probability of occurrence is less than 10^{-6}) [Rodgers, 1996]. The MPFL scenarios were developed and integrated with the PFP SAR based on the requirements of RLID 5480.7A (1/17/94) and WHC-SD-GN-FHA-30001, Rev 0

[WHC, 1994] as directed by WHC [Bucci, 1996]. Since the propane deflagration scenario is not a credible event, it is not considered to be a MPFL fire scenario. However, since WHC's analysis is based in part on administrative controls which could potentially change in the future, an analysis of the worst case propane deflagration scenario is included in Appendix B with the understanding that the fire scenario should be evaluated prior to changing any administrative controls which affect the use of propane in PFP facilities.

6.3.2 Analysis of Office and Laboratory Area Fires

In order to evaluate the fire scenarios on the first floor, the following is provided:

(1) A description of the first floor "zones" and construction,

(2) A description of the fuel load,

(3) Development of fire scenarios, and

(4) An analysis of fire scenarios and their effect on the specific zones.

6.3.2.1 General First Floor Description

The first floor of Building 234-5Z consists of a number of offices and laboratories within three primary zones as defined by the FSAR; Zone 1, Zone 3a, and Zone 3. The zones are based on ventilation, contamination, and construction. Figure 6-1 depicts the general locations of the zones on the first floor.

Zone 1 is the space along the north end of the building. The atmospheric pressure is maintained between 35 and 42 Pa (0.14 and 0.17 WC). It is approximately 1,630 m^2 (17,540 ft^2) in floor area and 3.1 m (10 ft) high with a 1.91 cm (3/4 in.) thick plaster on metal lath ceiling. There is a minimum 0.85 m (2.8 ft) gap between the plaster ceiling and the base of the 0.038 m (1.5 in.) steel deck floor. The ceiling has a number of penetrations, including vents and light fixtures. Without penetrations, the plaster and metal lath would provide protection, approximately two-hours, to the structural elements above the ceiling [UBC, 1994]. Zone 1 is composed of a large number of office spaces constructed of metal studs with 1.91 cm (3/4 in.) plaster, on metal lath. There is no contamination in Zone 1.

Zone 3a runs along the south wall of the building. The atmosphere in Zone 3a is maintained at a pressure between -27 Pa and -35 Pa (-0.11 and -0.14 WC). This zone is approximately 1,896 m^2 (20,400 ft^2) in floor area and 4.6 m (15 ft) high. The ceiling is also 1.91 cm (3/4 in.) plaster on metal lath and with a minimum 0.85 m (2.8 ft) gap between the ceiling and the metal deck floor. The zone contains a mixture of office spaces and laboratory spaces with various numbers of gloveboxes and hoods. Zone 3a is considered a contaminated zone.

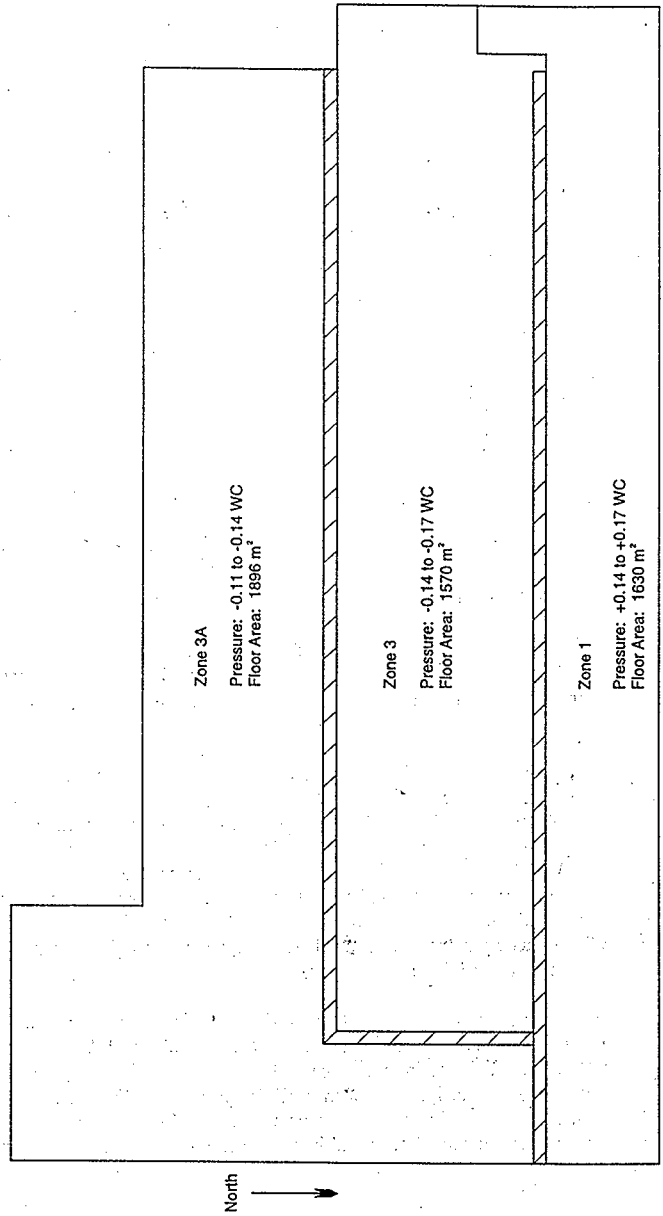


Figure 6-1 Approximate zone locations for Building 234-5Z (first floor)

(not to scale)

Zone 3 is located in-between Zone 1 and Zone 3a. The atmosphere in the space is maintained between -35 Pa and -42 Pa (-0.14 and -0.17 WC); the lowest pressure of the 3 zones. This zone is approximately 1,570 m^2 (16,900 ft^2) in floor area and has a ceiling height of 5.2 m (17 ft). In this zone, there is approximately a 0.20 m (8 in.) gap between the plaster ceiling and the steel deck floor. This zone consists primarily of glovebox process areas, laboratories and storage areas. There are also office spaces located at the east and central portions of the zone. The ceiling is 1.91 cm (3/4 in.) plaster on metal lath and has a number of penetrations. The walls between rooms are 1.91 cm (3/4 in.) plaster on metal lath and also have penetrations preventing a fire rating classification. Zone 3 is also a contaminated zone.

Each zone is separated from the other zones by concrete walls, each 0.2 m thick (see Figure 6-1). The concrete walls do not comply with UBC criteria for a fire wall due to miscellaneous penetrations which are not provided with fire resistance rated opening protections. The penetrations identified appear to be able to limit fire spread; however, smoke and radiological contamination can potentially pass from zone to zone, depending on the zone pressurization.

6.3.2.2 First Floor Construction Description

An issue of importance for determining the MPFL is whether the structural integrity of the building is maintained during a fire. An understanding of the composition of the first floor is necessary to evaluate the fire effects.

Figure 6-2 shows a typical first floor construction configuration. In the space between the first floor plaster ceiling and the steel metal deck floor on the duct level, all beams, joists, and columns are exposed. The plaster ceiling, exposed structural components, and metal deck comprise the first floor ceiling assembly. Below the ceiling assembly, the first floor columns are protected with a minimum 1.91 cm plaster. Although the plaster does not provide a fire rating in accordance to American Society of Testing and Materials (ASTM) E-119 and the UBC [1994], heat transfer calculations in Section 6.3.2.5 demonstrate that the plaster provides adequate fire protection to maintain structural integrity for the worst case fire scenarios anticipated in these spaces.

A typical cut-away section of the plaster on metal lath ceiling is shown in Figure 6-3. Plaster and metal lath ceilings have been shown to remain in place after severe fire exposure and are considered to have fire protection capacities [NBS, 1942; AISG, 1964]. The suspended ceiling is supported by 3.8 cm cold rolled channels and 1.9 cm furring channels. These are spaced at approximately 1.5 m and 0.3 m, respectively. The cold rolled channels are attached to either the beams or the joists with stainless steel wire.

In some areas, the plaster ceiling contains miscellaneous penetrations such as pipes, ducts, and flush mounted light fixtures. Without these penetrations, the 1.91 cm (3/4 in.) plaster would provide a 2-hour fire resistance rating to the structural elements above the ceiling. Based on the site survey, the penetrations did not appear large enough to allow direct flame spread into the ceiling assembly. However, the openings may allow smoke and contamination spread to the duct

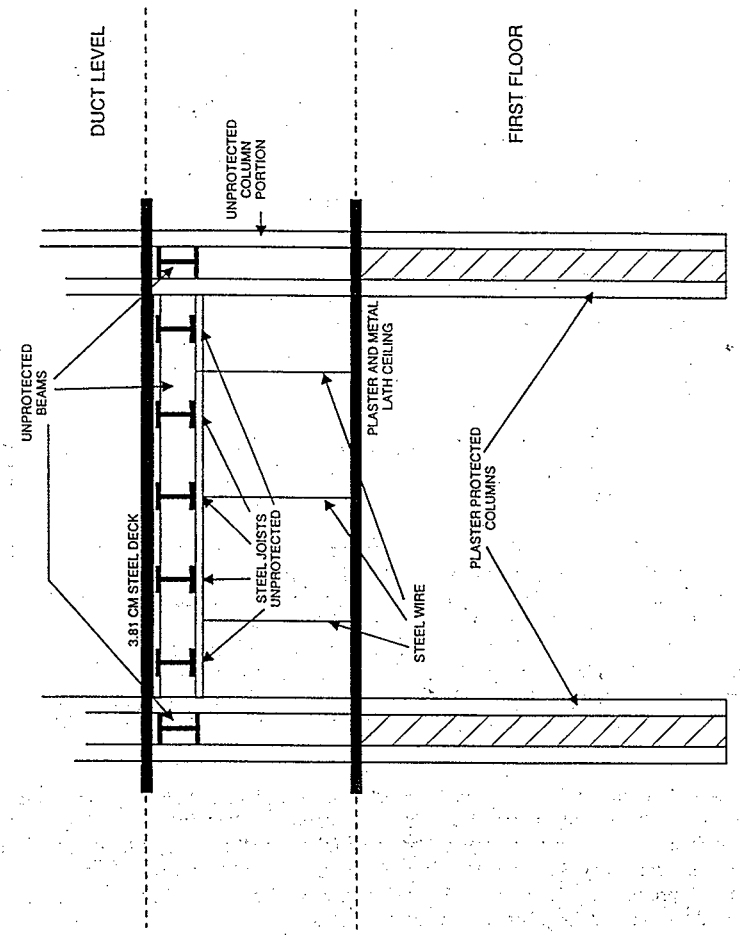


Fig. 6-2. Cut away view of typical structural layout

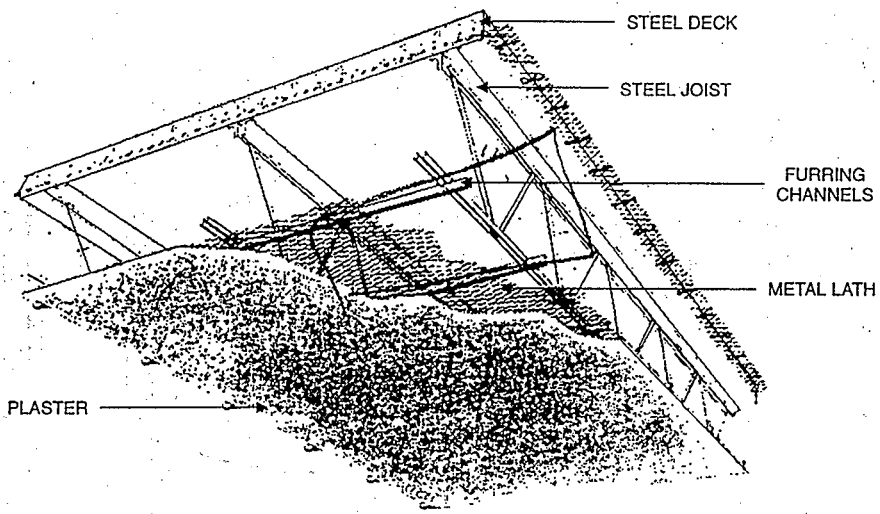


Figure 6-3 Plaster on metal lath ceiling details

level and can also allow radiant heating of the unprotected structural members in the ceiling assembly.

Non-rated flush mounted light fixtures provide the most significant unprotected openings in the plaster ceiling. The light fixtures are mounted in the ceiling assembly by a positive mechanical attachment (i.e., metal frame, screws, wire, etc.). Light fixtures installed in this manner are not expected to fall from the ceiling during a fire. However, the back metal surface of the fixture will heat up rapidly exposing the beams and joists located above. The exposure is caused by the light fixture radiating energy to the beam causing it to increase in temperature. Fire protection ratings for plaster ceilings with light fixtures are obtained in some instances by providing insulation on the back of the light fixture.

Additional penetrations include pipes and air ducts. In many areas, the pipe penetrations are well sealed; however, in some locations, small openings where the pipe penetrates the ceiling provide an exposure to the structural members within the ceiling assembly. The size of these openings are minor compared to the unprotected duct and light fixtures.

The duct openings typically consist of circular vents measuring approximately 30.5 cm to 61.0 cm (12 in. to 24 in.) in diameter. The ventilation system in the 234-5Z Building is entirely ducted; therefore, the vents do not provide a direct opening within the ceiling assembly. Similar to the light fixtures, the metal ducts serving the vent openings can provide a radiant exposure to the beams and joists located above in the ceiling assembly.

The floor of the duct level is a 0.038 m steel deck supported by open web steel joists. The joists, designated as SJ126, are spaced unevenly at distances ranging from 1.07 m to 1.52 m. Figure 6-4 shows the dimensions of this joist. Column spacing in the 234-5Z Building is also uneven and ranges from 4.6 m to 9.1 m. Floor beams connect each column and have designations ranging from W14x26 (lightest) to W16x40 (heaviest). Joists span the grid between beams.

Walls constructed of 1.9 cm (3/4 in.) plaster on metal lath partition the offices and laboratory spaces on the first floor. A schematic of a typical wall section is shown in Figure 6-5. These walls would have a one-hour fire resistance rating if there were no penetrations [UBC, 1994]. However, due to unprotected openings (e.g., doors, windows, etc.) and miscellaneous penetrations (e.g., pipes, ducts, etc.), the walls do not qualify for a fire rating. In general, no credit is taken in this study for the passive fire protection features of the plaster walls.

6.3.2.3 Fuel Loading

The fuel load in office and laboratory areas is noted to be limited with a few exceptions. In this section, based on the site survey and previous fire protection assessments, conservative estimates of the maximum fuel loading present in the office and laboratory spaces is determined. In addressing the MPFL and MCFL scenarios, it is generally assumed that the fire load in each of the office and laboratory spaces is at the maximum (i.e., the maximum concentration of combustibles observed during the site visit).

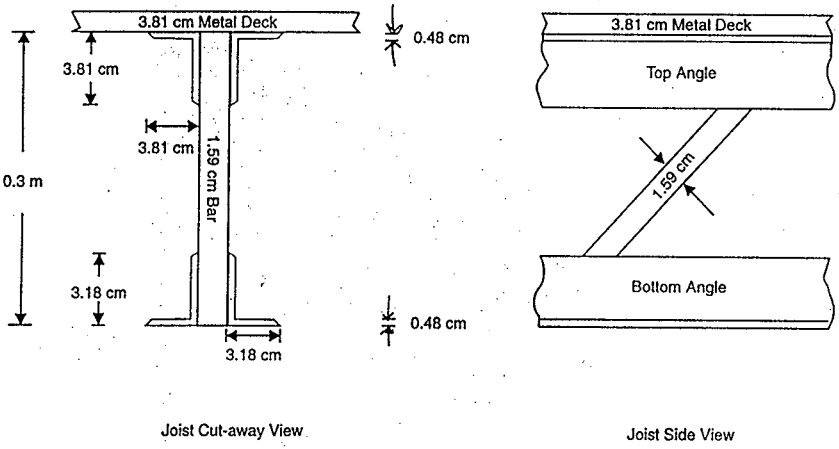


Figure 6-4 Open web steel joist details (SJ126)

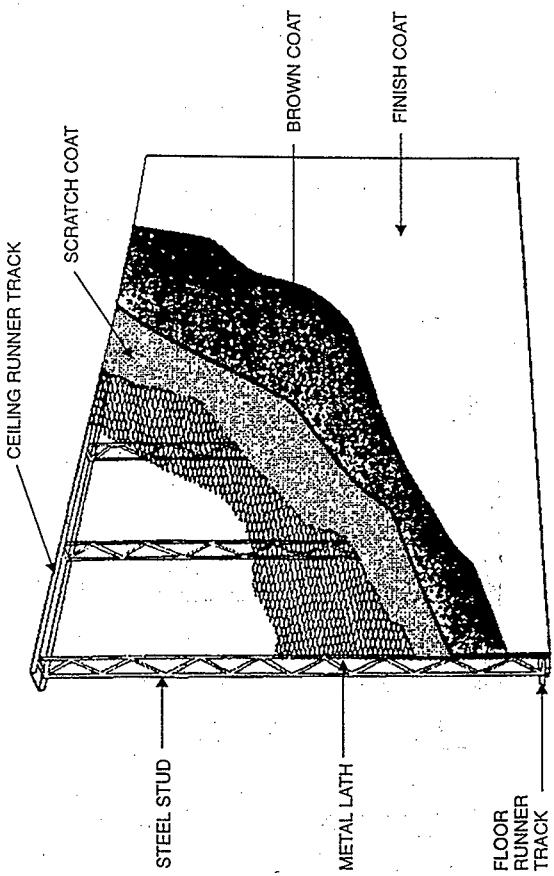


Figure 6-5 Schematic of typical plaster on metal lath wall section

The fuel loading in office spaces typically consisted of metal desks and bookcases, chairs, books, general office supplies, miscellaneous paper and plastic items. In the laboratory areas, the quantity of these combustibles are limited; however, combustible items used in gloveboxes and hoods in addition to miscellaneous chemicals may also be present. The office and laboratory spaces varied in size, ranging from approximately 9 m^2 to 43 m^2 (100 to 460 ft^2) in floor area with ceiling heights ranging from 3.0 m to 4.5 m (10 to 15 ft). A detailed inventory of the actual fuel loading in every PFP room was not performed. Rather, a conservative estimate of the fuel loading is determined based on information gathered. Based on this estimate, worst case fire scenarios are evaluated in the office and laboratory spaces.

Based on the site visits in 234-5Z, the maximum fuel load in an office space is estimated as 510 kg (1,122 lb). In order to compare the heat output from different types of fuels, it is useful to express the fuel load as an equivalent cellulosic (wood) mass. Plastic type fuel can be converted to a wood equivalent mass using the ratio of the heat of combustion of plastic to the heat of combustion of wood. As such, the wood equivalent office fuel load (510 kg) mass accounts for both cellulosic and plastic type fuels.

The estimated office fuel load is higher than the combustible fuel load of 227 kg (500 lb) wood equivalent identified for PFP office spaces in the FSAR [WHC, 1995] and is also higher than the 296 kg (652 lb) wood equivalent fuel load identified for the most severe PFP office in the previous FHA [WHC, 1989]. As noted, the fuel loading used in this document is intended to provide a bounding analysis.

The maximum fuel load in a laboratory space is estimated to be 500 kg (1,100 lb). As with the office fuel load, this is expressed as a wood equivalent mass and accounts for both cellulosic and plastic type fuels in the laboratory spaces.

The fuel loads identified above are considered to be conservative estimates of the maximum combustible content in the office and laboratory areas. The quantities are representative of medium size office and lab spaces (approximately 19 m^2 (200 ft^2)), particularly those located in the south-east corner of the first floor (i.e., the analytical labs). Some larger offices and labs can potentially have a greater total fuel loading; however, the fire severity is not expected to increase due to the larger floor area and room volume. Based on the site survey, the fuel loading in the larger rooms is typically spread out and will result in a less severe fire than for the smaller concentrated areas.

In addition to office and lab spaces, there are several storage rooms located on the first floor. The fuel load in these areas is typically greater than that found in the office and lab spaces. However, based on the exposed combustible content observed during the site visit, the conservative fuel loading estimate used for the office and lab spaces is anticipated to bound the storage areas also. Although the level of conservatism is not as great for these areas, the storage rooms are generally spread out and surrounded by areas having less concentrated fuel loadings.

Since the office fuel load is slightly higher than the lab space (510 kg vs. 500 kg), the office fuel loading is considered to bound the two areas and is used throughout this analysis for

both office and lab spaces (including the storage rooms in these areas). Again, this fuel loading is considered conservative for both areas.

6.3.2.4 Fire Scenario Development

In this section, the burning duration and thermal exposure resulting from a fire in an office or lab space is determined. The fire scenario is developed using the estimated fuel loading identified in the previous section and is based on full-scale room fire tests having similar fuel loadings. Once the fire characteristics are determined, the structural performance of the first floor columns and the steel members within the ceiling assembly is assessed. The purpose of this analysis is to determine the maximum extent of fire spread and potential structural failure of building members.

The expected worst case fuel load is identified in Section 6.3.2.3 as roughly 430 kg (946 lb) cellulosic contents and about 30 kg (66 lb) plastic based materials, or approximately 511 kg (1,124 lb) wood equivalent. Based on the site walk-down, this was noted to be a conservatively large amount of fuel for an office and/or lab space, the average being less. The total energy content of the fuel within a compartment, assuming a heat of combustion of 14,000 kJ/kg for the wood based materials [Drysdale, 1992], is approximately 7,150 MJ. Due to the large variation in fire development and peak heat release rate as a result of the number of possible fuel configurations, the fire development is estimated by comparing the fuel load and geometry to full-scale test data obtained from fires of similar fuel load and arrangement.

Full-scale fire test series are used to estimate the fire growth rate in the office and lab spaces in the PFP [Fang and Breese, 1980]. The test series was conducted by the National Bureau of Standards (NBS), currently referred to as the National Institute of Standards and Technology (NIST), in a burn room measuring 3.3 by 3.3 meters (10.8 ft by 10.8 ft) floor area with a 2.4 m (8 ft) ceiling height. The room had a doorway opening measuring 0.76 m by 2.03 m (2.5 ft by 6.7 ft) high. The test room was constructed of 20 cm (8 in.) thick concrete blocks covered with either 16 mm (0.6 in.) gypsum wallboard or 16 mm plywood. The floor and ceiling were concrete with a 16 mm thick layer of gypsum lining on the ceiling.

For each test within the room, the fuel load, wall lining material, and the ventilation characteristics (door open/closed and forced/no forced air supply) were varied. For the closed door and no forced air supply configurations, the fires typically burned out due to oxygen limitations prior to reaching flashover conditions. In order to obtain a more severe fire exposure, this analysis focuses on the tests conducted with an open door configuration and similar fuel loadings. Contents of the test rooms included room furnishings such as chairs, sofas, tables, and books and bookcases.

The reported results from the tests include the average heat release rate, the peak heat release rate, the fire duration and the peak upper gas layer. The heat release rate versus time and temperature versus time are available for several tests. Table 6-1 summarizes the test data from three tests that are similar to the arrangement at the PFP under consideration. The PFP office fuel load data is listed at the bottom of Table 6-1 for comparison.

The fire load in the room for each of the tests qualitatively appears greater than that found in the PFP office and lab areas. The actual combustible mass for the tests is less than that reported in Section 6.3.2.3 because conservative estimates are made regarding the PFP fuel load. For example, while many of the furnishings at the PFP are metal (e.g., desks, tables, book cases), all of the contents in the tests are combustible. In addition, the fuel load mass for the NBS tests shown in Table 6-1 is the actual mass of combustibles while the PFP fuel load is expressed in terms of a wood equivalent mass.

Table 6-1. NBS Fire Test Summaries

Test	Room Size (m^2)	Fire Load (kg)	Fire Duration (s)	Total Energy Content (MJ)	Average Heat Release Rate (kW)	Total Energy Consumed (MJ)	Avg (Peak) Gas Temp (°C)
2	10.9	271	612	5532	3010	1842	757 (831)
4	10.9	318	840	5693	3070	2634	806 (952)
6	10.9	338	612	6474	4920	2981	813 (958)
PFP Office/Lab	Variable	511*		7150			

* Fire load for PFP office/lab space is a wood equivalent mass.

The higher estimated PFP fuel loading will result in a longer burning duration and thermal exposure to structural elements in the analysis. Therefore, representative heat release rate and temperature data are used from the full-scale fire tests along with the higher estimated fuel loading and resulting duration for the PFP areas in order to provide a bounding analysis.

The total energy content in Table 6-1 is calculated from the test data by combining the combustible content, carpet, and interior finish contributions. The tests qualitatively contained more plastic and plastic-based materials than the PFP office spaces and comparable quantities to the laboratory areas. The tests show that the average heat release rates for the compartments are between 3000 and 5000 kW and that the fire durations are on the order of 10 to 15 minutes. The total energy content consumed is the product of the average heat release rate and the fire duration. This represents the rough fraction of the fuel that was consumed during the test (i.e., the burning efficiency). The data in Table 6-1 indicates that the burning efficiency is less than 50 percent for the test series under consideration. In this analysis, the fire severity in office space is estimated assuming that 75 percent of the fuel is consumed in the fire. This provides a conservative estimate of the burning efficiency and will result in longer predicted burning duration.

Based on the NBS fire test results and the average heat release rates reported, three fire scenarios are developed for the PFP office and/or lab area. Table 6-2 summarizes the fire durations assuming a 3000 kW, 4000 kW, and a 5000 kW average heat release rate fire in the space. The burn duration, t_b, is calculated using the following relation:

$$t_b = \chi_b \frac{Q}{\dot{q}_{avg}} \qquad (6\text{-}1)$$

where χ_b = the burning efficiency (0.75),
Q = the total energy content present in the compartment (kJ), and
q_{avg} = the average heat release rate in the compartment (kW) from Table 6-1.

Table 6-2. Predicted PFP Office/Lab Fire Durations

Average Heat Release Rate (kW)	Estimated Fire Duration (s)
3000	1788 (30 min)
4000	1341 (23 min)
5000	1073 (18 min)

The fire durations estimated in Table 6-2 are up to approximately 3 times greater than those observed for the NBS full-scale test series. This is because the assumed burning efficiency is greater than that observed during the actual fire tests and conservative approximations are made regarding PFP fuel loadings. In order to provide a bounding analysis of the thermal exposure to the structural elements on the first floor and within the ceiling assembly, a fire duration of 30 minutes is considered in this analysis (i.e., the maximum duration in Table 6-2). This burning duration is also greater than the office fire duration presented in the FSAR [WHC, 1995] of 22 minutes. This further supports the conservative nature of the approach used in this study.

The fire scenarios developed in this analysis will have three primary effects on the first floor of Building 234-5Z that will result in repairs or replacement of equipment or the building:

(1) structural effects,

(2) maximum fire spread and involvement, and

(3) maximum area of radiological contamination.

The following sections address each of these aspects of the fire scenario.

6.3.2.5 Structural Effects

Structural damage resulting from a fire could occur in two manners. First, direct exposure to the columns located in, or partially in, the office and lab spaces. Even though the columns are protected by 1.91 cm (3/4 in.) plaster, failure is still possible if the fire is located near the column and burns long enough. The second manner in which structural damage can occur is via heat transfer through the ceiling assembly. As noted earlier, unprotected light fixtures, duct openings, and pipe penetrations provide an exposure to the steel structural members in the ceiling assembly. The transient heat transfer will depend on the location of the unprotected openings with respect to the structural element under consideration.

6.3.2.5.1 Column Analysis

The columns modeled in the analysis are the lightest column members on the first floor. Based on the structural drawings, the lightest columns are W14x26. This assembly has a minimum fire resistance rating of one hour based on fire test data [AISG, 1964] Details of this column and the vermiculite plaster on metal lath protection are shown in Figure 6-6. Based on the site survey and the drawings provided by WHC, the columns are located within the partition walls between offices, laboratories, and corridors. Therefore, the column exposure resulting from a fire in a room will typically consists of direct flame impingement over one half of the column, with the other half exposed to the adjacent space. However, since no credit is taken for the passive fire protection provided by the partition walls, a direct flame impingement exposure over the entire column surface area is also considered in this analysis.

The response of the column assemblies to the fire is modeled using a two-dimensional finite volume heat transfer model. The finite volume heat transfer software STAR*CD [1994] is used to solve the time-dependent two-dimensional heat transfer equations. In essence, this program determines a temperature distribution within a modeled structure resulting from a heat flux of elevated temperature imposed on the boundary of the structure. The resulting temperature distribution is a function of the thermophysical properties of the assembly (i.e., conductivity, density, and specific heat).

Based on the fire durations estimated in Table 6-2, it is considered that a column assembly can be exposed to direct flame impingement for a period of up to 30 minutes. A direct flame impingement exposure is estimated based on an average flame temperature of 1000°C and flame emissivity of 0.8. This temperature and emissivity provide an incident flame heat flux of approximately 120 kW/m^2 to the column surface, which based on test data conservatively represent heat fluxes measured within the flame region (see Table 6-3). The material properties of the steel and plaster are presented in Table 6-4. The mesh arrangement for the column slice is shown in Figure 6-7.

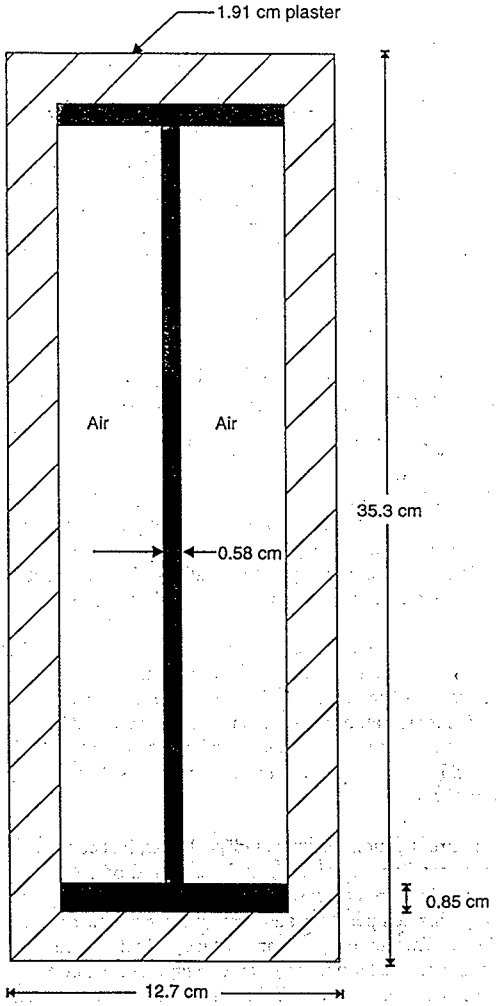


Figure 6-6 W14x26 column assembly details

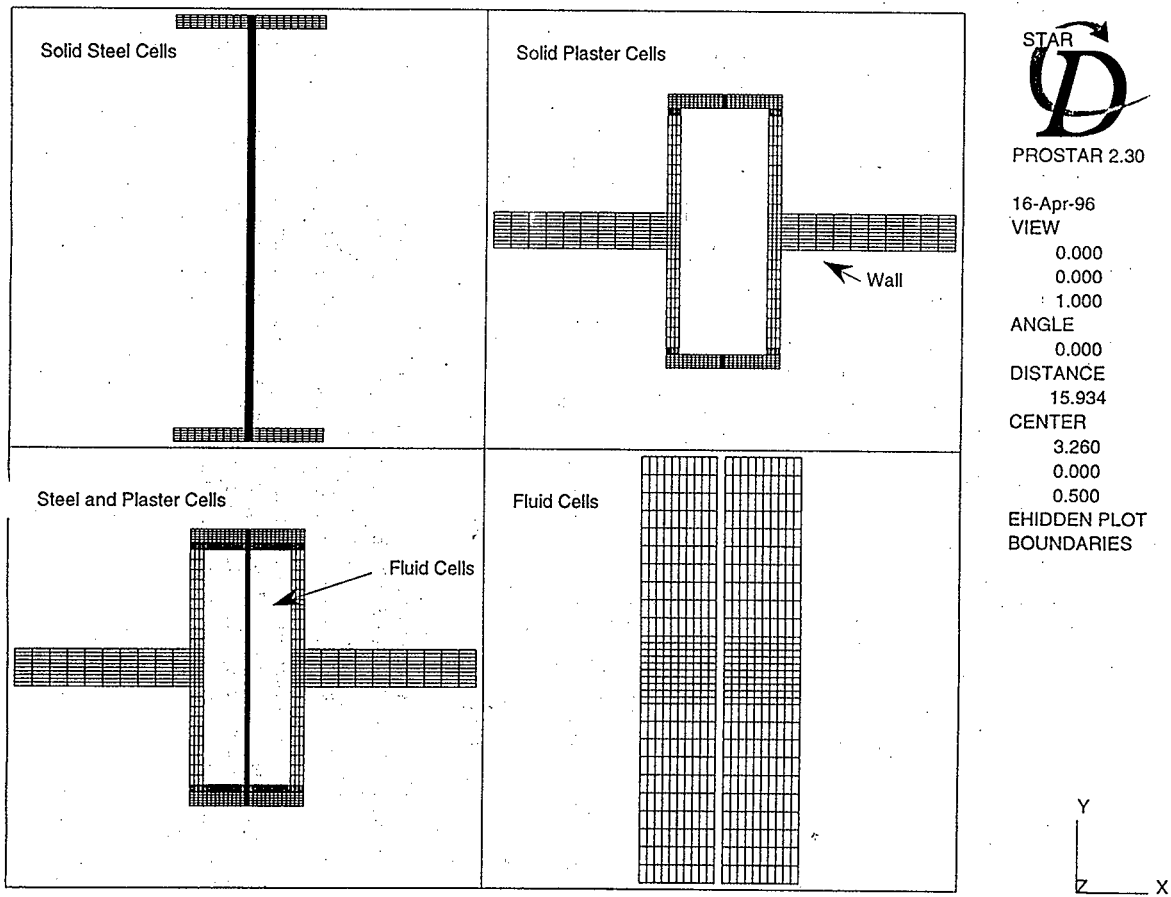


Figure 6-7 Mesh arrangement for W14x26 column assembly slice

Table 6-3. Large Scale Pool Fire Maximum Average Heat Flux Measurements

Large Calorimeters	Heat Flux (kW/m^2)
Gregory, Mata, Keltner [1987]	120
Wachtell and Langhaar [1966]	85
Anderson et al. [1974]	100
National Academy of Science [1973]	110
Moodie [1987]	100
McLain [1988]	85
Taylor et al. [1975]	75

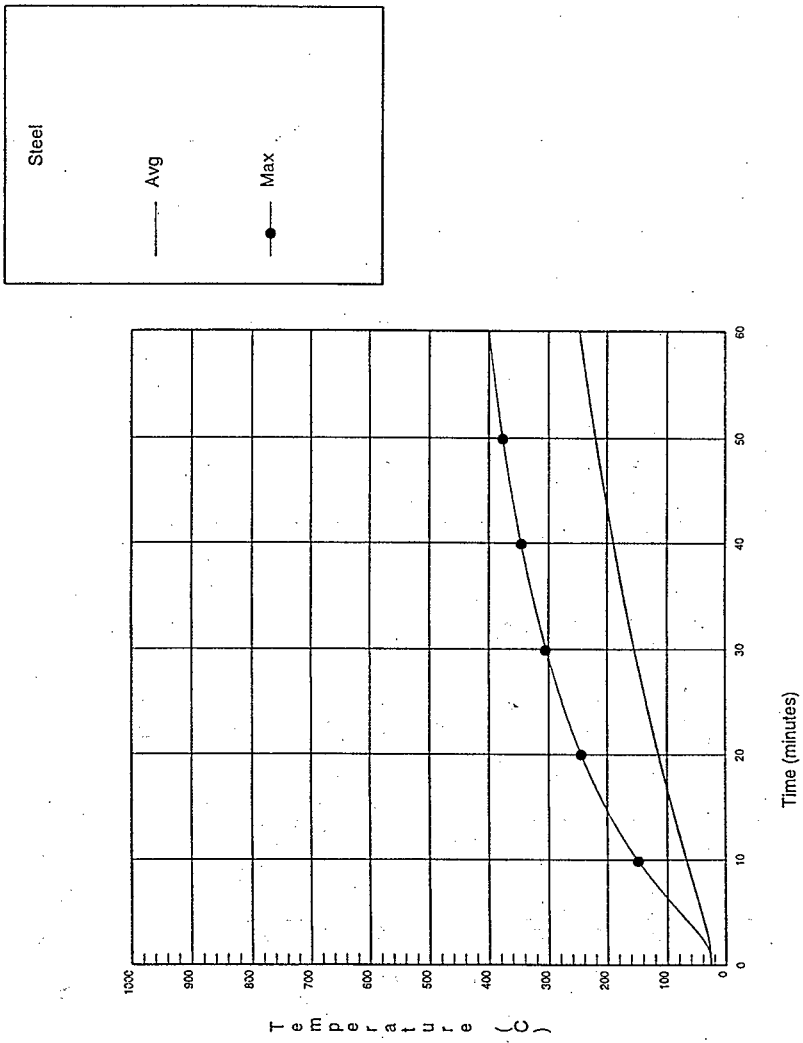
Table 6-4. Thermal Material properties of Plaster and Steel

Material	Thermal Conductivity (W/m-°C)	Heat Capacity (J/kg-°C)	Density (kg/m^3)	Surface Emissivity	Surface Absorbtivity
Plaster	0.19	1200	678	0.9	0.9
Steel	51.0*	1250	7700	0.6	0.6
Air	0.01	1000	1.0*	1.0	0.0

* Decreases with temperature

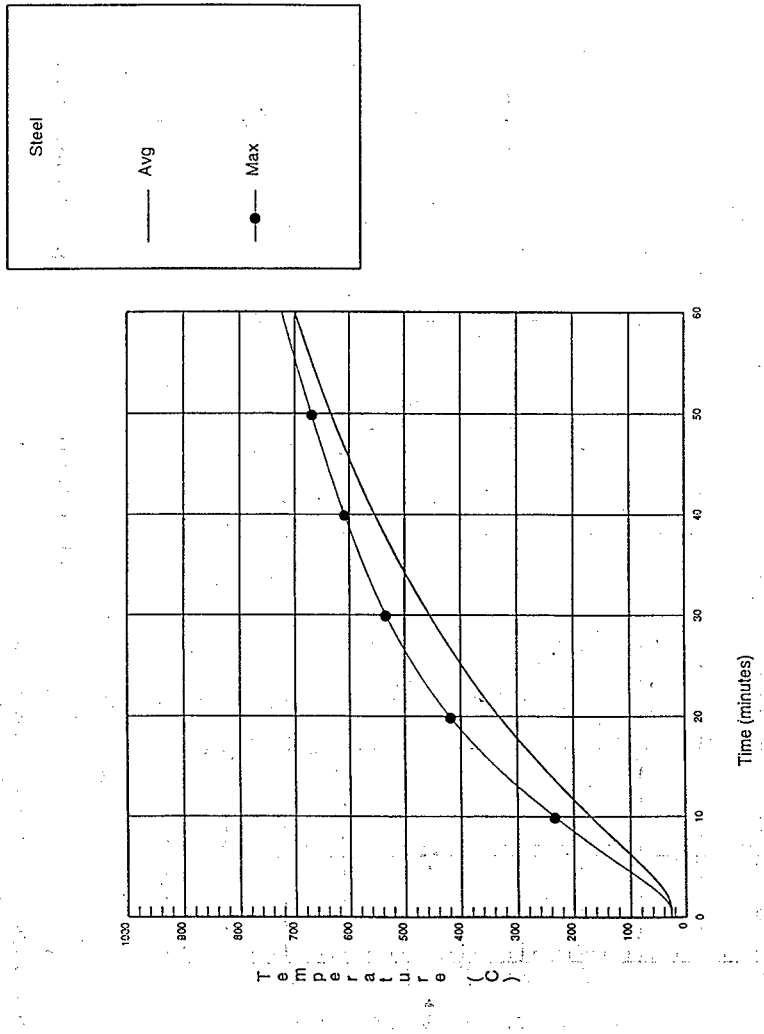
Typically, steel will begin to lose its structural integrity at temperatures of about 600°C (~1100°F). ASTM E-119 [1993], which is used to determine fire-resistive properties of materials and assemblies, specifies that no singe point on the steel column can exceed 649°C (1200°F), and the average temperature cannot exceed 537°C (1000°F) during the fire exposure.

Figures 6-8a and 6-8b show the average and single point maximum temperatures for the W14x26 column protected with 1.91 cm plaster on metal lath for both the half column and full column flame exposure scenarios. The exposures assume that there is direct flame impingement for 30 minutes, the fire duration for the 3000 kW fire.



Steel Average and Maximum Temperatures versus Time
Fire Exposure on One Side of Column/Plaster Assembly

Figure 6-8a Time-temperature results for one-sided column exposure



Steel Average and Maximum Temperatures versus Time
Fire Exposure on Both Sides of Column/Plaster Assembly

Figure 6-8b Time-temperature results for full column exposure

For the half column exposure, the resulting maximum steel temperature of 300°C and the average temperature of 155°C at 30 minutes do not exceed the ASTM E-119 failure criteria. In fact, as seen in Figure 6-8a, the column can withstand direct flame impingement on one side for over one hour without exceeding the failure criteria. For the full column exposure, the resulting maximum steel temperature of 540°C and the average temperature of 455°C at 30 minutes also do not exceed the ASTM E-119 failure criteria. A 30 minute full column exposure is a worst case scenario since the partition walls containing the columns will provide some passive fire protection. Although a fire can potentially spread through the wall, the exposure to the column on each side will not be simultaneous during the entire fire duration.

Since the columns do not fail the ASTM E-119 temperature criteria during the maximum fire duration for the worst case thermal exposures, the expected fire scenarios in the office and/or laboratory spaces on the first floor are not expected to cause structural failure of a column. This is not surprising since the fires are of relatively short duration and the columns are well protected.

6.3.2.5.2 Ceiling Assembly/Joist Analysis

Flush mounted light fixtures, duct openings, and pipe penetrations provide an exposure hazard to the steel structural members in the ceiling assembly. Previous fire tests and heat transfer analyses have shown that heating, ventilation and air conditioning (HVAC) duct penetrations, measuring up to 91 cm (3 ft) in diameter, in the interstitial floor/ceiling assembly space do not compromise the integrity of steel beams and joists during a fire exposure for a period of at least 2-3 hours [American Iron and Steel Institute, 1971; and Hughes Associates, Inc., 1995]. For the fire tests, the joists and structural members were located within 8 cm (3 in.) of the metal duct during ASTM E-119 fire exposures. Therefore, it is concluded that the ducted openings in the PFP first floor ceiling will provide a fire resistance to the structural members of at least 2 hours.

In this section, an analysis is conducted to determine the maximum exposure provided by a flush mounted light fixture to the steel structural members located above. The exposure to the ceiling members resulting from the miscellaneous pipe penetrations in ceiling are small compared to the exposure from the unprotected flush mounted light fixtures. As such, the analysis of the light fixtures is assumed to bound other miscellaneous penetrations.

The effects of the fire scenarios on the structural elements above the ceiling are determined by analyzing the effects on the lightest structural member above the plaster ceiling. The analysis assumes that a light fixture is directly below the lightest structural member, in this case a steel joist (SJ126). The dimensions of the flush mounted light fixtures on the first floor are 0.30 m (1 ft) wide and have lengths varying from 0.91 m to 4.6 m (3 ft to 15 ft). In this analysis, the largest flush mounted light fixture (i.e., 0.32 m by 4.6 m) is used to provide a bounding scenario. As a conservative estimate, it is assumed that the room is exposed to post-flashover conditions for the duration of the fire (e.g., 30 minutes based on the longest fire duration in Table 6-2).

The maximum post flashover upper gas layer temperature resulting from the NBS fire test series (see Section 6.3.2.3) is 958°C. Since the light fixture is directly exposed to this temperature, the back side of the fixture is assumed to have a conservative temperature of 958°C for the duration of the fire. The resulting thermal exposure to the joist is a radiation heat flux that depends on the distance between the lower angle, middle bar, and upper angle of the joist referenced off of the backside of the light fixture. The temperature of the air surrounding the joist is also conservatively assumed to be 958°C. Although convective exposure between the joist and the heated air surrounding the joist is considered, the convective exposure is small compared to the radiative exposure from the heated light fixture.

The radiation configuration factor between the backside of the light fixture and the steel bar joist is given as a function of the distance between the joist element member (lower angle, middle bar or upper angle) and the fixture, "c" (m); the length of the light fixture, "b" (4.6 m); and the width of the light fixture, "a" (0.30 m) [Howell, 1992]:

$$F = \frac{2}{\pi}\left(\frac{X}{\sqrt{(1+X^2)}}\tan^{-1}\frac{Y}{\sqrt{(1+X^2)}} + \frac{Y}{\sqrt{(1+Y^2)}}\tan^{-1}\frac{X}{\sqrt{(1+Y^2)}}\right) \qquad (6\text{-}2)$$

where $X = a/c$, and
$Y = b/c$.

The equation calculates the configuration factor for the point on the joist that is directly over the middle of the panel. Other locations on the joist will have a lower configuration factor; however, the higher value is conservatively used throughout. The height between the light fixture and joist's lower flange, middle bar, and upper flange is 0.46 m, 0.61 m, and 0.76 m, respectively (consistent with the offices and labs located in Zones 1 and 3; the ceiling assembly is somewhat different in Zone 3a and is addressed separately in Section 6.3.3). These correspond to configuration factors of 0.55, 0.45, and 0.37, respectively.

The joist exposure is modeled using FIRES-T3 [Iding, 1977], a finite element heat transfer program designed for fire exposures, as three two-dimensional slices: one through the lower angle, one through the middle bar, and one through the top angle. Figures 6-9 and 6-10 show the boundary conditions and the mesh arrangement that is employed for this analysis. The material properties are identical to those listed in Table 6-4 for steel and air.

The ASTM E-119 failure criteria for joist-beam assemblies where joists are spaced greater than 1.22 m is 704°C (1300°F) for a single point hot spot, and 593°C (1100°F) for the average temperature across any section. Based on ASTM E-119 criteria, the average temperature is obtained by averaging the temperature of two points on the lower flange, one at the middle of the bar, and one on the upper flange. Figure 6-11 shows the temperature versus time of the four locations as well as the average (dotted line). It is seen that the joist temperature does not exceed the 704°C single point criteria nor the 593°C average temperature during the 30 minute exposure (3000 kW fire).

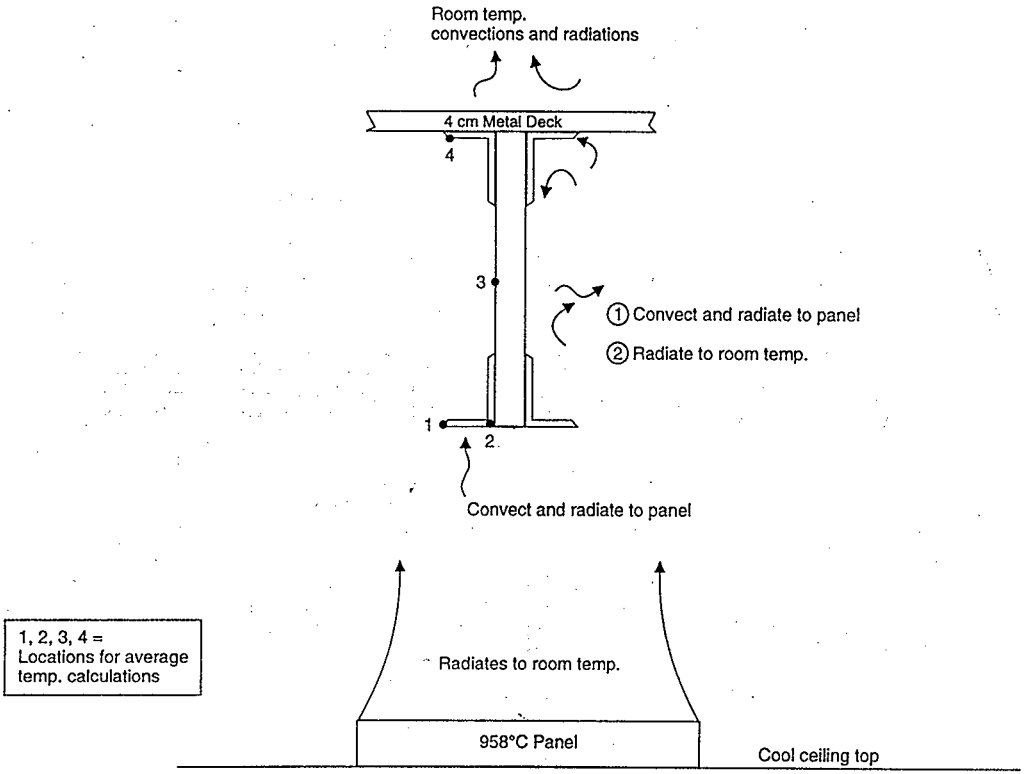


Figure 6-9 Boundary conditions for joist exposure analysis

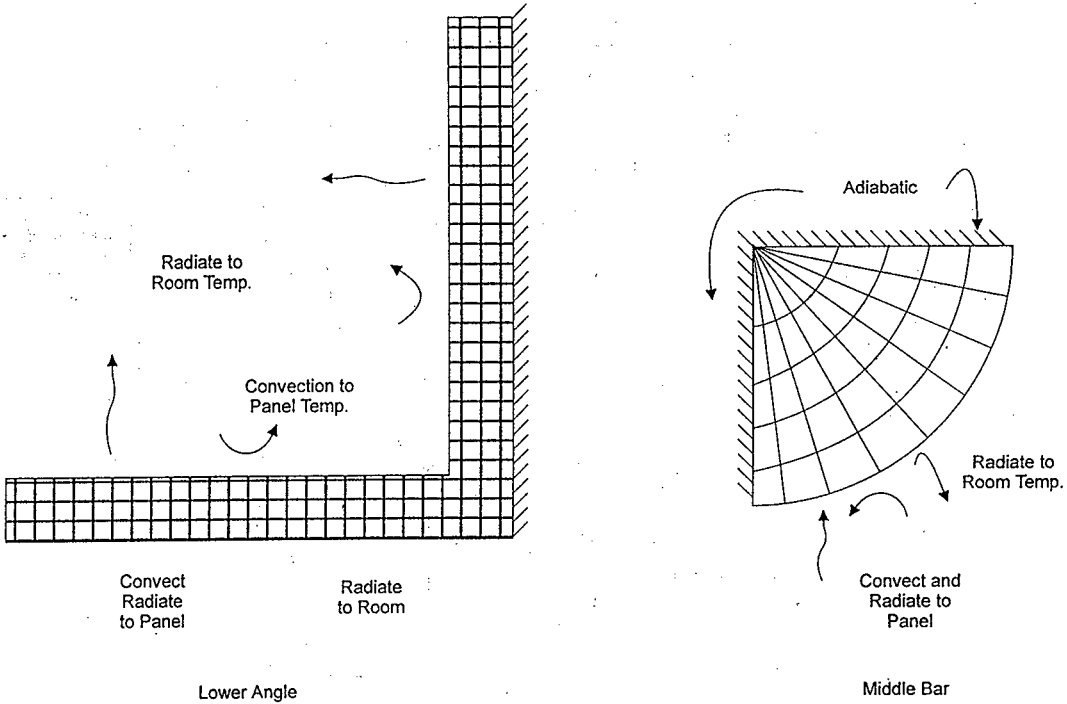


Figure 6-10 Mesh arrangement for open web steel joist

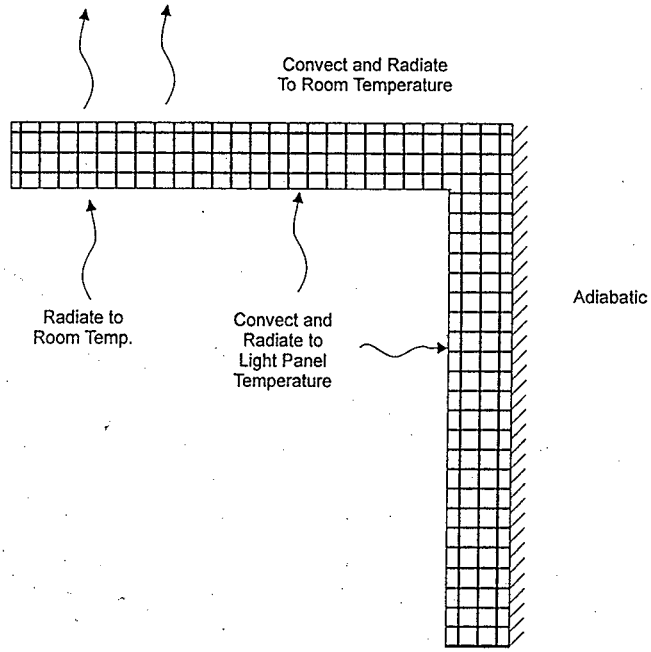


Figure 6-10 Mesh arrangement for open web steel joist (continued)

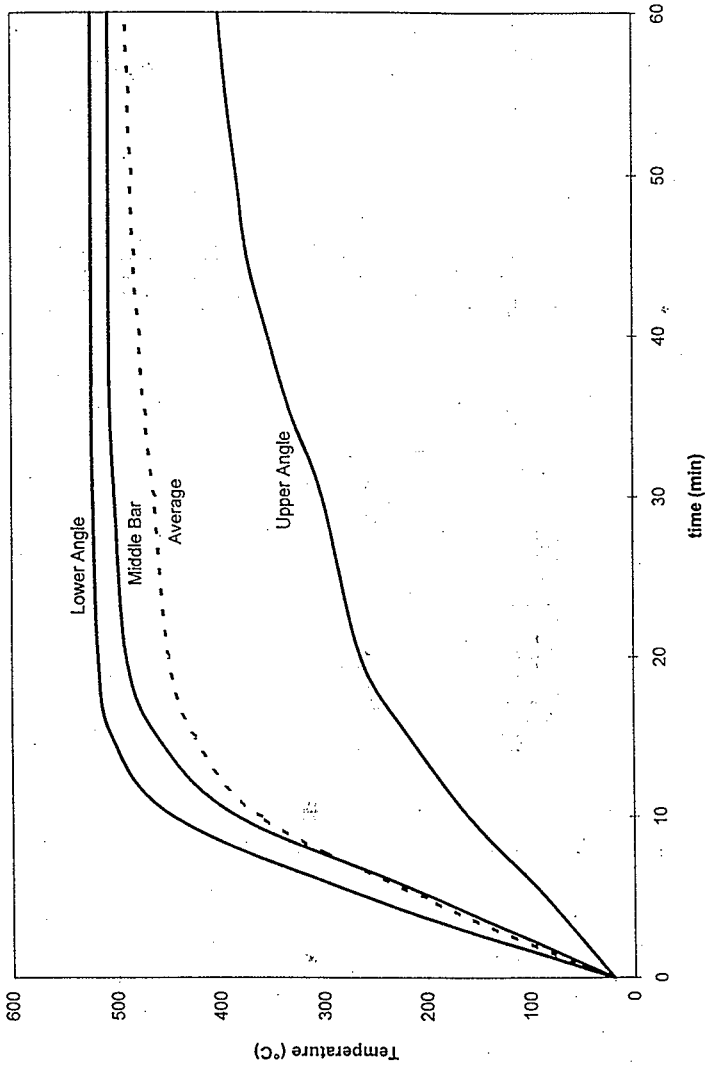


Figure 6-11 Time-temperature results for joist exposure (office/lab fire scenario)

Several conservative assumptions are made in this analysis, including:

(1) An actual fire will have a growth and decay period and, therefore, will not result in post flashover temperatures during the entire fire duration,

(2) The light fixtures used on the first floor of the PFP are typically 0.25 m by 1.22 m, smaller than the assumed dimensions used in this analysis. This would result in a less severe radiant exposure to the structural members, and

(3) The temperature of the light fixture will have some thermal lag between the upper gas layer temperature. This will result in a less severe radiant exposure to the structural members.

This analysis over compensates for actual conditions in order to provide bounding results which can be applied to all of the office and lab areas on the first floor of Building 234-5Z. Since conservative estimates are made regarding fuel load, fire duration, ceiling openings, and thermal exposures, it can be concluded that a fire in an office and/or lab space is not expected to cause structural failure for areas in Zone 3a. The ceiling height, gap height, and the structural member size in Zone 3a are the same for the office locations in Zone 1. Therefore, this discussion can be extended to include those spaces as well. A separate analysis is presented in Section 6.3.3 for areas in Zone 3 which have different fuel loadings and less advantageous ceiling configurations.

6.3.2.5.3 Fire Spread and Involvement

The maximum number of spaces that a fire can involve depends on a number of factors, including whether the doors are open, the amount of combustibles present within the offices, laboratories, and halls, and also the extent of the penetrations in partition walls. This analysis assumes that all doors are open, providing the maximum possibility for flame spread. Without penetrations, a vermiculite plaster wall of such a construction has a fire rating of 1 hour. However, since many of the walls have penetrations and unprotected openings, no credit is taken for their passive protection capabilities.

The 20 cm concrete wall separating Zone 3a from Zone 3 will provide passive fire protection for a period of at least 1-hour (see Section 3.1). During the site visit, there were no combustibles present in the hallway adjacent to the wall which could provide a direct fire exposure. Therefore, exposures to the concrete wall result from flames and hot gases emitted through openings in the wall of the office and laboratory spaces across the hall. Openings in the concrete wall are typically not directly exposed to other corridor openings. Where doors in the concrete wall are exposed, they are typically doors serving contaminated areas; therefore, they are being kept closed. Also, there are no combustibles in the vicinity of these doors. Since an office and/or lab fire is not anticipated to last longer than 30 minutes based on the available fuel load, a fire in these spaces is not expected to spread to the north areas of the building beyond the concrete wall.

Since Zone 3 is at a lower pressure than Zone 3a, smoke and radiological contamination resulting from a fire in Zone 3a is assumed to spread throughout Zone 3. The same is true for the first floor ceiling assembly; while the plaster prevents structural failure and fire spread through the ceiling assembly, smoke and contamination is assumed to spread to the duct level through small penetrations and unprotected openings.

While a fire can occur in any of the office and laboratory spaces on the first floor, this analysis focuses on the area resulting in the maximum fire spread and potential monetary damage. A fire in the south-east corner of the first floor (e.g., analytical labs) has been identified as the worst case fire scenario based on the value of the contents in this area and the extent of potential fire spread.

Since no credit is taken for partition walls between spaces, a fire in the analytical labs can spread laterally until it reaches a point where either there is no fuel to propagate the fire, or some barrier provides a fire stop. Figure 6-12 shows the maximum area of fire spread which can potentially result from a fire in the analytical labs. As noted earlier, the limited fuel load and concrete wall separating Zones 3 and 3a prevents fire spread beyond the north end of the analytical labs.

To the west, the fire can continue to spread through the Instrument Shop, offices, change room, and room nos. 166 and 170. Because of limited fuel load in the exposing area and exposed area, the fire is not expected to spread beyond the airlock (i.e., room 171) into the Plutonium Can Storage area. This is because there are no combustibles within the airlock nor in the storage room to sustain a fire capable of penetrating the plaster partition wall. In addition, the vaults adjacent to the airlock are constructed of concrete walls which will further prevent any fire spread. Since there are limited combustibles in the hallway adjacent to the fire area (i.e., corridor 3 and 5), this is not expected to be a viable route for fire spread.

The 4-hour fire wall which separates Building 234-5Z from 234-5ZA prevents fire spread to the east of the analytical labs. This fire wall is important because it prevents the fire from spreading into Building 234-5ZA and back into 234-5Z on the other side of the concrete walls located along column lines C and E. Therefore, it is recommended that a 1-hour fire resistance rating be maintained for this wall. However, the 2-hour fire resistance rating of the 234-5ZA roof assembly is not required and should not be maintained.

While the plaster ceiling will protect the steel structural members for the duration of the expected fire scenarios, heat transfer through the ceiling assembly can cause the steel deck on the duct level floor to exceed ignition temperatures for ordinary combustibles. During the site visit, there were no combustibles observed in the duct level. Therefore, there is no means for the fire to spread to the duct level. If conditions change and combustible materials are stored in the duct level, the maximum fire spread analysis will have to be re-assessed.

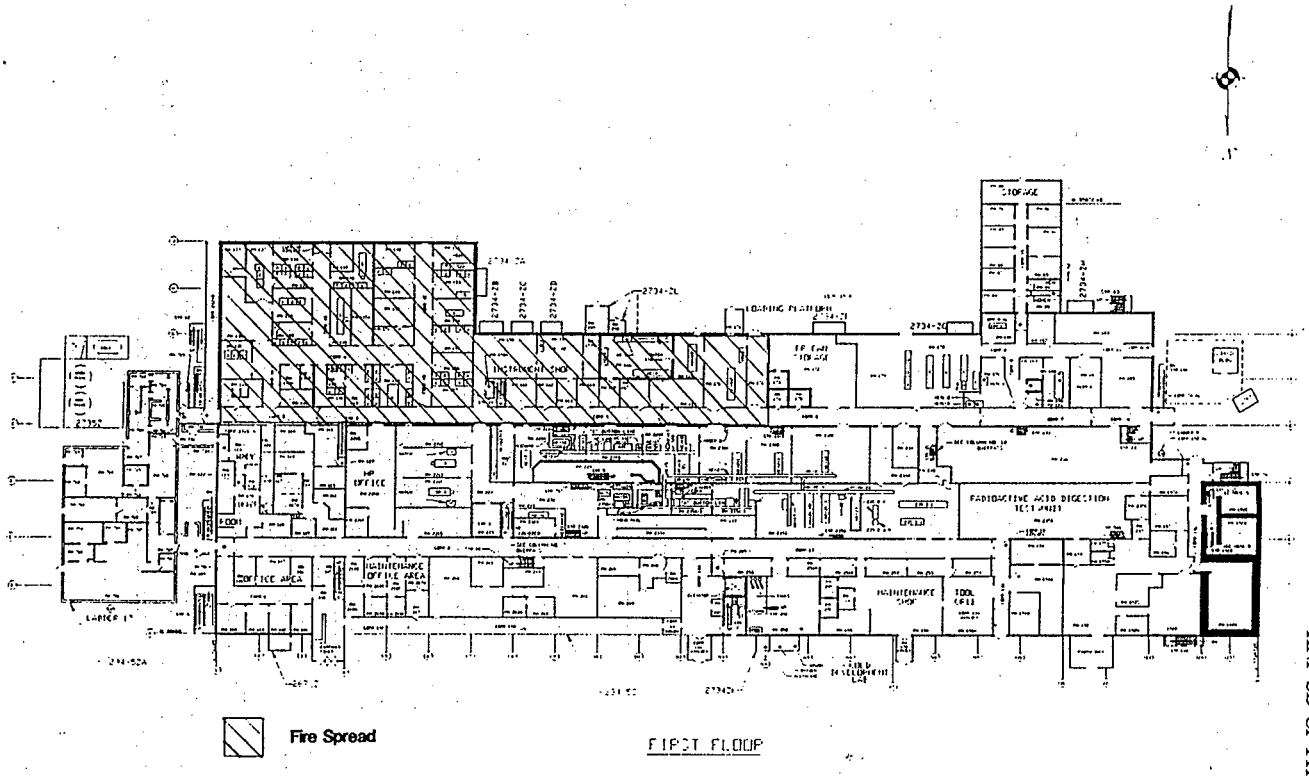


Figure 6-12 Maximum fire spread for Analytical Lab fire scenario (based on no active suppression systems)

Since Zone 3a is a contaminated zone, smoke from the fire will contaminate all zones and areas of equal and lower pressure. As discussed in Section 15.5, the smoke and combustion products resulting from a fire in this area can potentially clog the High Efficiency Particulate Air (HEPA) filters in the E-3 filter banks. This can result in contamination spreading throughout the building as the differential pressure between zones is compromised. In addition, a chance of the loss of negative pressure in the building relative to the outside exists and, therefore, a radiological release can occur. A release to the environment is expected to be minimal because there are no direct openings to the outside. However, smoke and contamination products can escape through doors, cracks, and other small openings.

The contamination area requiring cleanup is estimated for the analytical lab fire scenario by calculating the total wall, floor and ceiling area for the perimeter of each level for the entire building (i.e., the first floor, duct level, and second floor). The area of the first and second floors is tripled and the area of the duct level is doubled to conservatively account for the surface area of individual room partitions and walls. Table 6-5 shows the contamination areas by level for a fire in the analytical labs.

Table 6-5. Maximum Contamination Areas for Office Fire

Location	Contaminated Surface Area (m^2)
First Floor	48,900
Duct Level	30,400
Second Floor	45,600
Total	**124,900**

The maximum damage resulting from an office or laboratory fire in either Zone 1 or Zone 3a is fire involvement in the analytical labs. This area contains the highest concentration of expensive equipment as well as a large number of office and lab spaces close together. This area is also contaminated and results in a larger surface area requiring cleanup of radio nuclides than if the fire were located in Zone 1 or Zone 3. Structural damage is not expected based on the conservative fire scenarios considered. In order to ensure that the worst case fire scenarios have been considered for the first floor, the potential for structural damage and fire spread for a fire occurring in the glovebox process line area of Zone 3 is considered in Section 6.3.3.

6.3.2.6 Impact of Automatic Sprinkler System

The results of the previous sections assume that the automatic sprinkler system, which is installed throughout the PFP office and lab areas, does not operate. In this section, the effectiveness of the automatic sprinkler system is assessed.

DETACT-QS, as included in FPETOOL [Nelson, 1990], is used to determine the response time of the automatic sprinkler system. The heat release rate of the fire is assumed to be characteristic of a fast growing fire, which is consistent with the NBS test results presented in Section 6.3.2.4. It is assumed as a worst case scenario that the fire starts at a point which is in the center of the sprinkler spacing. Based on a ordinary hazard occupancy, the sprinklers in the office and lab spaces are installed on an approximate 3.0 m x 3.7 m (10 ft x 12 ft) spacing. This yields a maximum radial distance of 2.4 m (7.8 ft) between the fire and the closest sprinkler. The activation temperature of the sprinklers is taken to be 74°C (165°F). Because the RTI value of the actual sprinklers is unknown, a typical value of 165 $(m/s)^{1/2}$ (300 $(ft/s)^{1/2}$) is assumed. The fire is assumed to occur at the floor level and the sprinklers are located approximately 3.0 m (10 ft) above the floor.

A predicted response time of 180 seconds is calculated. At this time, the fire has grown to a size of approximately 1500 kW. Since DETACT-QS assumes an unconfined ceiling, which is not the case for the office and lab spaces, the predicted results will be conservative compared to the actual response time. Sprinkler activation within 3 minutes (i.e., 180 seconds) is expected to control the fire to the room of origin and prevent fire spread to adjacent areas. Therefore, the maximum damage resulting from a fire in an office and lab space protected by an operational automatic sprinkler system is limited to loss of contents in a single room. Depending on the location of the fire, contamination of the facility is also possible. The maximum contamination for this scenario is bounded by that described in Section 6.3.2.5.3.

6.3.3 Analysis of Glovebox Process Area Fire

6.3.3.1 Fuel Loading

The process areas located in Zone 3 contain a number of gloveboxes and hoods which typically have plastic window panels and other combustibles (See Section 7.0). The worst case scenario for the process areas is selected based on the largest concentration of gloveboxes and process equipment. The area which contains the former RMC-line, located roughly in the center of Zone 3 (Rooms 228A, 228B, and 228C), has been qualitatively identified as having highest fuel load potential. The total fuel load within this space is reported in the FSAR [WHC, 1995] as 2790 kg of wood equivalent, or approximately 5 times the estimated office/lab fuel load.

Since most of the fuel in this area consists of plastics, the wood equivalent mass is converted to a plastic equivalent mass using the method described in Section 6.3.2.3. Using this method, the heat output from 2790 kg of wood is equivalent to approximately 1000 kg plastic fuel load. While the heat output from the two different fuel loads is equivalent, the fire growth rate for cellulosic (wood) and plastic fires will be different. For the office and lab fuel loads, full-scale fire tests are used to estimate the fire growth rate based on similar fuel loads and configurations. For the process area fire, the growth rate is conservatively estimated based on literature correlations consistent with plastic fuel loadings.

6.3.3.2 Fire Scenario Development

The actual process area containing the former RMC glovebox process line consists of three rooms which are semi-connected. The total floor area of these three process rooms is approximately 126 m^2 (1350 ft^2), or about 42 m^2 (450 ft^2) per space. The distance between the plaster ceiling and the duct level floor is the smallest in this area for the three zones on the first floor. As a result, the heat transfer to the unprotected steel beams, columns, and joists within the ceiling assembly will be at a maximum in this location.

Based on the site survey, the three rooms containing the former RMC line appear to have similar fuel loadings and configurations. In this analysis, the three rooms are considered as a single compartment since they have similar fuel loads and are open to one another. In addition, the fuel load reported in the FSAR is for the three rooms as a whole. Rather than divide the fuel load evenly between the rooms and consider each room individually, the total fuel load is used based on the floor area and volume of all three rooms. Since ventilation conditions are uniform in the rooms, the effects from a fire will be equivalent.

A fire involving the gloveboxes in Rooms 228A, 228B and 228C can be characterized based on the fuel load, ventilation air supply, and room geometry. Several fire scenarios are developed and used to determine the most severe duration-temperature combination. The fuel load in this area consists primarily of the plastic window panels on the gloveboxes. The are limited amounts of other combustibles. The fire is assumed to grow quadratically as a function of time. The heat release rate versus time for a fire is calculated from the following equation [Evans, 1986]:

$$\dot{Q} = \alpha t^2 \quad (kW) \tag{6-3}$$

where Q = the heat release rate (kW),
α = the fire growth rate coefficient (kW/s^2), and
t = time (s).

The growth rate of the fire is expected to be a fast fire with α equal to 0.0469. This heat release rate is consistent with plastic based materials in various configurations [NFPA 72E, 1993]. The fire is assumed to grow at the 'fast' growth rate until either of two events occur:

(1) All fuel is consumed, or

(2) Flashover occurs within the space.

Flashover is considered the point where the fire stops growing and either declines or levels off, burning under ventilation limited conditions. This typically occurs when the room upper gas layer temperature reaches 500°C to 600°C, which is generally hot enough to ignite most combustible surfaces and results in an increase in the heat release rate to the point the fire becomes ventilation limited.

The total fuel available for combustion is estimated to be 2700 kg wood equivalent or about 1000 kg of equivalent plastic materials, as described in Section 6.3.3.1. The mass loss rate for the fuel is determined by dividing the heat release rate by the heat of combustion of the fuel and the duration is determined when the integral of the mass loss rate over time equals the total mass of fuel available (i.e., 1000 kg). The heat release rate and heat of combustion are known for the plastic fire in the process area. A fire that continues to grow at the "fast" rate and which develops without constraint requires approximately 1345 seconds (22 minutes) to consume 1000 kg of fuel. Using Equation 6-3, when all of the fuel is consumed, this corresponds to a peak heat release rate of 84,750 kW within the space. This is an unreasonable fire because of ventilation limitations, but serves as a bounding scenario. A fire in the C-Line gloveboxes will reach a ventilation limited condition before all of the mass is consumed and will burn at a steady state value depending on the ventilation until all of the fuel is consumed.

6.3.3.2.1 Ventilation

The ventilation of the process area consists of several doors and an air supply through ceiling vents. The total flow rate for the supply air is reported as 17.9 m^3/s (37,900 cfm) for all of Zone 3 [WHC, 1995]. Based on the HVAC drawings, the air flow in Zone 3 is uniform based on air changes per hour. This results in equal air flows per unit floor area of spaces with equal room heights. The rooms containing the former C-Line comprise less than 1/8 the total floor area of Zone 3. Assuming that the supply rate is proportional to the floor area in each of the rooms in Zone 3, this yields an air supply rate of approximately 2.2 m^3/s (4,660 cfm) for Rooms 228A,B,C. Since higher ventilation rates can support larger fires, the supply is conservatively assumed to be ½ the total supply to the zone, or 8.95 m^3/s (18,950 cfm) for a bounding analysis.

In addition to the supply, there are two doors connecting the space to the adjoining hallway in Zone 3a and two doors connecting the space to the adjacent Room 230A. The two doors between Rooms 228A-C and the hallway are double width and measure approximately 1.82 m wide by 2.13 m high. The remaining two doors that connect to Room 230A measure approximately 0.91 m wide by 2.13 m high.

6.3.3.2.2 Fire Growth and Duration

In order to calculate the fire effects on the structural elements, the burn duration and upper gas layer temperature over time are required. Based on the potential ventilation conditions in the process area, four different configurations are considered in order to determine the worst case upper gas layer temperature - fire duration combination. These four ventilation configurations are listed in Table 6-6.

The doors between the compartments in the process area are assumed to be open at all times. However, while the doors leading to the hallway are assumed to be open in estimating the peak fire sizes and temperatures for two of the scenarios, these doors are normally kept closed since they serve contaminated areas and are used maintain negative pressure between zones.

Table 6-6. Ventilation Configurations for Glovebox Process Area Fires

Configuration	Supply Fans	Doors to Hallway
1	On	Open
2	On	Closed
3	Off	Open
4	Off	Closed

The multi-zone computer fire model, CFAST Version 2.0.1 (Consolidated Model of Fire Growth and Smoke Transport), is utilized to appraise the potential conditions developed for the various configurations.

CFAST was developed at the National Institute of Standards and Technology (NIST) [Peacock, et al., 1991]. CFAST is capable of modeling steady or non-steady burning conditions in multiple compartment configurations. In CFAST, the initiating fire is user-specified, but internally controlled by fuel and air supply rates. The model divides each compartment into two zones in vertical relationship with the development of the fire. The two zones are an upper zone which contains a hot layer and a lower zone which is, at least initially, relatively cool. The basic equations describe the mass and energy transfer from zone to zone. Mass and energy transfer between the zones is produced by plumes, mixing at vents (connections between compartments), radiation between layers, and heat transfer at the boundary surfaces. The prime equations in CFAST are based on the application of mass and energy conservation principles (control volumes) to homogeneous upper and lower gas regions in multi-compartment systems.

The CFAST model and its predecessor, FAST, have been extensively tested. The results have been reported in peer reviewed documents. The two most applicable are "Comparing Compartment Fires with Compartment Fire Models" by Nelson and Deal [1991] and "Verification of a Model for Fire and Smoke Transport" by Peacock, Jones, and Bukowski [1993]. These analyses showed good agreement between CFAST (or FAST in the case of Nelson and Deal) and fire tests for the estimation of temperature and interface layer. There are cases of variation between the tests and the predictions of the model. In these, the upper layer temperatures predicted by CFAST are somewhat higher than experimental measurements, a conservative result.

Each ventilation configuration in the process area is modeled in CFAST to determine when the fire becomes ventilation limited. Once each fire scenario reaches steady state burning conditions, the fire is allowed to run in CFAST until the fuel is exhausted while burning at the steady state heat release rate. After the fire becomes ventilation limited, a 75 percent burning efficiency is used as decribed in Section 6.3.2.4. A copy of the CFAST input data is provided in Appendix C.

The duration of the fire after it has become ventilation limited is calculated from:

$$t_d = \chi_b \frac{(m_t - m_L)\,\Delta H_C}{\dot{Q}} \tag{6-4}$$

where
χ_b = the burning efficiency (0.75),
m_t = the total fuel mass available (1000 kg plastic),
m_L = the mass lost during the fire growth as calculated from the fast fire growth equation, and
ΔH_c = the heat of combustion for plastic (38000 kJ/kg).

Table 6-7 shows the fire characteristics for each configuration and Figure 6-13 shows the upper gas layer temperature versus time for each case as predicted using CFAST. Although CFAST is a pre-flash over model and each configuration flashes over, the model is only used to determine the average upper gas layer temperature. Since the layer drops almost to the floor, this reduces to an energy balance where the model is injecting a known quantity of energy into the layer and calculates the heat transfer losses to the wall and the resulting temperature rise of the gas layer.

Table 6-7. Fire Characteristics Glovebox Process Area Fires

Configuration	Time to Ventilation Controlled Burning (s)	Mass Lost During Growth (kg)	Steady State Heat Release Rate (kW)	Burn Time at Steady State (s)	Peak Upper Gas Layer Temperature (°C)
1	864 (14.4 min)	265	35000	599 (10.0 min)	1028
2	669 (11.2 min)	123	21000	1190 (20.0 min)	854
3	786 (13.1 min)	200	29000	786 (13.1 min)	966
4	584 (9.7 min)	82	16000	1635 (27.3 min)	770

6.3.3.3 Effects of Glovebox Process Area Fire

A fire in the area containing the former RMC glovebox process line is expected to be the worst case fire scenario for all areas within Zone 3. This is due to the high fuel load in the space compared to other areas, and also the small distance between the plaster ceiling and the unprotected structural elements in the ceiling assembly. Since a fire in this zone will not contaminate a greater area than the fire scenario considered for the analytical labs (Section 6.3.2), only two issues are considered. First, does the larger fire size and smaller separation between the unprotected structural elements and the light fixture in the ceiling present a structural danger; and second, what is the largest area expected for fire involvement?

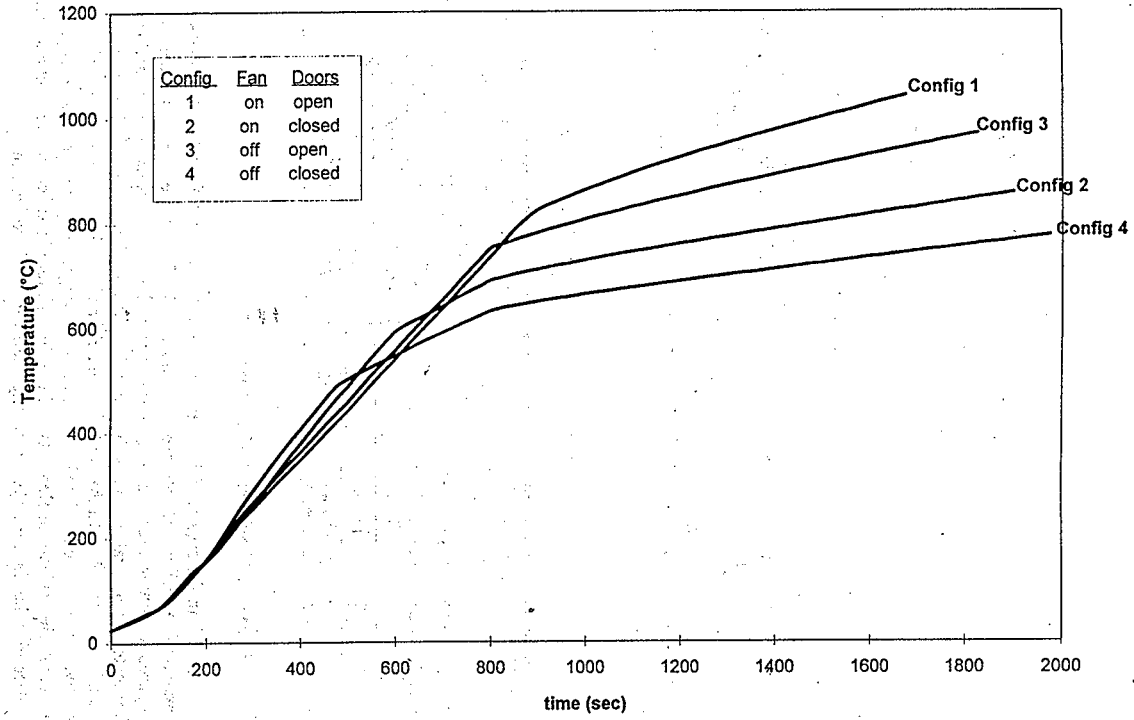


Figure 6-13 Upper gas layer temperature results for process area fire scenarios

6.3.3.3.1 Column Analysis

The structural analysis for the fire is performed in a similar manner as for the areas in Zone 3a (i.e., the analytical labs, Section 6.3.2). The columns in the process area are assumed to be exposed to direct flame impingement for the duration of the fire. As with other areas of the PFP, the lightest column member is W14x26 protected by 1.91 cm (3/4 in.) plaster. Based on the fire durations presented in Table 6-7, the longest fire in the process area, including the growth period and steady burning, is approximately 37 minutes (configuration no. 4). As seen in Figure 6-8 in Section 6.3.2.5.1, the maximum and average temperatures of the column do not exceed the ASTM E-119 criteria within 37 minutes. Therefore, structural failure of the columns is not expected.

6.3.3.3.2 Ceiling Assembly/Joist Analysis

The exposure to the unprotected elements in the ceiling assembly is done similar to the analysis in Section 6.3.2. As with the analytical labs fire scenarios, a SJ126 joist is used as the lightest structural member. However, the separation distance between the ceiling and the joist member is much smaller for this scenario: 0.22 m between the lower angle and the light fixture, 0.37 m between middle bar and the light fixture, 0.52 m between the top angle and the light fixture.

The resulting radiation configuration factors, assuming that all portions of the joist elements are directly over the center of the light fixture are 0.81 for the lower flange, 0.63 for the middle bar, and 0.50 for the upper bar (Equation 6-2). The upper gas layer temperature curves that are calculated in section 6.3.3.2.2 using CFAST are used to approximate the exposure temperature rather than assuming a constant peak post flashover temperature. This is because the space will not reach flashover conditions as rapidly as the smaller offices and labs considered earlier. In addition, given the smaller spacing of the ceiling assembly, a slightly less conservative approach is followed. The boundary conditions are otherwise the same as with the joist calculation in Section 6.3.2.5.

Figure 6-14 shows the joist average and peak temperatures for the worst-case ventilation conditions (i.e., doors open, fans on). In all cases, the peak temperature and average temperature are below the ASTM E-119 failure criteria for joists (i.e., 704°C and 537°C, respectively). Since the fire scenarios postulated in the process area are worst case fire scenarios within Zone 3, structural failure of the ceiling assembly is not expected.

6.3.3.3.3 Fire Spread and Involvement

The maximum area of fire involvement resulting from a fire in the glovebox process area is shown in Figure 6-15. No involvement is expected into Room 236 because of the absence of combustibles as observed during the site visit. The wall between Room 235B and the Radioactive Acid Digestion Test Unit is plaster on metal lath that without penetrations will have at least a 1 hour rating. Although small penetrations will permit smoke and contamination spread, they are considered too small to permit flame spread. In addition, there are limited

combustibles in the Radioactive Acid Digestion Test Unit area to permit fire spread. Finally, the fire is not expected to travel to room 224 for similar reasons. The wall between Room 227 and Room 224 is the same plaster on metal lath, and the space between Rooms 233 and Room 224 (Room 232) is essentially a hallway/stair area without any combustibles for spread. The length of this section is about 12 m. Thus, the area of fire involvement is confined to the C-Line and A-line of the glove boxes and to several adjoining office and laboratory spaces. The concrete walls are expected to limit fire spread as discussed in Section 6.3.2.5.3.

6.3.3.4 Impact of Automatic Sprinkler System

The results of the previous sections assume that the automatic sprinkler system, which is installed throughout the RMC process area, does not operate. In this section, the effectiveness of the automatic sprinkler system is assessed.

DETACT-QS, as included in FPETOOL [Nelson, 1990], is used to determine the response time of the automatic sprinkler system. The heat release rate of the fire is based on the growth rate described in Section 6.3.3.2 for the process area fuel load. It is assumed as a worst case scenario that the fire starts at a point which is in the center of the sprinkler spacing. Based on an ordinary hazard occupancy, the sprinklers in the process area are installed on an approximate 3.0 m x 3.7 m (10 ft x 12 ft) spacing. This yields a maximum radial distance of 2.4 m (7.8 ft) between the fire and the closest sprinkler. The activation temperature of the sprinklers is taken to be 74°C (165°F). Because the RTI value of the actual sprinklers is unknown, a typical value of 165 $(m/s)^{1/2}$ (300 $(ft/s)^{1/2}$) is assumed. The fire is assumed to occur at the floor level and the sprinklers are located approximately 4.9 m (16 ft) above the floor.

A predicted response time of 215 seconds is calculated. At this time, the fire has grown to a size of approximately 2,150 kW. Since DETACT-QS assumes an unconfined ceiling, which is not the case for the process area, the predicted results will be conservative compared to the actual response time. Sprinkler activation within 3-4 minutes (i.e., 215 seconds) is expected to control the fire to the process area and prevent fire spread to adjacent areas. Therefore, the maximum damage resulting from a fire in the RMC process area with automatic sprinkler actuation is limited to the loss of contents in the process area. Fire involvement of the gloveboxes is expected to be controlled prior to breaching the glovebox window panels. Therefore, fire spread through the gloveboxes does not occur (see Section 7.0).

6.3.4 Analysis of Hydraulic Oil Fire in Room 321

The most severe fire exposure on the second floor of Building 234-5Z results from a breach of the hydraulic elevator pump, piping, or reservoir located in Room 321 between column Ba-14 and the elevator. This scenario can potentially result in 568 liters (150 gallons) of hydraulic oil spilling on the floor in Room 321 with subsequent ignition. The oil is used in the elevator hydraulic lift and the amount which can potentially spill in Room 321 will depend on the location of the elevator. As a worst case scenario, all 568 liters (150 gallons) is assumed to spill and ignite.

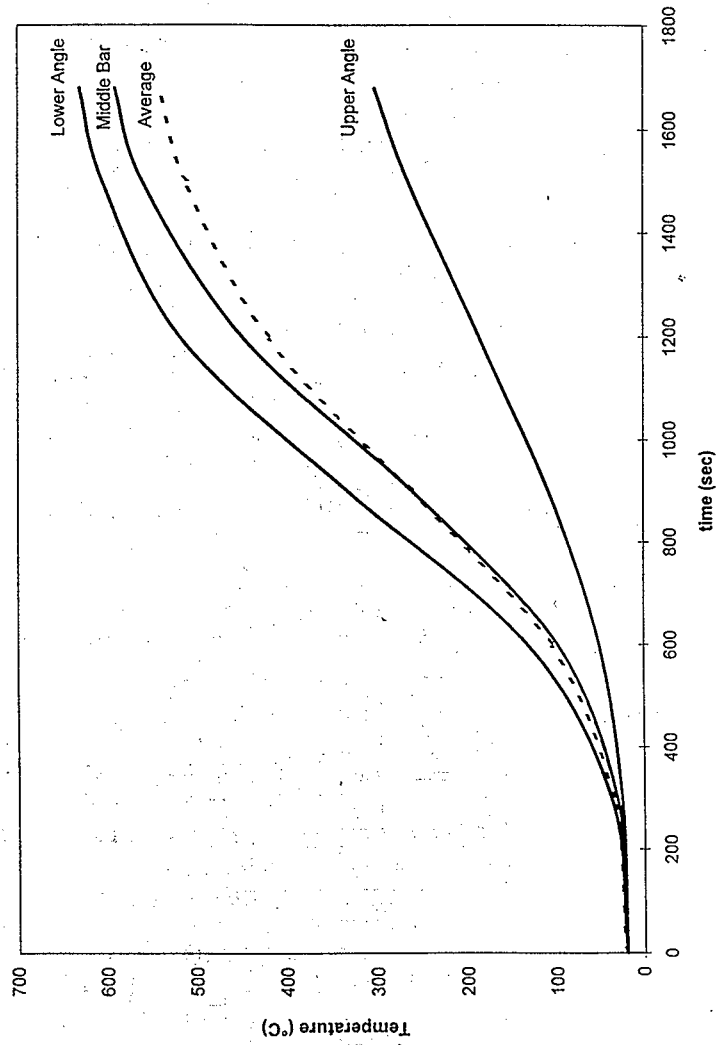


Figure 6-14 Time-temperature results for joist exposure (process area fire scenario)

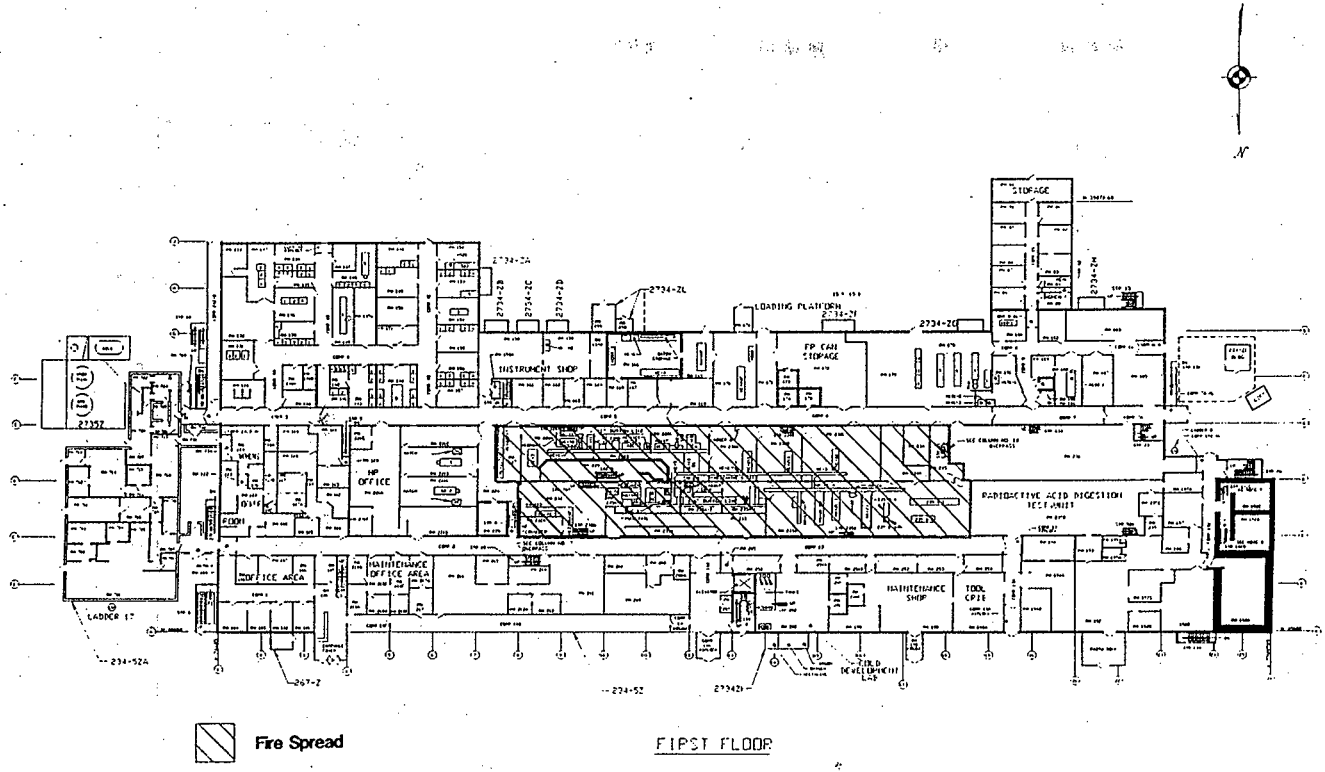


Figure 6-15 Maximum fire spread for RMC Process Area fire scenario (based on no active suppression systems)

The concerns for the analysis of the fire include the extent of structural damage to the building and the degree of fire propagation resulting from the initial fire event. The thermal exposure to the structural elements in the building is estimated in two ways. The first approach is to calculate the potential hazards, using zone fire models, to estimate the average upper gas layer temperature. The second is to estimate the direct exposure of the structural members located within the spill fire. Based on the degree of structural damage and the available fuel load, the maximum extent of fire propagation can be determined.

6.3.4.1 Fire Development

The size of the fire will depend on the rate at which the fuel is spilled and the area in which the oil spreads out over the floor. Since there are no barriers to confine the hydraulic oil spill, the geometric size of the fire is not well defined and can vary significantly. In order to determine the maximum impact of the fire on the fan room, a range of fire sizes are chosen and evaluated. Table 6-8 summarizes the pool fires used in this analysis. In this analysis, all spill configurations are assumed to be circular; however, the actual configuration can have a variety of geometric shapes. Changing the shape of the pool fire for a constant surface area does not affect the total heat output from the fire and does not change the overall results of this analysis.

Table 6-8. Pool Fire Characteristics

Diameter (m)	Area (m^2)	Mass Loss Rate (kg/sec)	Heat Release Rate (MW)	Fire Duration (min)
3.0	7.1	0.31	13.1	25.6
4.0	12.6	0.55	23.3	14.5
5.0	19.6	0.86	36.3	9.3
6.0	28.3	1.25	52.4	6.7

For each of the postulated fire scenarios, the computer fire model CFAST is used to estimate the conditions in the fan room. Figures 6-16, 6-17, and 6-18 show the heat release rates, upper gas layer temperatures, and layer interface heights as estimated by CFAST for each of the four scenarios, respectively. The 13.1 MW fire is the only configuration of the four which does not reach ventilation controlled conditions. The larger fires reach their maximum heat release rates and begin to decay as oxygen becomes limited in the room. As seen in Figure 6-17, the 52.4 MW fire yields the maximum upper layer temperature of approximately 420°C. This is below the 500-600°C temperature criteria typically used to determine flashover in a compartment. Therefore, flashover conditions are not expected in the fan room.

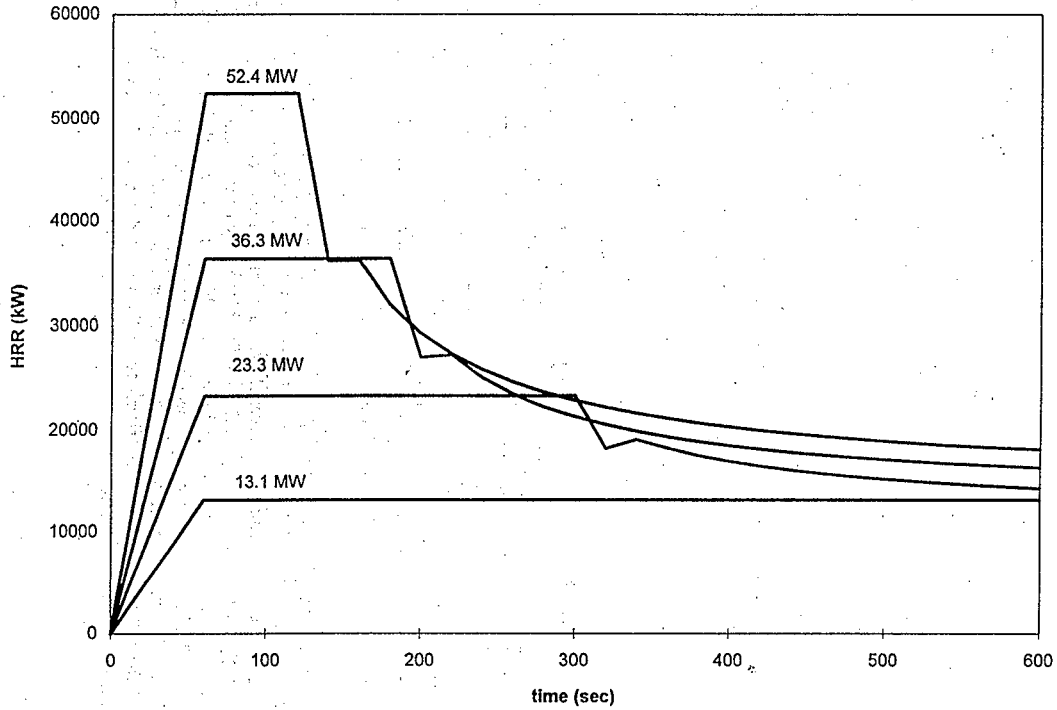


Figure 6-16 Heat release rate results for hydraulic oil spill fire scenario (room 321)

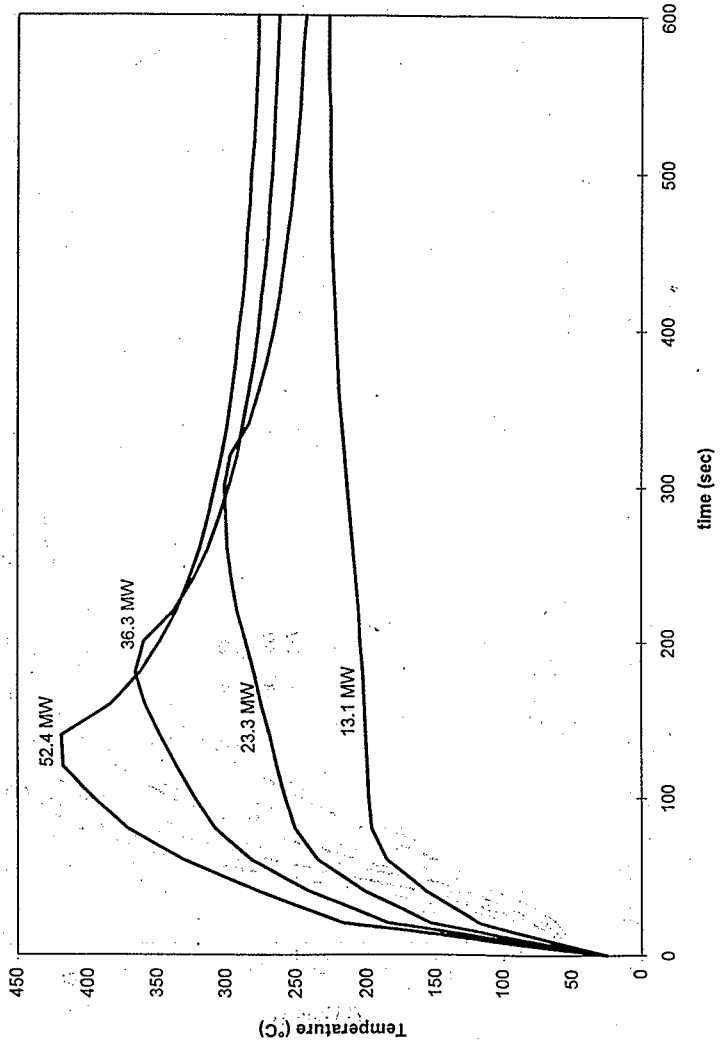


Figure 6-17 Upper gas layer temperature results for hydraulic oil spill fire scenario (room 321)

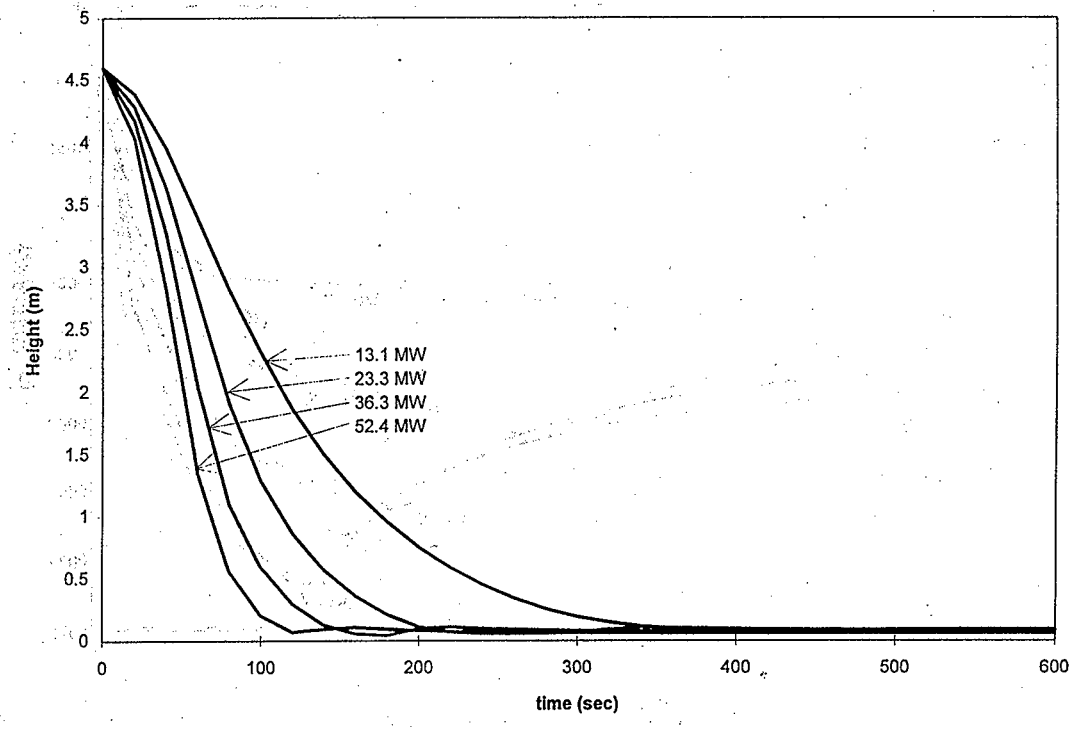


Figure 6-18 Layer interface height results for hydraulic oil spill fire scenario (room 321)

Figure 6-18 indicates that the hot gas layer descends to the floor within 5 minutes for all four fire configurations. Therefore, all equipment (including the fans) in the room will be exposed to elevated temperatures during the fire. Typically, temperatures on the order of 175-250°C are sufficient to cause electrical damage resulting in equipment failure. While the upper gas layer temperatures for the various spill configurations are not sufficient to cause damage to structural members, the temperatures are expected to thermally damage all of the equipment in the fan room.

6.3.4.2 Localized, Direct Exposure of Structural Elements

Most of the structural members on the second floor are exposed steel. Several of these unprotected columns and beams will be directly exposed to the pool fire for this scenario. Typically, steel will begin to lose its structural integrity at temperatures of about 600°C (~1100°F). ASTM E-119 [1993], which is used to determine fire-resistive properties of materials and assemblies, specifies that no singe point on the steel column can exceed 649°C (1200°F) and the average temperature cannot exceed 537°C (1000°F) during the fire exposure. As such, once the thermal exposures are known, heat transfer models can be applied to the structural elements in order to determine the possibility of reaching critical failure temperatures.

The response of the exposed column members to spill fire is modeled using a two-dimensional finite volume heat transfer model. The finite volume heat transfer software STAR*CD [1994] is used to solve the time-dependent two-dimensional heat transfer equations. In essence, this program determines a temperature distribution within a modeled structure resulting from a heat flux of elevated temperature imposed on the boundary of the structure. The resulting temperature distribution is a function of the thermophysical properties of the assembly (i.e., conductivity, density, and specific heat).

A direct flame impingement exposure is estimated based on an average flame temperature of 1000°C and flame emissivity of 0.8. This temperature and emissivity provide an incident flame heat flux of approximately 120 kW/m^2 to the column surface, which based on test data conservatively represent heat fluxes measured within the flame region (see Table 6-3). As with the earlier column analysis, the lightest structural member is used in the model (i.e., W14x26).

Figure 6-19 shows the boundary conditions for the exposed columns. The maximum single point and average steel temperatures for the column as determined using STAR*CD are shown in Figure 6-20. It is seen that the steel temperatures exceed both the ASTM E-119 single point and average temperature criteria within 1-2 minutes.

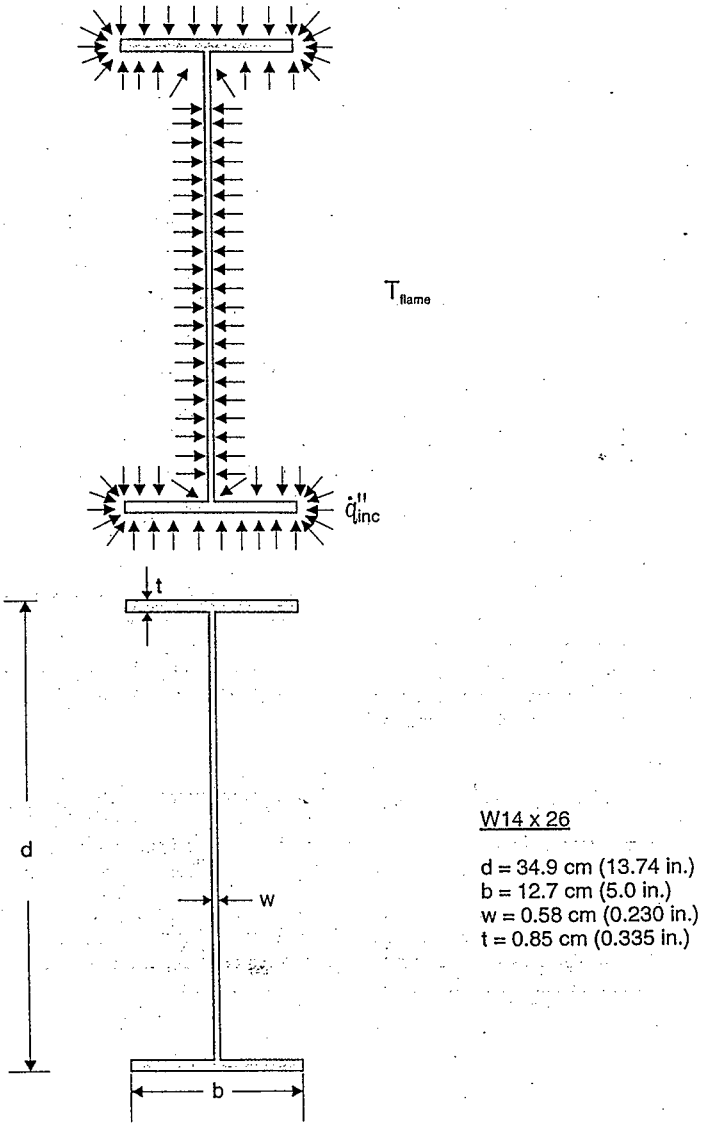


Figure 6-19 Boundary conditions for W14x26 exposed column exposure

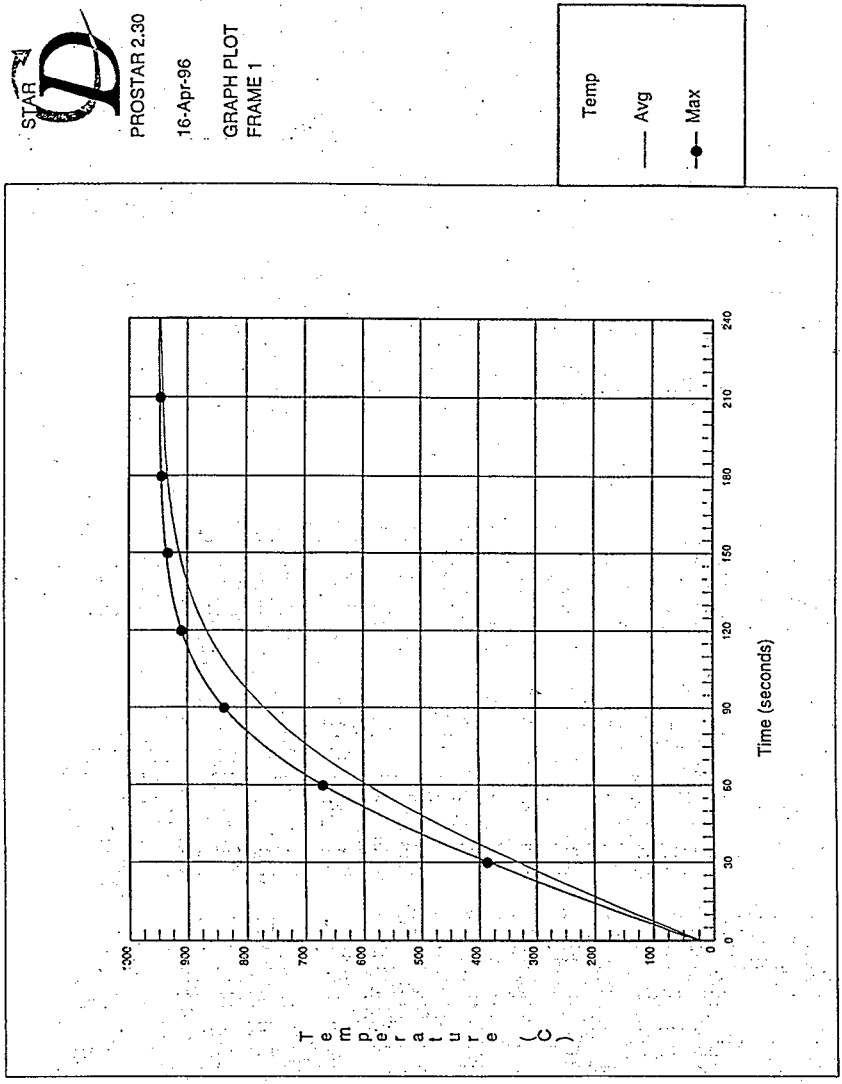


Figure 6-20 Time-temperature results for W14x26 exposed column exposure

For direct fire exposures, steel columns will typically exceed failure temperatures within 2 to 5 minutes. The estimated failure time predicted using the heat transfer software is somewhat faster than this because conservative assumptions are made regarding flame heat flux and column dimensions. Even so, the pool fire durations, as seen in Table 6-8, are sufficient to cause structural failure to exposed column members. As a conservative estimate, it is assumed that exposed columns can withstand no more than a two minute hydrocarbon pool fire exposure. The maximum number of columns which can fail is determined by the largest size fire which will consume all 568 liters of fuel in 2 minutes. This corresponds to a 90 m^2 (970 ft^2) spill configuration having an equivalent diameter of 10.7 m (35 ft). Whereas a number of spill configurations are possible, a circular spill centered at column Ba-15 will expose and fail columns A-14, A-15, A-16, Ba-14, Ba-16, and C-16.

Column failure resulting from direct flame exposure can potentially result in collapse of the ceiling assembly. This can have several impacts on the facility. For one, collapse of the roof can provide an opening to the exterior. If areas of contamination are involved in the fire, this provides a means for spreading contamination to the outside. Second, failure of the columns and ceiling assembly can potentially cause the walls separating adjacent areas, including the backside of the facility, to collapse. This can allow the fire to spread to these areas if combustibles are present.

6.3.4.3 Fire Spread and Damage

Office and storage areas adjacent to the fan room contain combustible materials including typical office supplies, storage boxes and crates, paper goods, and miscellaneous plastic materials. This fuel load provides a means for propagating the fire beyond the fan room. All of the partition walls are constructed of plaster on metal lath and contain miscellaneous penetrations. Further, local failure of the roof assembly in the fan room can potentially violate the partition walls. Therefore, the passive fire protection features in this area are not considered.

The fire can spread throughout much of the front side of the second floor. The extent of fire spread is expected to involve all of room 321 and the offices and spaces along corridor 31. Unprotected columns and beams in the office areas will also likely exceed failure temperatures, and can potentially result in additional structural failure. This will provide additional openings to the exterior and result in additional damage to partition walls and assemblies. The fire can continue to spread west until it reaches the 1-hour fire wall protecting room 304 (i.e., the Plastics/Supply Shop). Since office fires are not expected to burn longer than 30 minutes (see Section 6.3.2.4), the fire is not expected to penetrate the 1-hour fire wall.

Structural failure of columns and roof assembly can potentially collapse the wall separating the front side from the back side. This allows fire spread into areas which are potentially contaminated. Since there are limited combustibles (almost none) in the backside of the second floor, the fire is expected to be contained primarily to the front side. However, as a worst case analysis, the walls enclosing the E-4 filter banks are assumed to collapse, thus exposing the contaminated HEPA filters to the fire. It should be noted that fire spread to this area is unlikely but is considered in order to evaluate the consequences of such an event.

The filter boxes on the backside of the second floor (e.g., room no. 308) are also contaminated. However, they are further from the fire than the filter rooms and there are no combustibles to allow fire propagation to the filter boxes. Therefore, while structural collapse of the roof assembly may breach and expose the filter boxes, their contents are not expected to become involved in the fire.

Figure 6-21 shows the extent of fire spread and damage resulting from this scenario. Fire spread is primarily contained to the front side of the floor. However, given the large number of column and beam failures expected as a result of the direct flame exposures, structural collapse of the entire roof assembly can not be precluded. Contamination resulting from the fire will include the entire second floor and release to the environment through the breached roof assembly. The total floor, ceiling, and wall surface area which will require cleanup on the second floor is approximately 15,200 m^2 (163,650 ft^2). The extent of contamination to the outside is assessed in Section 15.2.

6.3.4.4 Impact of Automatic Sprinkler System

The results of the previous sections assume that the automatic sprinkler system installed throughout the PFP facility does not operate. In this section, the effectiveness of the automatic sprinkler system in controlling the hydraulic oil spill fire is assessed.

A combustible liquid oil fire presents a special problem in that the water flowing from the sprinklers may carry the floating burning liquid from the source to other areas in the space. Therefore, while sprinkler activation will occur during the first several minutes of the fire, the sprinklers are not expected to fully control the spill fire. As a result, thermal damage and fire spread in the fan room can occur.

Although automatic sprinkler protection in the fan room is not expected to extinguish the liquid pool fire, sprinklers in adjacent spaces will prevent fire spread throughout the second floor. In addition, while the pool fire can spread out and continue to burn following sprinkler actuation, the cooling effect of the water is expected to prevent significant damage to the structure. Therefore, the maximum damage resulting from the hydraulic oil spill fire is limited to loss of contents in the fan room and localized structural damage resulting from the pool fire exposure. Since automatic sprinkler protection contains the fire to within the fan room, there is no contamination resulting from this scenario.

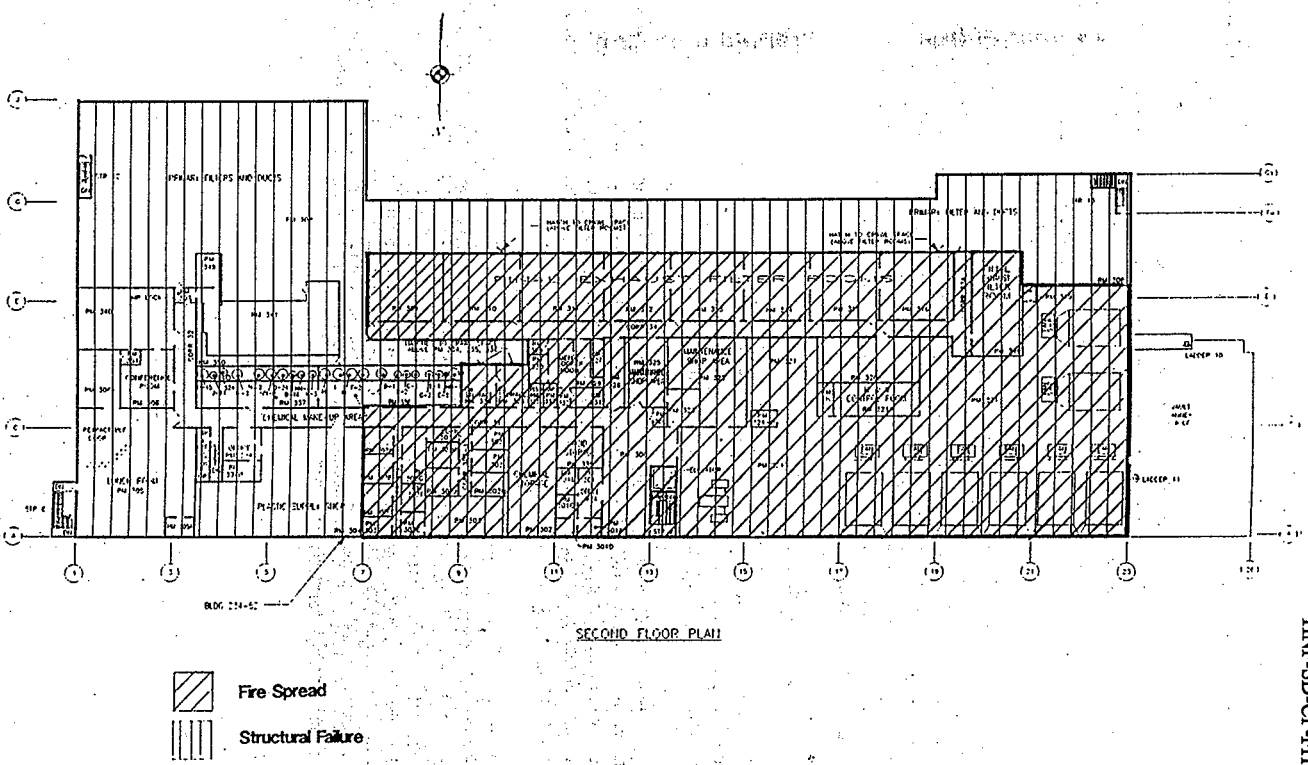


Figure 6-21 Maximum fire spread and structural damage for hydraulic oil spill fire scenario (based on no active suppression systems)

6.3.5 Analysis of Hydrogen Generation in Plutonium Storage Rooms

The largest plutonium solution storage area in Building 234-5Z is Room 236. Hydrogen generation data for stored plutonium solutions in Room 236 was provided by WHC [Genoni and Washburn, 1985]. The data reflects a bounding analysis based on the storage of plutonium nitrate solutions. The analysis assumes that the plutonium concentration in the plutonium nitrate solution is 450 g per liter and 8.5 to 10 liters of solution are stored per container. In reality, the concentrations are maintained at about 350 grams per liter to reduce solids formation [Rodgers, 1996]. An analysis is performed to determine if a flammable concentration of hydrogen can be generated in the storage room. The lower flammable limit (LFL) for hydrogen gas in air is 4.0% volume [Beyler, 1988].

The bounding hydrogen generation rate calculated in the WHC analysis [Genoni and Washburn, 1985] is 0.82 liter per week per container. Since the containers are vented to the room, the maximum volume of hydrogen introduced into the room is 0.82 liter per week per container. The maximum number of containers in Room 236 at any one time is 378 [Rodgers, 1996]. As such, the maximum volume of hydrogen introduced into the storage room is 310 liters per week or 44.3 liters per day. Because of the high diffusion rate of hydrogen and the layout of the drums on the floor, any hydrogen mixture generated in the space will be well mixed. Therefore, only well mixed hydrogen environments are considered in this analysis.

Under normal conditions, the air flow rate through Room 236 is 193 m^3/min (6800 cfm) [Rodgers, 1996]. The steady state hydrogen concentration is calculated using the following equation:

$$\%H_2 = \frac{H_2 \textit{ generation rate}}{\textit{ventilation rate}} \times 100 \qquad (6\text{-}5)$$

where the H_2 *generation* rate is 44.3 liters/day or 3.076×10^{-5} m^3/min, and
the *ventilation rate* is 193 m^3/min.

Substituting into Equation 6-5 yields a steady state hydrogen concentration of 0.000016%. This is much less than the LFL of 4.0% for hydrogen. Therefore, assuming a well mixed hydrogen mixture, it is not credible to generate a flammable concentration of hydrogen in the room while the ventilation system is operating under normal conditions.

If the ventilation system is not operating, the hydrogen generated in the plutonium solution storage containers can vent to the room and accumulate. Over time, this may result in an explosive concentration of hydrogen. Assuming that the room is completely sealed and no leakage occurs, the time dependent average hydrogen concentration in the room is estimated using the following equation:

$$\%H_2 = \frac{H_2 \text{ generation rate} \times \text{time}}{\text{room volume}} \times 100 \qquad (6\text{-}6)$$

In order to determine the time needed to generate a flammable concentration of hydrogen in the room, the LFL (e.g., 4.0%) for hydrogen is substituted for the $\%H_2$ in Equation 6-6. Room 236 has nominal dimensions of 7.9 m x 30.5 m x 5.9 m (26 ft x 100 ft x 19.5 ft). This yields a room volume of approximately 1,422 m^3 (50,700 ft^3). Solving Equation 6-6 for time, using a H_2 generation rate of 0.0443 m^3/day, indicates that a period of 1,284 days is required to generate a flammable concentration of hydrogen in the storage room. Again, this assumes that the room is completely sealed and the hydrogen mixes throughout the room. In reality, leakage will occur through the walls, doors, and cracks in the room; thus resulting in a lower hydrogen concentration.

Another possible hazard associated with the plutonium storage is the potential to accumulate an explosive concentration within the sealed containers. Since the containers are normally vented, this scenario assumes failure or omission of the vent. The free space volume of the drum containers is approximately 189 liters [Genoni and Washburn, 1985].

In order for damage to occur as a result of hydrogen generation in a single container, a detonable atmosphere is necessary. For a detonation to occur, hydrogen concentrations on the order of 10 to 15 percent in air are required [Dorofeev, et al., 1996]. As a conservative estimate, a detonation hydrogen concentration of 10 % volume is assumed. Substituting into Equation 6-1 with a $\%H_2$ concentration of 10%, a hydrogen generation rate of 0.82 liters/week, and setting the room volume equal to the free volume in the container (i.e., 189 liters) yields a time period of 23 weeks or 161 days. Therefore, containers which are not vented can accumulate hydrogen concentrations which can potentially result in a detonation.

The maximum pressure rise resulting from a detonation is estimated in order to determine its impact on the room and the facility. The maximum local pressure at the completion of combustion for the hydrogen-air mixture is estimated using the following equation [Zalosh, 1988]:

$$\frac{P_m}{P_o} = \frac{T_{ad}}{T_o} \qquad (6\text{-}7)$$

where P_m = maximum pressure at completion of combustion,
P_o = initial pressure prior to ignition,
T_{ad} = adiabatic flame temperature of the hydrogen-air mixture, and,
T_o = initial temperature of the propane-air mixture.

Since a stoichiometric hydrogen-air mixture has the highest adiabatic flame temperature, and will result in the maximum pressure rise, it is assumed that stoichiometric concentrations

coated with Butvar prior to the area being sealed. The fire performance of the Butvar is unknown since both combustible and noncombustible forms of the material exist and there is no documentation stating which type was used in 242-Z. However, based on the facility being sealed with welded doors and caulking, the space being unoccupied, sprinkler protection being provided and being capable of protecting the entire area of concern, and the fuel load specified by facility staff and the FSAR, the interior finish is not a concern.

Since detailed information regarding fuel loading and potential fire hazards was not available for within the 242-Z facility, the fire hazard identified for 242-Z is the exposure hazard from a fire in the annex (i.e., TC-66) located along the west wall of the building. TC-66 is constructed of corrugated metal walls and roof and provides enclosed access to Building 242-Z. Currently the structure is used to store rolls of plastics and cardboard boxes. During the site visit, there were approximately 120 rolls of plastic each having a mass of approximately 45 kg (100 lb). The plastics generally consisted of fire retardant polyvinyl chloride (PVC), polyethelenes, and vinyl/nylon laminate fabrics.

6.4.2 Analysis of Fire Scenarios

Although the plastics in the storage area are fire retardant, they will readily burn if exposed to an external heat source. A fire involving cardboard boxes or other transient combustibles in the space can ignite the plastic rolls and provide the necessary heat input to burn the fire retardant plastics. Once the fire begins to grow, radiant feedback from the flames and hot gas layer will continue to spread the fire throughout the storage area.

Cone calorimeter test results for fire retardant PVC yield peak heat release rates of approximately 60 to 120 kW/m^2 for external heat fluxes ranging from 20 to 70 kW/m^2, respectively [Babrauskas and Grayson, 1992]. Small fires involving ordinary combustibles which impinge upon the plastic rolls will easily provide heat fluxes in the range of 20 to 70 kW/m^2. As an estimate of heat release rate, a value of 120 kW/m^2 is assumed for the fire retardant plastics.

The heat release rate resulting from a fire involving the plastic rolls is dependant on the storage configuration of the rolls and the actual surface area of the fuel involved in the fire. The total mass of the plastic will impact the burning duration but will not effect the overall heat release rate. In general, the rolls were stacked horizontally on top of one another with the stacks occupying approximately 40 to 50 percent of the total floor area. The storage annex has approximate dimensions of 6 m x 11 m (20 ft x 35 ft). For this scenario, it is estimated that the plastic rolls occupy 50 percent of the floor area. This yields a maximum possible heat release rate of 4.0 MW (33 m^2 x 120 kW/m^2) assuming unlimited oxygen supply.

Figure 6-22 shows the layout of TC-66. An airlock is located in the northeast corner which leads directly into the 242-Z Building. the upper portion of the east wall of TC-66 is the exterior wall of the 242-Z Building. This presents an exposure hazard to the 242-Z facility. An analysis is performed to determine the potential fire intensity and burning duration in the storage annex. With this, the exposure and fire spread potential to the 242-Z Building is assessed.

exist. The stoichiometric adiabatic flame temperature for hydrogen is 2380 K [Zalosh, 1988]. For an initial room temperature of 295 K and initial pressure of 101 kPa (14.7 psia), Equation 6-7 yields a maximum pressure of 815 kPa (118 psia) or a maximum pressure rise in the container of 714 kPa (103.3 psig). The maximum pressure rise in the room, ΔP_{rm}, is approximated as follows [Zalosh, 1988]:

$$\Delta P_{rm} = \left(\frac{V_{can}}{V_{rm}}\right) \Delta P_{\max} \tag{6-8}$$

where V_{can} = the volume of the plutonium storage container (0.189 m^3),
V_{rm} = the volume of the storage room (1422 m^3), and
ΔP_{max} = the maximum local pressure rise in the drum (714 kPa).

Solving Equation 6-8 yields a maximum pressure rise of approximately 0.095 kPa (0.014 psig). This pressure rise corresponds to a hydrogen deflagration. For detonations, which can occur at higher hydrogen concentrations (e.g., greater than 10 percent volume), peak pressures are approximately four times those resulting from a deflagration. Therefore, the maximum pressure rise due to a hydrogen detonation is on the order of 0.38 kPa (0.06 psig). PFP 234-5Z Building Wall Panel Testing [WHC, 1989] shows that simulated PFP wall panels can survive a maximum pressure rise of 3.4 kPa (0.49 psig). Therefore, while a detonation can result in metal shrapnel fragments which can cause local damage in the room, the resulting shock wave is not expected to cause failure of the room walls or ceiling assemblies.

6.3.5.1 Impact of Automatic Sprinkler Protection

Because of the rapid nature of a detonation resulting from a flammable hydrogen-air mixture, automatic sprinkler protection will not prevent the immediate damage resulting from the detonation. Since the detonation in the storage room does not cause structural damage to the facility and the fire is expected to be contained to within the storage room due to the limited fuel load, automatic sprinklers provide little to no benefit in the area of the detonation. In the event that a fire did develop in the storage room, the sprinkler protection would help limit the damage resulting from the fire. However, even without the sprinklers, the fire is expected to be contained to within the storage room.

6.4 BUILDING 242-Z

6.4.1 Fuel Loading

Building 242-Z was not accessible at the time of the site survey because the building has been sealed shut and is inaccessible. Based on facility staff input and FSAR, the fuel loading in the facility is similar to the miscellaneous treatment room (room 41) in Building 236-Z (see Section 6.5.1). This includes gloveboxes and process equipment with little to no transient combustibles in the room. In addition to the room contents, the interior surfaces of 242-Z were

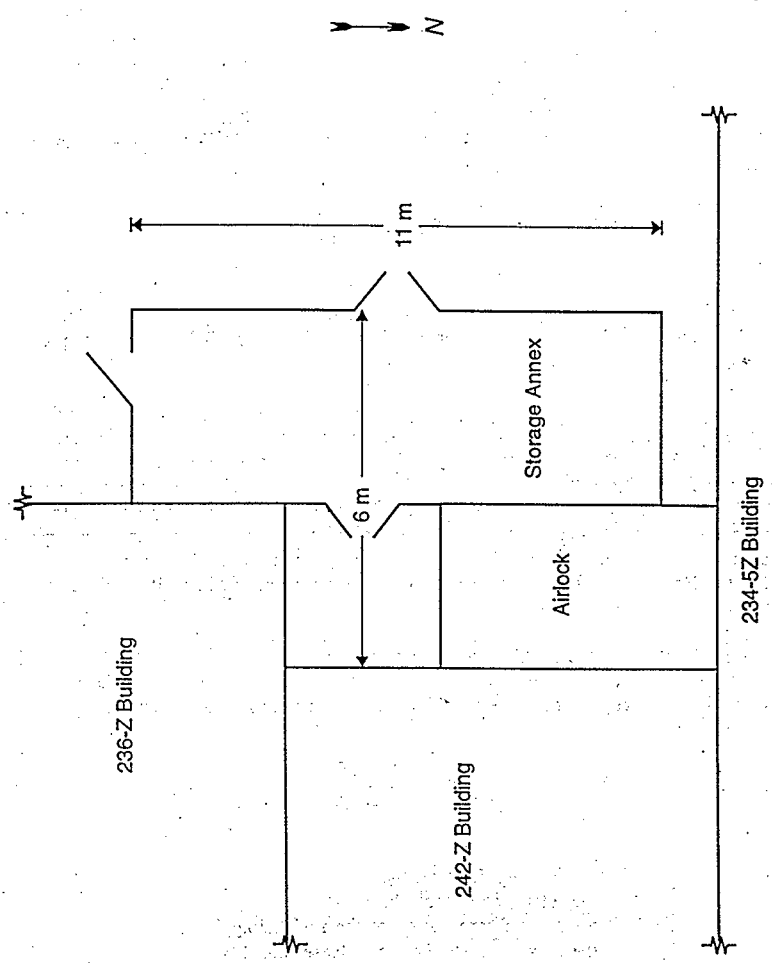


Figure 6-22 TC-66 storage annex layout

The CFAST [Peacock et al., 1993] computer model is used to estimate the peak heat release rate and temperature history in the storage compartment. It is assumed that the south door of the facility is open, thus providing oxygen to the fire. The growth rate of the fire will depend on the ignition source, specific configuration of the plastic rolls, and thermal properties of the materials. Plastic rolls stacked horizontally will have a slower growth rate than rolls stacked vertically. It is estimated that the fire growth rate is characteristic of a fast growing fire [NFPA 72E, 1993]. During the growth period, the heat release rate is a function of time and is given as [Evans, 1986]:

$$\dot{Q}(t) = 0.047\ t^2 \quad [kW,\ s] \tag{6-9}$$

At this growth rate, it takes approximately 5 minutes to reach the maximum heat release rate of 4.0 MW (assuming unlimited oxygen supply). A copy of the CFAST input data is provided in Appendix C.

Figures 6-23 and 6-24 show the heat release rate and temperature results for the storage room fire. The fire becomes ventilation limited reaching a steady heat release rate of approximately 3,650 kW. The potential for a space to flashover provides an indication of the severity of a fire in the space. Flashover typically occurs when upper layer temperatures exceed 500-600°C. If flashover occurs, all exposed combustibles in the room will ignite. In addition, flashover temperatures can cause failure of structural steel assemblies if the exposure is prolonged long enough. As seen in Figure 6-24, temperatures in the space reach flashover conditions within 10 minutes. Because the fire is ventilation limited at this point, the intensity of the fire does not significantly increase.

Because the purpose of this analysis is to determine the exposure to the 242-Z Building, it is desirable to know the burning duration of the fire. The burning duration is estimated based on the maximum steady heat release rate of the fire using the following equation:

$$t_b = \frac{m\ \Delta H_c}{\dot{Q}_s} \tag{6-10}$$

where
- t_b = the burning duration (s),
- m = the total mass of fuel (kg),
- ΔH_c = the heat of combustion of the fuel (kJ/kg), and
- $\dot{Q}_s$ = the maximum steady heat release rate (kW).

The total mass of the fuel is approximately 5,400 kg (45 kg/roll x 120 rolls). The heat of combustion is based on Cone Calorimeter results for fire retardant PVC and is given as 10,000 kJ/kg [Babrauskas and Grayson, 1992]. Substituting into Equation 6-10 yields an approximate burning duration of 4.1 hours.

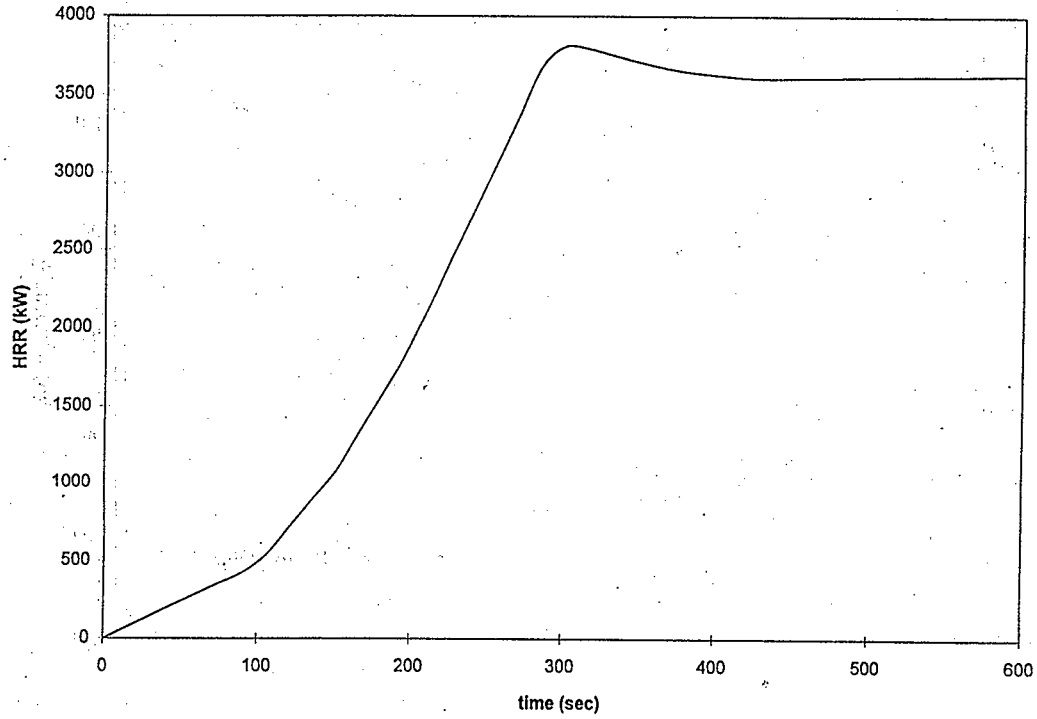


Figure 6-23 Heat release rate results for TC-66 fire scenario

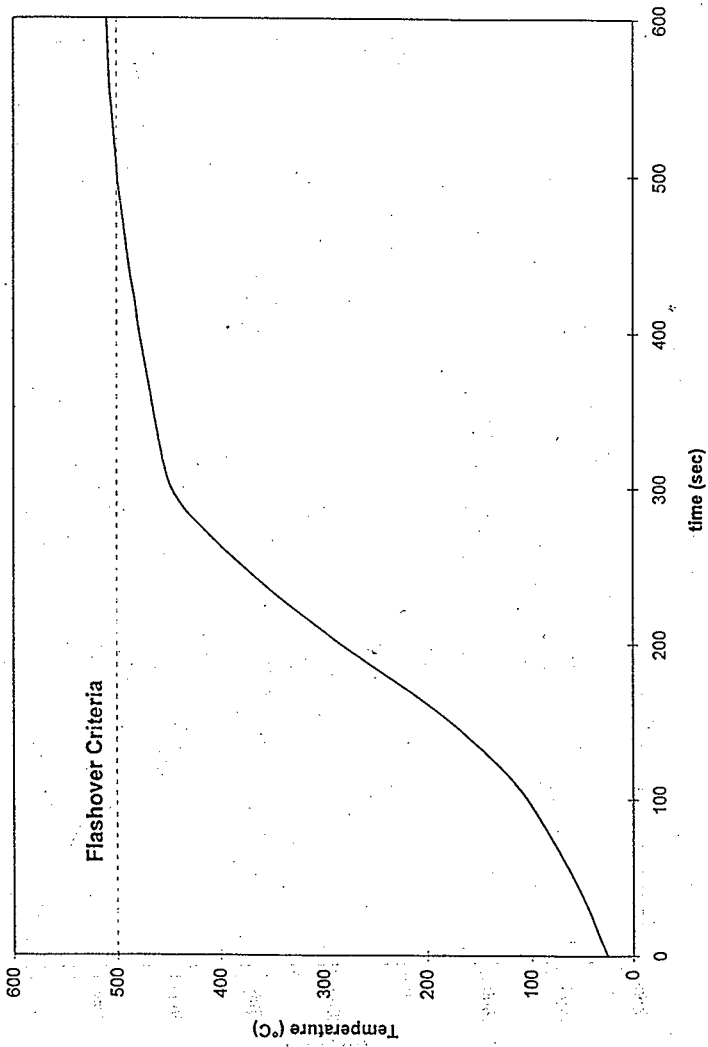


Figure 6-24 Upper gas layer temperature results for TC-66 fire scenario

For post flashover conditions, this exposure time is more than sufficient to fail structural steel members and wall assemblies. The wall separating TC-66 from Building 242-Z, which is constructed of corrugated metal and braced steel framing, is expected to fail during the fire exposure. Therefore, fire spread into the 242-Z facility is possible. Since the fuel load in the 242-Z facility is unknown, a worst case scenario must assume loss of the entire 242-Z facility.

In order to limit the exposure hazard to the 242-Z facility, it is recommended that the plastic rolls be removed from TC-66 or that they be enclosed in non-combustible containers.

6.4.3 Impact of Automatic Sprinkler System

The storage annex is equipped with an automatic sprinkler system. Activation of the sprinkler system during the early stages of the fire is expected to control the fire and prevent flashover conditions. The activation time of the sprinkler system is estimated using DETACT-QS, as included in FPETOOL [Nelson, 1990]. The maximum sprinkler spacing in the annex is 3.0 m by 3.7 m (10 ft by 12 ft), based on an ordinary hazard occupancy. The fire is assumed to occur at the floor level, approximately 4.0 m below the sprinklers, at a point which is in the center of the sprinkler spacing. Because the RTI value of the sprinklers is unknown, a typical value of 165 $(m/s)^{1/2}$ (300 $(ft/s)^{1/2}$) is assumed. Based on the fire growth rate shown in Figure 6-23, a predicted response time of 200 seconds is calculated. At this time, the fire has grown to a size of approximately 1900 kW. As seen in Figure 6-24, sprinkler activation occurs before the onset of flashover. With sprinkler activation, the wall separating the 242-Z Building is not expected to be compromised. As such, fire damage should be contained to within the storage building.

6.5 BUILDING 236-Z

6.5.1 Fuel Loading

The fuel loading in Building 236-Z is generally limited. The canyon area is currently inactive and contains almost no combustibles. The gloveboxes serving the canyon along the east and west walls have combustibles typical to other PFP gloveboxes (see Section 7.0). However, the window panels are typically glass which significantly reduces the fire spread potential. The liquid columns in the canyon area do not contain any organic solutions according to WHC personnel. Therefore, their use does not add to the fire hazard in the facility.

In addition to the light fuel load, the building is constructed of fire resistive construction throughout. Therefore, a significant fire is required to cause any effects on the structure or outside the structure.

Because there are no significant fuel loads, the fuel load in the building which would have the most serious consequences is determined from the FSAR. The FSAR discusses a fire scenario in the Miscellaneous Treatment (MT) process room (room no. 41). The process line consists of five gloveboxes connected by a conveyor glovebox. The window panels on all of the gloveboxes appeared to be glass. Combustibles in the gloveboxes consist of gloves and paper/plastic storage

containers. The contents of the gloveboxes include plutonium bearing materials and, therefore, pose a contamination hazard in the event of a fire. There were no other combustibles in the room during the site visit. The room is enclosed in noncombustible construction and there are limited combustibles in adjacent spaces.

6.5.2 Analysis of Fire Scenarios

As noted in the previous section, the combustible fuel loading in the MT gloveboxes is light. In order to determine the maximum effect on the room and facility resulting from a fire in the gloveboxes, a conservatively high fire growth rate and maximum heat release rate are used to analyze the effects of a fire. CFAST is used to determine the hot gas layer temperature in the room. With this, the potential for flashover and fire spread is assessed. The fire is modeled having a fast growth rate with a maximum heat release rate of 1.0 MW. This is greater than the actual fuel loading conditions are anticipated to permit, even if the fire were to spread throughout all of the MT gloveboxes. However, it provides a bounding analysis for the glovebox fire.

Figures 6-25 and 6-26 show the heat release rate and average upper gas layer temperature in the MT process area using the CFAST model. It is seen that the maximum temperature in the space is approximately 200°C while the fire burns at its maximum heat release rate. This is well below the 500-600°C flashover criteria. Since this fire is more severe than an actual anticipated fire in the gloveboxes, which have glass window panels and low combustible loading, flashover conditions are not expected.

Since there are limited combustibles in the room, there is no means for fire spread to adjacent spaces. Therefore, a fire in the MT gloveboxes is not expected to spread beyond the confines of the room. During the fire exposure, the glass window panels are assumed to crack and fall out resulting in spread of contamination to the room. Although smoke and contamination spread to the room, there is no means of fire propagation due to the limited combustibles in the space. The smoke and contamination in the MT room will spread to adjacent spaces through cracks and penetrations. Since there are no smoke tight barriers in Building 236-Z, it is assumed that the entire building is contaminated from the fire. Although this is likely overly conservative, it serves as an upper bound with respect to contamination. As a rough estimate, the maximum area of contamination is approximately 17,000 m^2 (180,000 ft^2). This is based on the total surface area of the floors, ceilings, and perimeter walls. The area is then tripled to account for interior partitions.

Based on the limited fuel load and fire resistive construction, the analysis of the MT glovebox fire is expected to bound any fire conditions in Building 236-Z. Effects will be facility contamination and loss of equipment in the MT room.

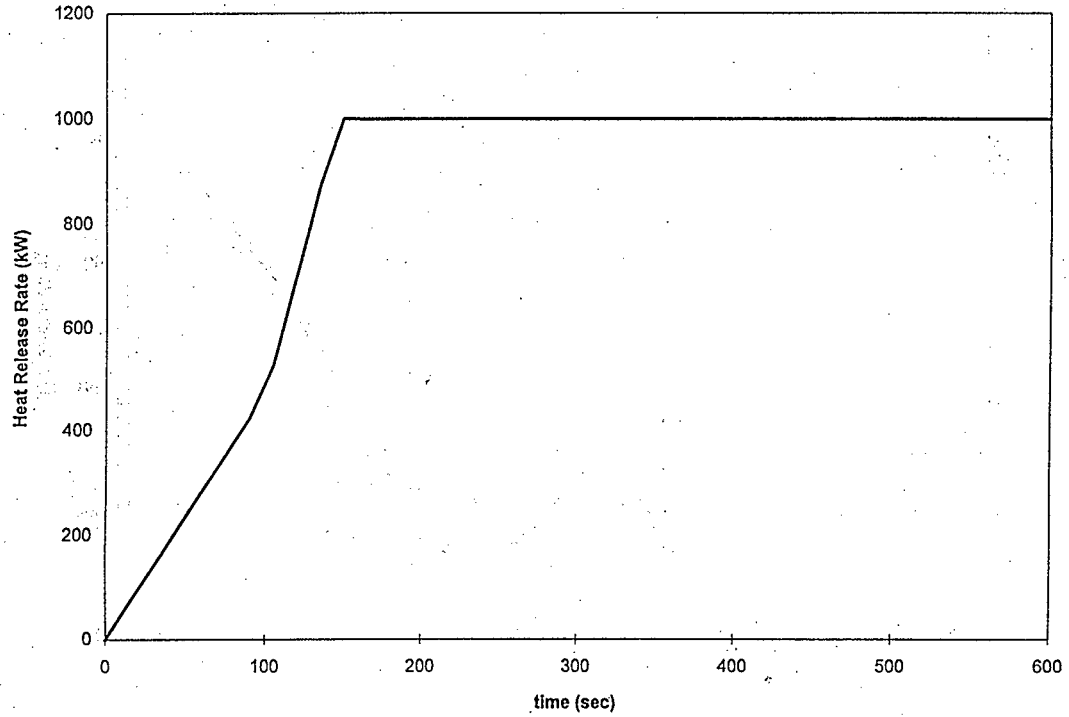


Figure 6-25 Estimated heat release rate for MT glovebox fire (Room 41)

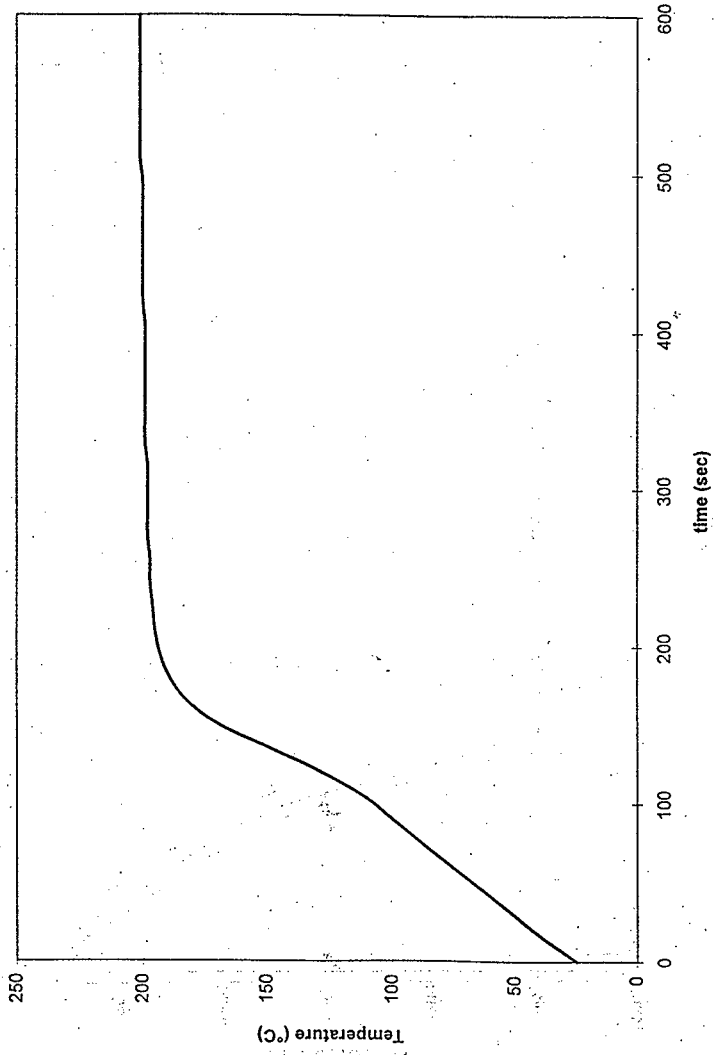


Figure 6-26 Upper gas layer temperature results for MT glovebox fire (Room 41)

6.5.3 Impact of Automatic Sprinkler System

Although there are no suppression systems within the MT gloveboxes, the room containing the process line (e.g., room 41) is protected by an automatic sprinkler system. Since the fire is expected to be contained to the gloveboxes, activation of the sprinkler system would have limited benefit. However, the sprinklers further ensure that a fire in the room will be contained and not spread to other areas. Since the fire can still spread throughout the gloveboxes whether the sprinklers operate or not, the extent of contamination may not be significantly reduced.

6.6 BUILDING 291-Z

6.6.1 Fuel Loading

The most notable fuel load in Building 291-Z is located in the Electrical Room where there are two oil filled transformers which serve the PFP Complex. Each of the transformers contain 1,890 liters (500 gallons) of oil. As such, a leak in one of the oil reservoirs could potentially result in spilling 1,890 liters of transformer oil onto the floor in Room 500 (e.g., the Electrical Room). During the site visit, other areas of the building had a very light fuel load. Combustibles consisted primarily of transient materials such as trash containers. All construction materials are noncombustible and, therefore, do not add to the fuel load in the building.

6.6.2 Analysis of Fire Scenarios

A fire resulting from a leak in one of the transformers in Room 500 provides the worst case fire scenario for Building 291-Z. It is assumed that the entire oil content (e.g., 1,890 liters) from one of the transformers spills onto the floor with subsequent ignition. Although there are drains on the floor, they are assumed to be clogged and do not provide liquid runoff for the transformer oil. In order to estimate the MPFL, the water deluge system protecting the transformers is assumed to fail. For the MCFL, activation of the deluge system is considered.

Room 500 has nominal dimensions of 10.7 m x 8.5 m x 4.4 m high (see Figure 6-27). There are two doors serving the Electrical Room; one leading directly to an exterior stairwell, the other leading to the main fan room. Both of these doors are normally kept closed and locked. The west wall of Room 500 is part of the fire wall which separates Rooms 500 and 501 from the main fan room. The fire wall is constructed of reinforced poured concrete having a nominal thickness of 30.5 cm (12 in.). The fire resistance rating of the fire wall is not identified on the facility drawings. A 30.5 cm (12 in.) concrete masonry wall will typically provide at least a 8 hour fire resistance rating [UBC, 1994].

The wall separating Rooms 500 and 501 is also constructed of 30.5 cm (12 in.) reinforced poured concrete. However, there are several penetrations in this wall including ventilation openings without dampers and pipe penetrations. As such, while the wall will provide some passive protection, it does not serve as a fire wall having a fire resistance rating.

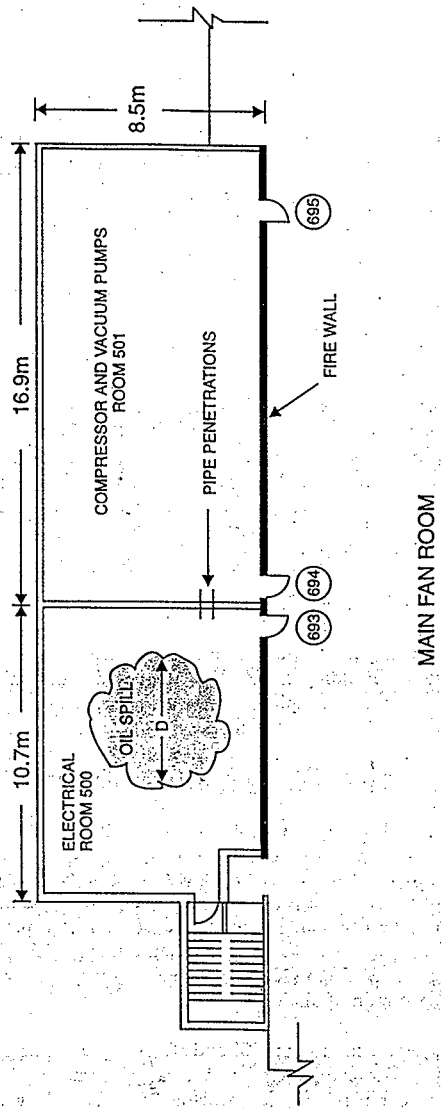


Figure 6-27 Layout of Building 291-Z Electrical Room and potential spill fire

Depending on the configuration of the oil spill in Room 500, the intensity and duration of the resulting fire can vary. In order to assess the effect of the fire on the facility, a range of spill configurations which bound the actual expected conditions are considered. A slow oil leak with immediate ignition can result in a smaller pool fire only a few meters in diameter. On the other hand, if all of the fuel spills rapidly, or if ignition does not occur right away, the entire floor area can be consumed by the pool fire. However, if a spill fire in this room becomes ventilation controlled, larger spills will not significantly increase the fire intensity and subsequent hazard to the facility. In this analysis, a range of spill configurations are considered in order to assess the potential hazard to the building.

The maximum free burning (i.e., not ventilation controlled) energy release rate for a hydrocarbon pool fire is estimated using the following equation:

$$\dot{Q} = \dot{m}'' A_b \Delta H_c \tag{6-11}$$

where A_b = the area of the pool fire,
ΔH_c = the heat of combustion of the fuel, and
$\dot{m}''$ = the mass burning rate of the fuel given by [Babrauskas, 1988]:

$$\dot{m}'' = \dot{m}''_{\infty} (1 - e^{-k\beta D}) \tag{6-12}$$

where $\dot{m}_{\infty}''$ = the mass loss rate for an infinite-diameter pool,
$k\beta$ = the product of the extinction-absorption coefficient of the flame and the mean-beam-length corrector, and
D = the diameter of the pool.

Flammable liquid fires are typically specified as very fast in NFPA 101M [1992]. Therefore, the predicted growth rate for the fire is assumed to correspond to a very fast growth rate fire. A very fast growth rate fire assumes that the heat release data is a quadratic function of time as follows [Evans, 1986]:

$$\dot{Q}(t) = 0.1876\ t^2 \quad (kW, s) \tag{6-13}$$

The physical and thermal properties for the transformer oil are estimated using data provided by Babrauskas in the Society of Fire Protection Engineers (SFPE) Handbook [Babrauskas, 1995]:

quantity: 1,890 liters (500 gallons)
density: 760 g/liter

ΔH_c: 46.4 MJ/kg
$\dot{m}_\infty''$: 0.039 kg/m^2-s
$k\beta$: 0.7

The burning duration of the fire is a function of both the quantity and burning rate of the fuel. For liquid pool fires where the burning rate quickly reaches an approximate constant value, the burning duration can be estimated using Equation 6-10 in Section 6.4.2.

Where the fire has an unlimited oxygen supply, the steady energy release rate is given by Equation 6-11. For ventilation controlled fires, where the limited available oxygen controls the burning rate of the fire, the steady energy release rate is determined using the computer fire model CFAST [Peacock et al., 1993]. The CFAST input data files used in the analysis are provided in Appendix C.

Although the doors to Room 500 are normally kept closed, it is assumed that the door leading to the outside is open during the fire. This results in a more severe fire exposure than if both doors are closed. Door no. 693, leading to the main fan room, is assumed to remain closed since it is part of the fire wall assembly. A pipe penetration opening measuring approximately 0.3 m x 1 m is included in the wall separating Rooms 500 and 501. CFAST is used to estimate the effects of the fire in these two rooms. The concrete fire wall will prevent the direct spread of hot gases and flames to the main fan room.

Table 6-9 provides a summary of the spill fire scenarios assessed in the analysis. Spill fires, ranging from 1.0 to 4.0 m diameter pools, are evaluated. Figures 6-28, 6-29, and 6-30 show the heat release rate and temperature results from the CFAST simulations.

Table 6-9. Summary of Spill Fire Scenarios

Pool Fire		Peak Heat Release Rate (kW)	Steady Heat Release Rate (kW) (CFAST)	Burning Duration (hours)
Diameter (m)	Area (m^2)			
1.0	0.8	720	720	25.7
2.0	3.1	4,280	4,280	4.3
3.0	7.1	11,200	6,600	2.8
4.0	12.6	21,400	8,650	2.1

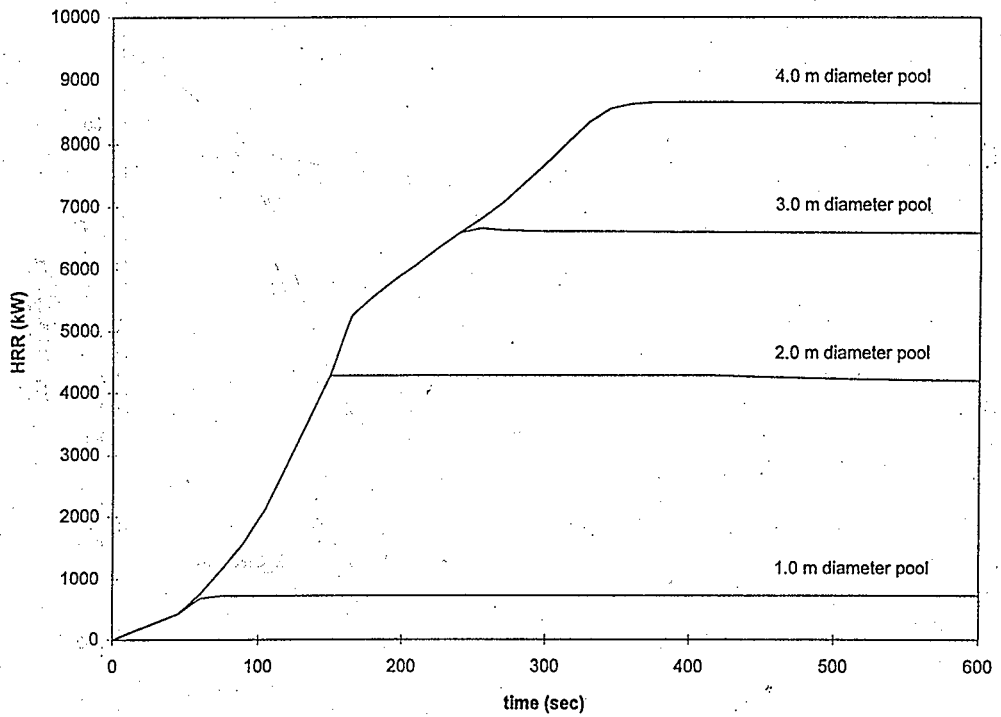


Figure 6-28 Heat release rate results for liquid spill fire (Room 500)

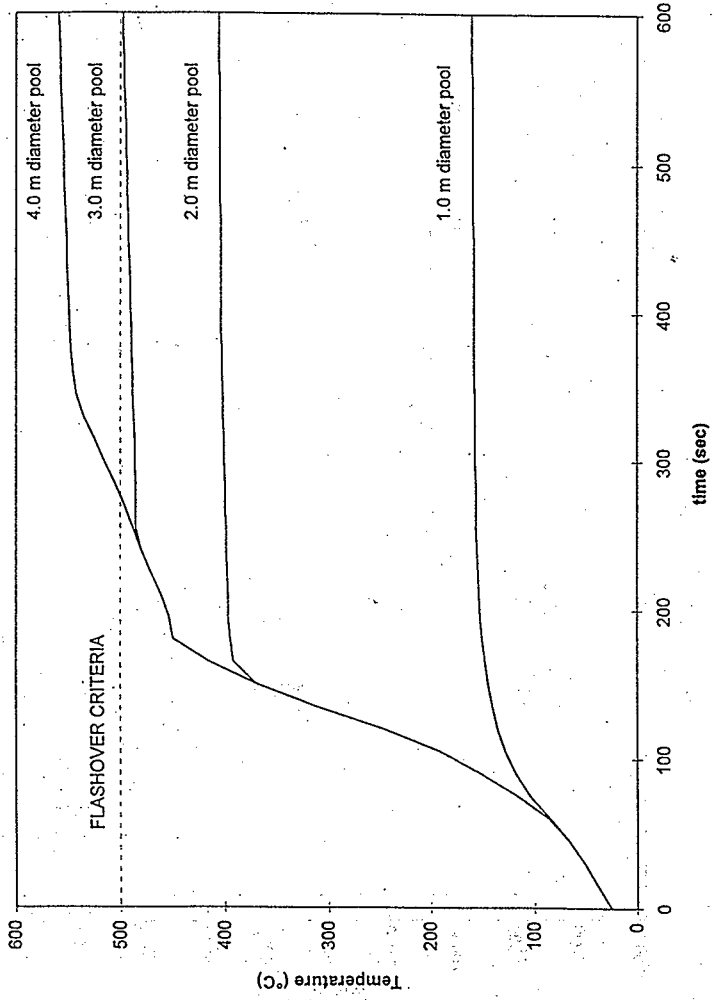


Figure 6-29 Upper gas layer temperature results for liquid spill fire (Room 500)

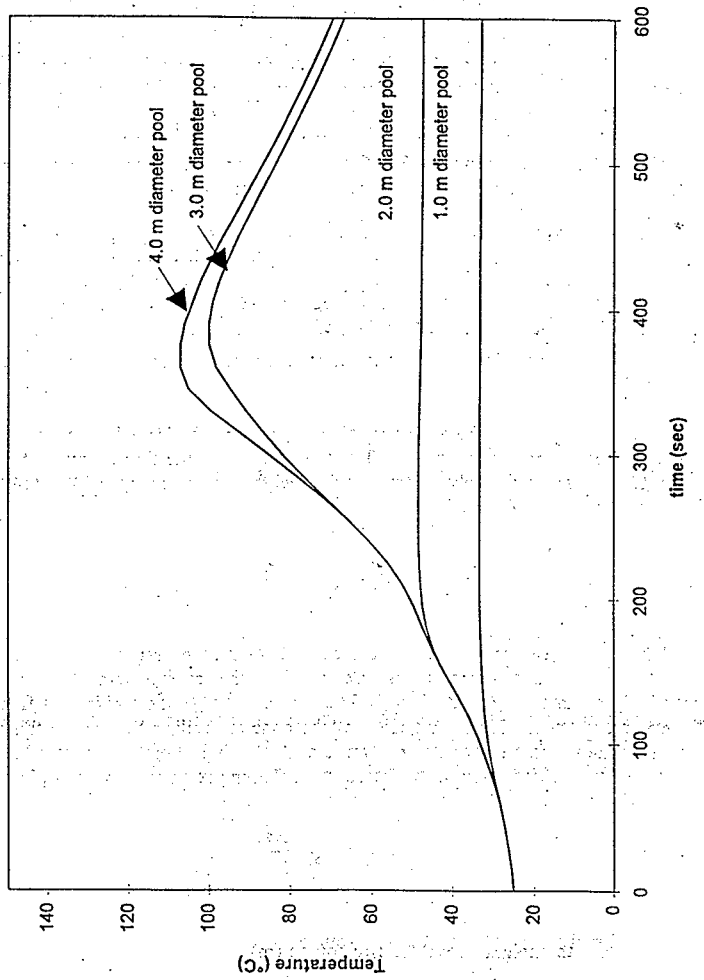


Figure 6-30 Upper gas layer temperature results for liquid spill fire (Room 501)

The potential for a space to flashover provides an indication of the severity of a fire in the space. Flashover typically occurs when upper layer temperatures exceed 500-600°C. If flashover occurs, all exposed combustibles in the room will ignite. In addition, flashover temperatures can cause failure of structural steel and concrete assemblies if the exposure is prolonged.

As shown in Figure 6-28 and summarized in Table 6-9, pool fires greater than approximately 2.0 m in diameter become ventilation limited and do not reach the peak heat release rate predicted by Equation 6-11 for unlimited oxygen conditions. The smaller pool fires (i.e., 1.0 m and 2.0 m diameter) have sufficient oxygen to reach their predicted peak heat release rates; however, they are not of sufficient size to cause flashover conditions in the room. As seen in Figure 6-29, the 3.0 m diameter pool fire is the minimum size fire needed to cause flashover in Room 500 based on a conservative 500°C flashover temperature criteria. Fires larger than this also result in flashover and will have similar effects on the facility.

Although the smaller fires do not cause the room to flashover, direct flame impingement on the roof assembly for prolonged periods of time could result in structural failure of the concrete roof. The compressive strength of concrete is significantly reduced at a critical temperature of 650°C (1200°F) for silicious aggregate or 760°C (1400°F) for carbonate aggregate [Fleischmann, 1988]. The temperature at the ceiling directly above the fire plume is estimated using the continuous flame height and intermittent flame temperature correlations of McCaffrey [Beyler, 1986].

The continuous flame height correlation yields a prediction of the height of the flame below which there is no intermittency. The temperature of the flame within this continuous flaming region is approximately constant with height and is about 800°C (1472°F). The continuous flame height, Z_c, is given as:

$$Z_c = 0.06\ \dot{Q}^{2/5} \qquad (6\text{-}14)$$

If the ceiling assembly is within the continuous flaming region, structural failure may occur since the flame temperature is greater than the critical temperature for concrete (conservatively assumed to be 650°C for this analysis). Above the continuous flaming region, the flame is intermittent. If the underside of the concrete ceiling lies within this region, it is useful to estimate the flame/plume temperature at the ceiling in order to determine the thermal exposure. The temperature within the intermittent flaming region is given as [Beyler, 1986]:

$$\Delta T = 63\ \frac{\dot{Q}^{2/5}}{Z} \qquad (6\text{-}15)$$

where Z = the height above the fire source (m).

The mean flame temperature in the intermittent flaming region decreases to a limit of approximately 500°C (932°F), corresponding to the visible flame height.

For the 2.0 m spill fire, and corresponding heat release rate of 4,280 kW, Equation 6-14 yields a continuous flame height of 1.7 m. The height of the concrete ceiling in Room 500 is 4.4 m, which is well above the continuous flame height. At 4.4 m, Equation 6-15 yields a temperature of approximately 405°C. Since this is below the lower 500°C temperature limit for the intermittent flaming region, it stands to reason that the ceiling is above the visible flame height for the 2.0 m spill. Moreover, the temperature at the ceiling directly above the pool fire is well below the critical failure temperature of 650°C (1200°F) for concrete. Therefore, structural failure is not expected for the smaller spill fire configurations.

The burning duration for the 3.0 and 4.0 m diameter fires is approximately 2.8 and 2.1 hours, respectively. These fires will result in flashover conditions in the space and, therefore, provide the maximum exposure to the facility. Since the 30.5 cm (12 in.) concrete fire wall has a fire resistance rating in excess of 8 hours, these exposures do not compromise the structural integrity of the fire wall nor do they pose an ignition hazard for combustibles on the unexposed side of the fire wall. During the fire exposure, heat transfer through the fire door may cause a temperature rise on the unexposed door face that is capable of igniting ordinary combustibles. However, there are no combustibles stored in the main fan room near the fire door. As such, fire spread to the main fan room is not expected.

Figure 6-30 shows the upper layer temperature results for Room 501. The 1.0 and 2.0 m diameter fires have little effect on the room temperature. Although the 3.0 and 4.0 m fires cause a slight temperature rise, the effect is not significant enough to cause ignition of combustibles or damage to the structure. However, since there are no fire dampers in the ventilation ducts between Rooms 500 and 501, this may provide an additional means for fire spread, potentially resulting in thermal damage to equipment in Room 501.

6.6.3 Impact of Automatic Suppression System

The automatic deluge system protecting the transformers in Room 500 is actuated by spot type heat detectors arranged over the top of the two transformers. Actuation of the system transmits a local alarm and signal to the Fire Department, via the radio alarm box. The purpose of the deluge system is to protect the transformers in the event of a fire. They are not intended to extinguish or control a fire in the room.

A combustible liquid oil fire presents a special problem in that the water flowing from the nozzles may carry the floating burning liquid from the source to other areas in the space, exposing additional components. In this scenario, given the quantity of fuel available, it is not expected that the deluge system would control the oil fire. Even with actuation of the deluge system, the contents of Room 500, including the two transformers, will be damaged.

6.7 BUILDING 2736-ZB

6.7.1 Fuel Loading

The heaviest fuel loading in Building 2736-ZB is in the office spaces and the NDA Lab. Combustibles consist of typical office supplies, storage boxes and containers, books/paper goods, and laboratory equipment. Metal desks and bookcases are used in the office and lab spaces. The fuel load in the Receiving, Shipping, and Staging Vaults generally consists of drum storage. The combustible contents in these rooms is low compared to other areas of the facility. Likewise, the fuel loading in the Mechanical Rooms is also low.

6.7.2 Analysis of Fire Scenarios

The worst case fire scenario resulting in the maximum damage to equipment and the facility is a fire in the NDA Lab. The analysis of this fire scenario is considered to be bounded by the description in Section 6.3.2 for the office/lab spaces in Building 234-5Z. Although the NDA lab is completely enclosed in concrete construction, the door serving the room is kept open while the lab is occupied. Therefore, a fire in the lab can potentially spread to the office spaces along corridors 623 and 625. The maximum possible fire spread includes the NDA lab and all of the office spaces in the back side. Fire spread into the storage vaults and to the front side is not anticipated because of the solid concrete walls separating these areas.

The NDA Lab contains plutonium bearing materials, and therefore, a fire in this space can potentially contaminate the building. Contamination to the outside is not expected since the fire will be contained to within the lab and office spaces, and there are no direct openings to the outside.

The maximum area of contamination is based on smoke and contamination spread throughout the facility. The total maximum contaminated area is approximately 8,500 m^2 (91,500 ft^2). This area includes the floors, ceilings, and perimeter walls. The area is then tripled to conservatively account for interior partitions.

6.7.3 Impact of Automatic Sprinkler System

Building 2736-ZB is protected by an automatic sprinkler system. The sprinkler system is expected to activate and control the fire in the NDA Lab similar to the sprinkler protection discussed in Section 6.3.3.4 for the office and lab spaces. However, the extent of damage in the room cannot be accurately determined since there are no separations or barriers in the space. Therefore, as a worst case event, it is assumed that all of the contents in the NDA Lab are damaged even with sprinkler activation.

6.8 BUILDING 2736-Z

6.8.1 Fuel Loading

During the site visit there were no ordinary combustibles or transient fuel loads present in either the hallway or vaults of the 2736-Z Building. Plutonium materials within the vaults do include combustible polycubes. However, these, like the other SNM stored in the vaults, are contained in sealed noncombustible canisters within specially designed concrete storage cubicles.

6.8.2 Analysis of Fire Scenarios

There are no credible fire scenarios which present a hazard to the structure or the special nuclear materials (SNM) in the vaults. It is possible to have a small electrical fire or a fire involving transient storage in the hallway. However, such fires would have little consequence (other than local damage to the equipment itself) and, therefore, are not presented.

6.8.3 Impact of Automatic Sprinkler System

The vaults are not provided with automatic suppression systems. The hallway has an automatic sprinkler system. Since there are no credible fire scenarios in the vaults a suppression system is not warranted (a small electrical fire would not activate a sprinkler system). In the hallway, the fuel load is very low; however, the potential exists for a small fire involving transient storage. Even without a sprinkler system, such a fire would not spread to the vaults or to Building 2736-ZB due to the solid concrete construction of the building walls.

6.9 BUILDING 2721-Z

6.9.1 Fuel Loading

The primary fuel load in Building 2721-Z is the diesel oil contained in the three 325 kW generators. Each generator contains 95 liters (25 gallons) of diesel fuel. During the site visit, there were no ordinary combustibles or transient fuels in the building. The building is constructed of noncombustible materials and therefore does not add to the fuel load.

6.9.2 Analysis of Fire Scenarios

A fire resulting from a leak in one of the emergency generator tanks provides the worst case fire scenario for Building 2721-Z. It is assumed that the entire oil content (e.g., 95 liters) from one of the generators will spill onto the floor with subsequent ignition. In order to estimate the MPFL, the dry pipe automatic sprinkler system is assumed to fail. For the MCFL, activation of the sprinkler system is considered.

The analysis of the fuel spill fire follows the methodology outlined in Section 6.6.2 for Building 291-Z. A range of spill configurations are considered in order to determine the fire size needed to cause flashover in the space. With this, the average gas layer temperatures and burning

durations are estimated in order to determine the overall exposure to the facility. The physical and thermal properties of the diesel fuel are assumed to be the same as those used for the transformer oil in Section 6.6.2. The CFAST input data files used in the analysis are provided in Appendix C.

Table 6-10 provides a summary of the heat release rate, temperature, and burning duration results for three different size fires. Based on a flashover temperature criteria of 500-600°C, a 2.0 m diameter pool fire will cause flashover in the space. Although the burning duration is only approximately 14 minutes for this fire, the actual duration can potentially be up to 3 times this if the diesel oil in the other two generators spills and ignites as a result of the fire exposure . Even so, while a 42 minute fire (3 x 14 minutes) can cause damage to contents and equipment within the building, it is not expected to cause significant structural damage to the concrete facility.

Table 6-10. Summary of Spill Fire Scenarios

Pool Fire		Peak Heat Release Rate (kW)	Steady Heat Release Rate (kW) (CFAST)	Peak Average Layer Temperature (°C)	Burning Duration (min)
Diameter (m)	Area (m^2)				
1.0	0.8	720	720	235	77
2.0	3.1	4,280	4,080	550	14
3.0	7.1	11,200	6,350	670	9

6.9.3 Impact of Automatic Sprinkler System

The southern area of Building 2721-Z is equipped with an automatic dry-pipe sprinkler system. Water discharge through the dry-pipe sprinkler system is not expected to extinguish the liquid pool fire. Although the cooling effect of the water will certainly reduce the severity of the fire in this building, thermal damage to the contents and equipment is still expected.

6.10 BUILDING 232-Z

6.10.1 Fuel Loading

The Process areas of Building 232-Z were not accessible during the site visit due to airborne contamination. A visual inspection from the Filter Room revealed a very light fuel load consisting primarily of transient combustibles including trash and linen containers. All construction materials are noncombustible and, therefore, do not add to the fuel load in the building.

6.10.2 Analysis of Fire Scenarios

The most probable fire scenario in this facility involves the burning of transient materials involving ordinary combustibles. In order to determine the effect on the structure, several fire scenarios involving the burning of one or more bags of trash are considered. Figure 6-31 shows the layout of the facility and location of the postulated fire scenarios. CFAST is used to estimate the room conditions during the fire scenarios.

Based on full-scale test results, heat release rates ranging from 50 to 300 kW appears to cover the bulk of the expected fires from typical trash bags containing ordinary combustibles [Babrauskas, 1988]. As a conservative approximation, a peak heat release rate of 300 kW is assumed for a single burning trash container. Where multiple trash containers are considered, the peak heat release rate is taken to be the sum of the individual peak heat release rates. Table 6-11 summarizes the number of trash bags and corresponding peak heat release rates used in the analysis.

Table 6-11. Summary of Trash Bag Heat Release Rates

Number of Trash Bags	Peak Heat Release Rate (kW)
1	300
2	600
5	1,500
10	3,000

The input data files for the CFAST simulations are provided in Appendix C. In order to provide the worst case fire scenarios, door no. 162 leading to the exterior is assumed to be open during the fire. This allows the trash bags to burn at their peak heat release rates without becoming ventilation controlled. Figure 6-32 shows the average upper layer temperature in the Process Room as a result of each of the trash bag fire scenarios. It is seen that even for 10 bags of trash burning (e.g., a 3,000 kW), the upper layer temperature does not exceed approximately 325°C. This is well below flashover conditions (e.g., 500-600°C) and will not result in structural damage to the facility.

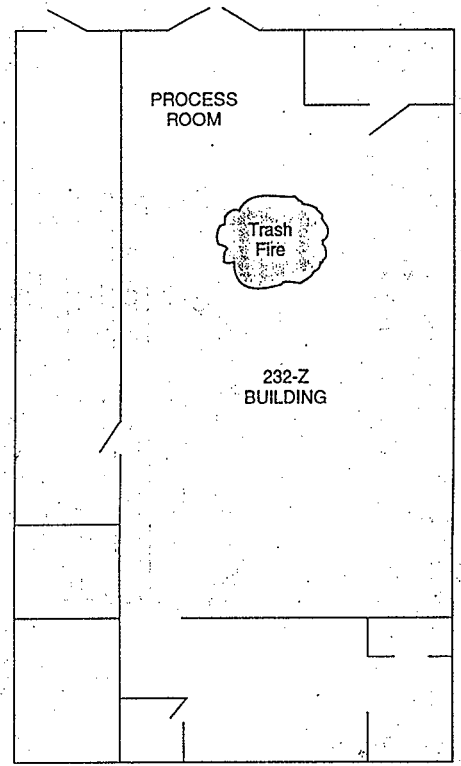


Figure 6-31 Layout of Building 232-Z and potential trash fire

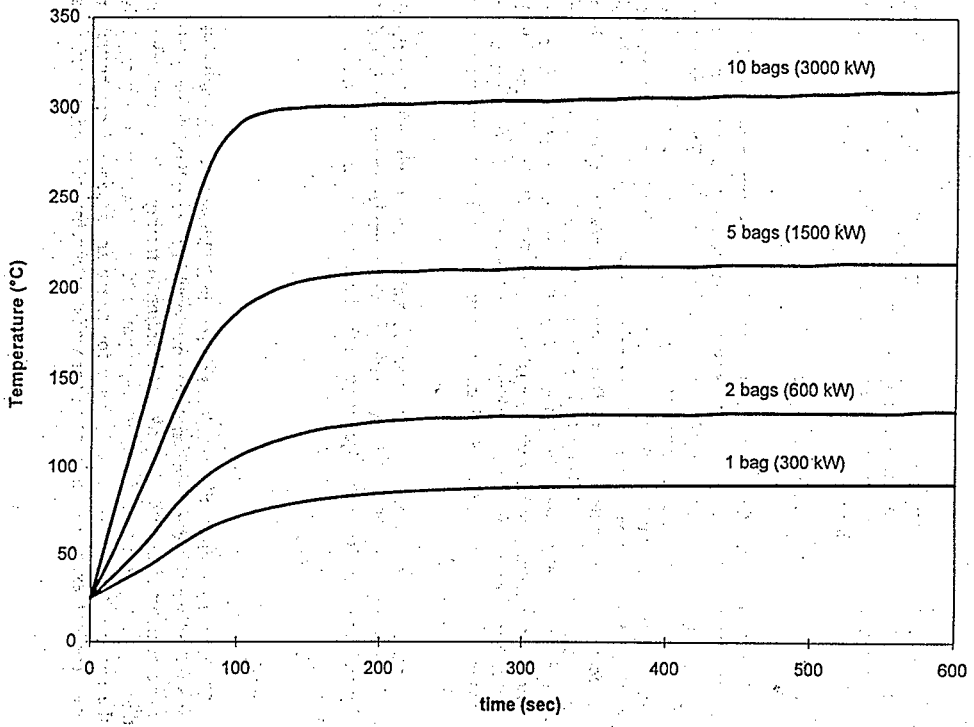


Figure 6-32 Upper gas layer temperature results for trash fire scenarios (Building 232-Z)

While a 3,000 kW fire resulting from the burning of 10 trash bags does not cause flashover in Process Area, flames from the fire may impinge the roof assembly, in which case, structural damage can result. The height of the flame is estimated using Equation 6-14 in Section 6.6.2 for the continuous flame height. The temperature of the flame in this continuous region is approximately constant with height and is about 800°C (1472°F). For a 3,000 kW fire, the continuous flame height is calculated to be 1.5 m. This is about half the height of the ceiling in Building 232-Z. Therefore, structural damage resulting from direct flame impingement on the ceiling assembly is not expected.

Since 10 bags of trash is a more severe fuel loading than that observed during the site visit, a fire involving the actual fuel loading will have less severe consequences. A fire in the facility can potentially cause damage to the contents of the Process Area but will not cause structural damage to the facility.

6.10.3 Impact of Automatic Sprinkler System

The automatic sprinkler system in Building 232-Z was temporarily out of service at the time of the site visit. However, since the system is scheduled to be reactivated, this analysis assesses the impact of the sprinkler system on the fire scenario. The response time of the sprinkler system is estimated using DETACT-QS. The heat release rate of the trash fire is assumed to be characteristic of a fast growing fire based on similar fuel load fire growth rates [NFPA 72E, 1993]. It is assumed as a worst case scenario that the fire starts at a point which is in the center of the sprinkler spacing. Based on a ordinary hazard occupancy, the sprinklers in the Process Room are installed on an approximate 3.0 m x 3.7 m (10 ft x 12 ft) spacing. This yields a maximum radial distance of 2.4 m (7.8 ft) between the fire and the closest sprinkler. The activation temperature of the sprinklers is taken to be 74°C (165°F). Because the RTI value of the actual sprinklers is unknown, a typical value of 165 $(m/s)^{1/2}$ (300 $(ft/s)^{1/2}$) is assumed. The fire is assumed to occur at the floor level and the sprinklers are located approximately 4.6 m (15 ft) above the floor.

A predicted response time of 210 seconds is calculated. At this time, the fire has grown to a size of approximately 2000 kW. Activation of the sprinkler system would reduce the fire intensity and limit fire damage to equipment in the immediate vicinity of the fire.

6.11 BUILDING 241-Z

6.11.1 Fuel Loading

There were no combustible fuel loads present in Building 241-Z during the site visit. The tank sumps are located underground and are constructed of noncombustible materials. There are little to no combustibles within the tanks. According to facility staff, the tank contents contain less than 1 percent organics and hydrogen generation does not present a hazard. It is possible that the above grade facility could be used for temporary storage of combustible materials. However, the roof, exterior walls, and interior walls are constructed of corrugated metal and the

floor is poured concrete. As such, a small fire involving transient combustibles does not present a hazard.

6.11.2 Analysis of Fire Scenarios

There are no fire scenarios which result in a hazard to the facility or which present an exposure hazard to other facilities.

6.11.3 Impact of Automatic Suppression System

There are no automatic suppression systems in Building 241-Z.

6.12 BUILDING 243-Z

6.12.1 Fuel Loading

During the site visit there was a very light fuel load in Building 243-Z. The limited amount of combustibles present consisted primarily of transient materials including trash and linen containers. All construction materials are noncombustible and therefore do not add to the fuel load in the building.

6.12.2 Analysis of Fire Scenarios

The most probable fire scenario in this facility involves the burning of transient materials involving ordinary combustibles. The analysis of the fire scenarios in this facility follows the methodology used for Building 232-Z. Several fire scenarios involving the burning of one or more bags of trash are considered to provide a conservative estimate of the actual fuel load in the facility. Figure 6-33 shows the layout of the building and location of the postulated fire scenarios. CFAST [Peacock et al., 1993] is used to estimate the room conditions during the fire scenarios.

As in the analysis of Building 232-Z, a peak heat release rate of 300 kW is assumed for a single burning trash container. Where multiple trash containers are considered, the peak heat release rate is taken to be the sum of the individual peak heat release rates. Table 6-12 summarizes the number of trash bags and corresponding peak heat release rates used in the analysis.

The input data files for the CFAST simulations are provided in Appendix C. In order to provide the worst case fire scenarios, a single door leading to the exterior is assumed to be open during the fire. This allows the trash bags to burn at their peak heat release rates without becoming ventilation controlled. Figure 6-34 shows the average upper layer temperature in the Process Room as a result of each of the trash bag fire scenarios. It is seen that even for 10 bags of trash burning (e.g., a 3,000 kW), the upper layer temperature does not exceed approximately 325°C. This is well below flashover conditions (e.g., 500-600°C) and will not result in structural damage to the facility.

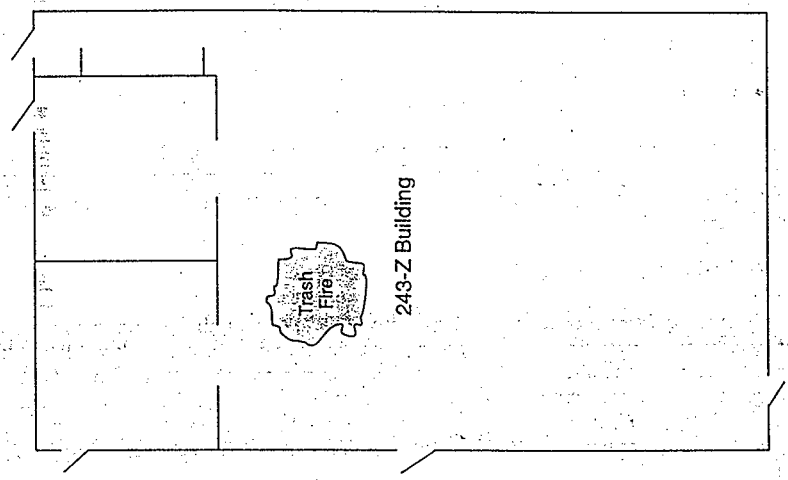


Figure 6-33 Layout of Building 243-Z and potential trash fire

Table 6-12. Summary of Trash Bag Heat Release Rates

Number of Trash Bags	Peak Heat Release Rate (kW)
1	300
2	600
5	1,500
10	3,000

While a 3,000 kW fire resulting from the burning of 10 trash bags does not cause flashover in Process Room, flames from the fire may impinge the roof assembly, in which case, structural damage can result. The height of the flame is estimated using Equation 6-14 in Section 6.6.2 for the continuous flame height. The temperature of the flame in this continuous region is approximately constant with height and is about 800°C (1472°F). For a 3,000 kW fire, the continuous flame height is calculated to be 1.5 m. This is less than half the height of the ceiling in Building 232-Z. Therefore, structural damage resulting from direct flame impingement on the ceiling assembly is not expected.

Since 10 bags of trash is a more severe fuel loading than that observed during the site visit, a fire involving the actual fuel loading will have less severe consequences. Although a 325°C temperature can cause damage to equipment in the facility, it will not cause structural damage to the building.

6.12.3 Impact of Automatic Sprinkler System

The building is protected throughout by an automatic sprinkler system. The response time of the sprinkler system is estimated using DETACT-QS. The heat release rate of the trash fire is assumed to be characteristic of a fast growing fire based on similar fuel load fire growth rates [NFPA 72E, 1993]. It is assumed as a worst case scenario that the fire starts at a point which is in the center of the sprinkler spacing. Based on a ordinary hazard occupancy, the sprinklers in the Process Room are installed on an approximate 3.0 m x 3.7 m (10 ft x 12 ft) spacing. This yields a maximum radial distance of 2.4 m (7.8 ft) between the fire and the closest sprinkler. The activation temperature of the sprinklers is taken to be 74°C (165°F). Because the RTI value of the actual sprinklers is unknown, a typical value of 165 $(m/s)^{1/2}$ (300 $(ft/s)^{1/2}$) is assumed. The fire is assumed to occur at the floor level and the sprinklers are located approximately 4.6 m (15 ft) above the floor.

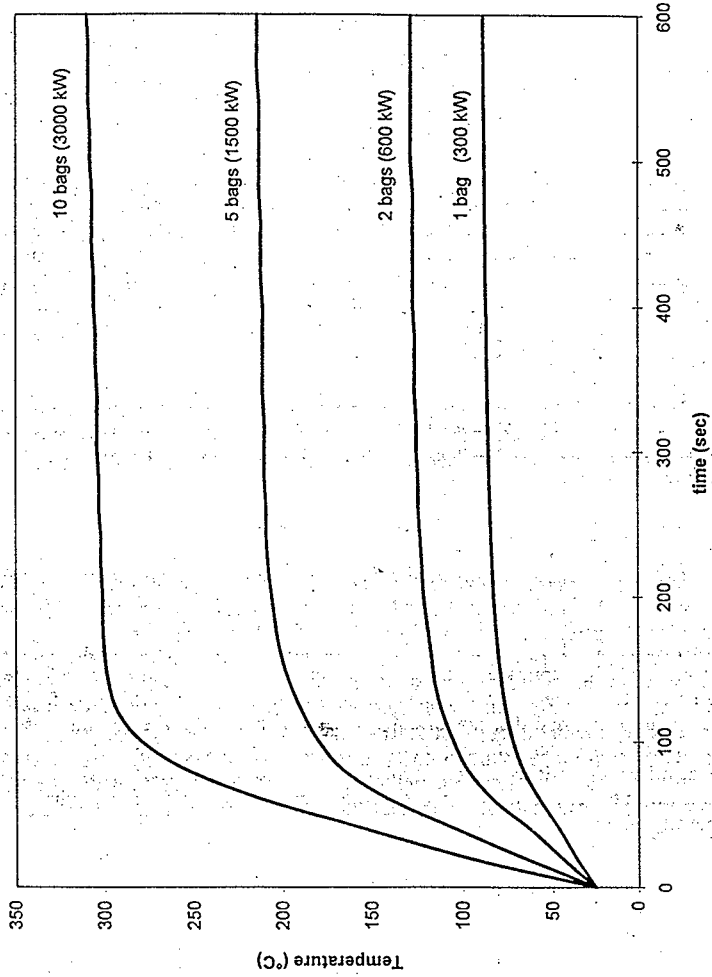


Figure 6-34 Upper gas layer temperature results for trash fire scenarios (Building 243-Z)

A predicted response time of 210 seconds is calculated. At this time, the fire has grown to a size of approximately 2000 kW. Activation of the sprinkler system would reduce the fire intensity and limit fire damage to equipment in the immediate vicinity of the fire.

6.13 COMPRESSED GAS STORAGE AREA

6.13.1 Fuel Loading

During the site visit, the compressed gas storage shed contained 4 large propane tanks and several P-10 cylinders along with other nonflammable gases.

6.13.2 Analysis of Fire Scenarios

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders* [1993 ed.] provides guidance regarding the location and storage conditions for flammable gas cylinders. The following summarizes the requirements for outside storage of flammable gas cylinders:

- Storage areas shall have a minimum of 25 percent of the perimeter open to the atmosphere.
- Storage areas shall be kept clear of dry vegetation and combustible materials for a minimum distance of 4.6 m (15 ft).
- Cylinders shall not be placed on the ground or surfaces where water can accumulate.
- Storage areas shall be provided with physical protection from vehicle damage.
- Storage areas shall are permitted to be covered with canopies or noncombustible construction.
- Smoking and open flames are not permitted in storage areas or within 6.1 m (20 ft) of storage areas.
- Gas cylinders shall be stored a minimum distance of 6.1 m (20 ft) from storage of flammable and combustible liquids and solids.
- Liquefied flammable gas cylinders shall be stored in the upright position or such that the pressure relief valve is in direct communication with the vapor space of the cylinder.

In general, the 2734-Z series compressed gas storage areas are in compliance with the criteria of NFPA 55. However, the 2734-Z storage shed containing the flammable gas cylinders is constructed of wood. In order to comply with NFPA 55, the open storage shed should be

constructed of noncombustible materials. The 2734-Z shed is currently being renovated to meet NFPA 55 criteria. During the renovations, the compressed flammable gases will be temporarily stored in other 2734-Z series storage sheds.

Even though the storage areas are generally in compliance with NFPA 55, it is still possible to have a propane leak with subsequent ignition from one of the cylinders. The fire hazard associated with the propane storage includes flaming jets, the formation of a flammable vapor cloud, and a boiling liquid expanding vapor cloud explosion (BLEVE) if the cylinders are exposed to a fire (e.g., liquid spill fire or fire involving the wood shed). Since all of the 2734-Z series storage sheds are open to the outside and all exposed facilites are noncombustible construction, it is not expected that the propane cylinders will pose an exposure hazard. Therefore, no additional analysis is considered.

6.13.3 Impact of Automatic Sprinkler System

There are no automatic suppression systems installed in the compressed gas storage areas.

6.14 HAZARDOUS PRODUCT AND WASTE EXTERIOR LAY DOWN AREAS

6.14.1 Fuel Loading

Transuranic waste (TRU) is temporarily stored within the fenced security area outside the PFP. The TRU waste is stored in 55-gallon steel drums for eventual transfer. The materials in the waste drums consists mainly of combustible materials such as paper, metals, and rubber, with surface and/or internal contamination, packaged in multiple layers of plastics [WHC, 1995]. Table 6-13 provides a summary of the contents of the waste drum transferred from PFP from 1978 to 1988. It is anticipated that new waste generated from PFP will be similar and that this description represents the container content for future waste to be stored outside of PFP.

Table 6-13. PFP TRU Mixed Drum Summary [WHC, 1995]

Time Span	Waste drums (55 gallon)		
	1978 to 1981	1982 to 1985	1986 to 1988
Total number of containers	4,945	5,258	1,212
Average TRU (g)	21.0	10.6	28.2
Average % combustible	79	85	81

During the site visit, there were a few dozen 55-gallon waste drums stored outside of the PFP buildings within the fenced area. The actual contents of the drums are unknown and, therefore are assumed to be characteristic of that described in Table 6-13. The primary hazard

associated with the drum storage is the potential to breach one or several drums and ignite the combustible contents resulting in an airborne release of the TRU.

Breaching the drums could occur in a number of ways, however, the most likely involves a vehicle crash into the storage drums. If the vehicle fuel tank ruptures as a result of the impact, a liquid pool fire can result which can expose nearby drums and ignite the contents of the breached drums. In addition, sealed solid waste storage drums exposed to liquid pool fires for several minutes are expected to experience lid loss failure due to a thermally induced pressurization and lid seal degradation [Rhodes, et al., 1995]. Lid loss failure typically results in expelling some of the drum contents with subsequent ignition. Drum contents which are not expelled typically ignite and burn within the drum. In general, all of the combustible contents in the drum are expected to burn following lid loss failure.

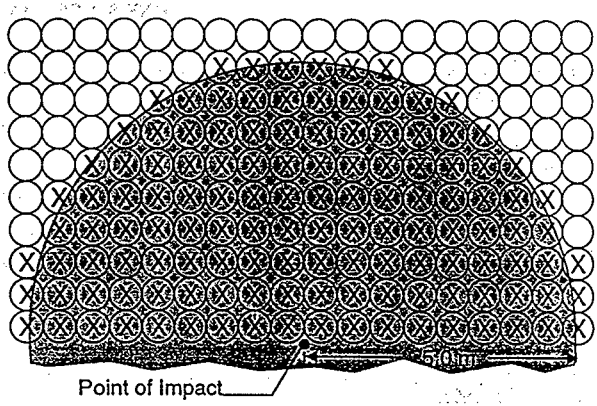
6.14.2 Analysis of Fire Scenarios

The primary hazard associated with a fire involving the solid waste storage drums is the contamination release potential to the environment. A liquid spill fire and resulting storage drum fire do not present an exposure hazard to any of the facilities. Therefore, there is no potential for a fire to spread to other areas. Also, since the storage waste has no replacement or salvage value, the primary cost associated with a drum fire event is the contamination cleanup.

A worst case scenario is considered in which a vehicle impacts a storage array of solid waste drums within the fenced area of PFP. The vehicle is assumed to have a fuel tank capacity of 227 liters (60 gallons) [WHC, 1995]. The fuel spill spread is assumed to occur in an optimal configuration such that the maximum number of storage drums are exposed to the fire for a period sufficient to cause lid loss failure. Figure 6-35 shows the layout of the storage drums and the configuration of the liquid spill fire.

Based on full-scale solid waste drum fire tests in which DOT 17H 208 liter (55-gallon) storage drums containing typical combustible wastes were exposed to liquid pool fires, an average exposure time of approximately 120 seconds was required to cause lid loss failure of a drum [Beitel, et al., 1994]. The drum fire tests considered several different exposures of the drums and demonstrated that lid loss failure can be expected where flames from a pool fire impinge the drum wall surface. In cases where the flames did not impinge the drums, lid loss failure did not occur.

In order to expose and breach the maximum number of drums to the pool fire, it is assumed that the fuel spills over an area such that the burning duration is 120 seconds (just long enough to cause lid loss failure). Kerosene properties are used to estimate the properties of the fuel. Based on values in the SFPE Handbook [Babrauskas, 1988], kerosene has a density of 820 kg/m^3 and a maximum mass burning rate of 0.039 kg/m^2-s. The area of the fuel spill is estimated using the following equation:



LEGEND
⊗ = Lid Loss Failure

Figure 6-35 Layout of TRU storage drums and liquid spill fire

$$A = \frac{m}{\dot{m}'' \, t} \tag{6-16}$$

where $\dot{m}''$= the mass burning rate (0.039 kg/m^2-s),
A = the area of the fuel spill,
t = the burning duration (120 seconds), and
m = the total mass of fuel.

The mass of fuel is approximately 186 kg (0.227 m^3 x 820 kg/m^3). Equation 6-16 yields a pool fire area of 39.7 m^2. Assuming a semi-circle spill configuration as shown in Figure 6-35 (a semi-circle spill configuration provides the maximum exposure to the drums) yields a diameter of 10.0 m. The diameter of a DOT 17H 208 liter (55-gallon) storage drum is 0.58 m. Assuming that the drums are arranged such that they are touching one another, approximately 18 drums in the first row are directly exposed to the pool fire. Figure 6-35 shows the drums which are expected to experience lid loss failure as a result of the fuel spill fire.

For this scenario, a total of 128 drums experience lid loss failure. It is assumed that all of the combustible contents within the breached drums burn. Although the liquid pool fire burns for only two minutes, the waste contents will continue to burn for several hours. Fire propagation through the storage array does not occur [Rhodes, et al., 1995]. This scenario bounds the solid waste drum fire event since conservative assumptions are made regarding drum spacing, fuel spill configuration, and lid loss failure. Contamination resulting from this event is addressed in Section 15.3.

6.14.3 Impact of Automatic Suppression System

There are no suppression systems protecting the outside solid waste drum storage areas.

6.15 SUMMARY OF FIRE HAZARDS

Based on the fire scenarios examined throughout Section 6.0, Table 6-14 summarizes the potential maximum effects.

Table 6-14. Summary of Fire Scenario Effects

Building	Fire Scenario	Potential Impact with Automatic Sprinkler Protection	Potential Impact Without Automatic Sprinkler Potential
234-5Z	Office/Lab/Process Area Fire First Floor	- Damage to fuel package and equipment - Contamination within facility	- Damage to Sections of building - Contamination of various levels of facility - Clogging of HEPA filters
	Office Fire/Combustible Liquid Fire Second Floor	- Damage to equipment	- Structural failure of second floor roof - Damage to equipment - Release of materials outside structure
	Hydrogen Generation Hazard	- Damage to drums	- Damage to drums
242-Z	Plastic Fire in Annex	- Damage to fuel of origin	- Loss of building contents - Structural failure of 242-Z
236-Z	Transient Combustibles in MT Glovebox Room	- Damage to glovebox and equipment - Contamination in facility	- Damage to glovebox and equipment - Contamination in facility
291-Z	Transformer Oil Fire	- Damage to transformers - Damage to equipment in Room 501	- Damage to transformers - Damage to equipment in Room 501
2736-ZB	Office/Lab Fire	- Damage to fuel of origin - Contamination in facility	- Damage to equipment/contents - Contamination in facility
2721-Z	Diesel Oil Fire	- Loss of equipment	- Loss of equipment - Damage to structure

Table 6-14. Summary of Fire Scenario Effects (continued)

Building	Fire Scenario	Potential Impact with Automatic Sprinkler Protection	Potential Impact Without Automatic Sprinkler Potential
232-Z	Transient Combustible Fire	N/A	- Damage to contents - Contamination
241-Z	Transient Combustible Fire	N/A	- Damage to contents
243-Z	Transient Combustible Fire	- Damage to equipment	- Damage to equipment
Compressed Gas Storage Areas	Propane Cylinder Leak	N/A	- Loss of storage structure - Damage to cylinders
Hazardous Product and Wastes Exterior Laydown Areas	Vehicle Fuel Exposure Fire	N/A	- Contamination release

N/A - Not applicable; sprinklers not provided in facility

SECTION 7 — GLOVEBOX FIRE PROTECTION ANALYSIS

As requested by Westinghouse Hanford Company (WHC),the fire safety features within the gloveboxes used in the Plutonium Finishing Plant (PFP) are assessed. The fire safety approach for gloveboxes includes analysis of existing active gloveboxes and existing gloveboxes which have been removed from service. In this analysis, the existing active gloveboxes used for the 94-1 Thermal Stabilization Process are specifically addressed for compliance with the Draft Glovebox Fire Protection Standard (DGFPS) [WHC, 1993] prepared for the U.S. Department of Energy by WHC. In addition, the fire hazards and potential fire spread for existing PFP gloveboxes is assessed based on the anticipated fuel loading. Recommended fire protection features are presented as a general guide; however, other alternatives are available for specific application based on a risk/cost analysis of the protection method versus overall hazard. The recommended glovebox fire protection features are proposed to be applicable to all existing gloveboxes used in PFP.

7.1 APPLICABLE CRITERIA

The need for fire safety systems is based on meeting the intent of the criteria found in the DGFPS based on its application to existing gloveboxes. Although not an official DOE document, the DGFPS is required by DOE-RL via RLID 5480.7, *Fire Protection* [1993]. Other criteria for glovebox fire protection is provided in NFPA 801, *Standard for Facilities Handling Radioactive Materials* [1995]. However, the DGFPS is generally more restrictive and incorporates most of the requirements for gloveboxes found in NFPA 801.

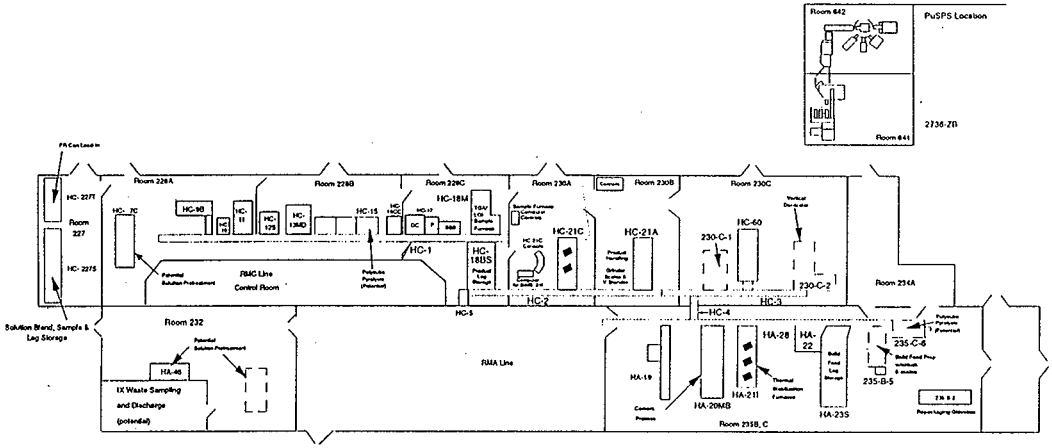
The DGFPS criteria applies to all *new* gloveboxes. Existing gloveboxes need only comply when a fire hazard analysis demonstrates conditions warrant their application. As such, this analysis investigates the fire hazards associated with *existing* PFP gloveboxes.

The DGFPS contains restrictive criteria regarding glovebox features including construction, ventilation, fire suppression and detection systems. An analysis of compliance of the existing gloveboxes with the DGFPS criteria is provided in Appendix D. Since it is often impractical to apply all of the DGFPS requirements to existing gloveboxes, an analysis of the potential fire hazards has been performed to determine what fire protection features are necessary based on criteria specified in Section 7.4.

7.2 94-1 THERMAL STABILIZATION PROCESS SUMMARY

The fire safety features required in the gloveboxes used for the 94-1 Thermal Stabilization Process are of particular concern to PFP facility staff. Figure 7-1 shows the layout of the gloveboxes and conveyors used for the 94-1 Stabilization Process. Plutonium bearing materials are sealed into glovebox 235-B-5, removed from the package, weighed, placed into a container called a boat, and then transferred via the conveyor system to glovebox HC-21C, HA-20MB, or HA-21I. The boat is placed into a muffle furnace and the appropriate temperature controller program started. The control program is pre-programmed to ramp and hold the furnace

Operational Logistics & Conveyors for 94-1 Stabilization



Solids: Thermal Stabilization Processing

Feed introduced into 235-B-5
- through airlock or can sphincter port
- Open cans, weigh, and change makeup
Leg Storage in HA-23S (feed)
Furnace operations in HC-21C and HA-21I
- control consoles in Room 230A
Product Handling in HC-21A
- weigh, sample, sealout, can, move to vaults
- leg storage rack for 8 items
Sample Analysis in Product Leg Storage HC-18M (TOA/LOI)

Liquids: Pretreat (if reqd), Vertical Denitrator Calciner

Feed from PR Cans in HC-227T to HC-227S
Blend, sample store in HC-227S
Transfer good feed directly to vertical denitrator via encased transfer line.
Transfer pretreatment feed to HC-7C for ion exchange (IX) with IX waste transferred to HA-46 (room 232) for sampling and disposal. IX clean product is transferred back to HC-227S for blending and sampling.
Powder from vertical denitrator transferred to 235-B-5, thermally stabilized

Figure 7-1 Operational logistics and conveyors for 94-1 Stabilization

temperature at rates and temperature soaks specific to the material being processed. The material is cooled, ground, blended, and sampled to verify that less than 1 percent volatiles remain. A Loss on Ignition analysis is used to verify that volatiles have been removed. The process material is then packaged for long term storage. [PFD-Z-190-00004, Rev B]

In addition to plutonium residues and oxides, solutions and combustible solids, including polycubes, will be stabilized and stored in the 94-1 gloveboxes. For a detailed description of the stabilization process and operations, the reader is referred to the *DNFSB Recommendation 94-1 Hanford Site Integrated Stabilization Management Plan* [WHC, 1995] and the *Thermal Stabilization Process Flowsheet Rooms 230 and 235, 234-5 Building* [PFD-Z-190-00004].

7.3 FIRE POTENTIAL FOR EXISTING GLOVEBOXES

In Appendix D, the fire protection features required to comply with the DGFPS criteria for new gloveboxes are identified for the 94-1 Stabilization Process Line. In this section, the performance of the existing gloveboxes under actual fire conditions is assessed based on the existing fuel load and glovebox conditions. The fire hazard associated with gloveboxes and acrylic window panels and the effectiveness of a fire suppression system within the gloveboxes are of particular concern. The purpose of this performance based design is to determine the minimum fire protection features required to provide an acceptable level of safety based on actual fire performance rather than prescriptive code criteria contained in the DGFPS.

7.3.1 Glovebox Fuel Load

In general, the combustible fuel load in PFP gloveboxes is low. The acrylic window panels and Hypalon gloves are the primary combustible fuels in the gloveboxes. These items are particularly important because they also provide containment for the gloveboxes. However, neither the plastic windows nor gloves are expected to be a primary ignition source. Rather, a fire within the glovebox will likely involve transient combustibles or other fuels associated with the glovebox process. A fire involving these fuels may then ignite the gloves or window panels, resulting in a more serious fire and potential loss of containment.

Transient combustibles may include rags, plastics, paper, insulation, flammable liquids and miscellaneous organic compounds. These combustibles may be plutonium-bearing residues and, therefore, represent a contamination hazard. In addition, some of the gloveboxes contain hydraulic oil filled systems. Although the hydraulic oils used in the PFP gloveboxes are Factory Mutual (FM) approved fire resistant oils (i.e., oils having a high flash point) [TWRS Industrial Safety and Fire Protection, 1995], they still pose an added fuel load.

Since the operational uses of the PFP gloveboxes are continuously changing, the ability to quantify the amount of combustibles in a particular glovebox at any given time is limited. However, the potential exists for any of the active gloveboxes to contain a number of transient combustibles. As such, this analysis focuses on the minimum amount of combustible materials required to pose a fire hazard in a glovebox.

7.3.2 Window Panel Fire Hazards

Most of the window panels on the PFP gloveboxes are constructed of acrylic plastic (i.e., polymethylmethacrylate or PMMA) and/or polycarbonate. PMMA readily ignites when exposed to small fires and results in a rapid rate of heat release and fire spread. The fire performance of polycarbonate is markedly better than that of PMMA (i.e., harder to ignite and lower rate of heat release). However, polycarbonate window panels still represent a significant fuel load in the gloveboxes.

Several of the window panels on the PFP gloveboxes are acrylic plastic (PMMA). Many of the PMMA panels extend the length and height of the gloveboxes along several sections. In a vertical configuration, such as the window panels, once the PMMA is ignited, it can sustain and propagate a flame without any external heating. Therefore, if a window panel is ignited, the fire can potentially spread from one glovebox to the next without intervention. In addition, if the PMMA is allowed to burn long enough, the window panel will burn through to the exterior or melt and deform away from the glovebox frame. In either case, the glovebox containment is compromised leading to potential fire spread and contamination of the room.

Because PMMA is inherently a fire hazard, it is necessary to either avoid igniting the PMMA window panels or control the fire before significant damage occurs. In this section, the minimum fire exposure required to ignite the glovebox windows is determined in order to assess the potential fire hazard based on the existing glovebox fuel load. In Section 7.3.3, suppression systems to control damage are discussed.

7.3.2.1 Fire Characteristics of Plastics

There has been a great deal of research regarding the ignition and burning characteristics of PMMA. This includes both small scale and full scale experiments and actual glovebox fire tests. Whereas the small and full scale tests provide insight as to the relative ease of igniting PMMA, the glovebox fire tests demonstrate its performance under realistic fire conditions. In addition to PMMA, experimental results for polycarbonate are also presented.

Table 7-1 provides ignition and heat release data for PMMA and polycarbonate [Babrauskas and Grayson, 1992]. The materials were tested in the Cone Calorimeter [Babrauskas, 1982] at three different exposure levels. In summary, the results indicate that PMMA ignites at very low incident heat fluxes and burns with a relatively high rate of heat release. By comparison, polycarbonate requires a much greater incident heat flux for ignition and burns at a much lower heat release rate.

Table 7-1. Ignition and Heat Release Rate Data for PMMA and Polycarbonate

Material	Time to Ignition (sec)			Average Rate of Heat Release (kW/m^2)			Flux for Time to Ignition of 10 minutes (kW/m^2)
Incident Flux	20 kW/m^2	40 kW/m^2	70 kW/m^2	20 kW/m^2	40 kW/m^2	70 kW/m^2	
PMMA	176	36	11	168	486	874	≤15
Polycarbonate	∞*	182	75	0*	89	115	34

* No ignition

The Cone Calorimeter results indicate that PMMA will ignite at incident heat fluxes as low as 15 kW/m^2. This flux is easily produced by even small fires impinging upon a PMMA panel. Fire tests involving 4 ft by 8 ft sheets of PMMA [Omega Point Laboratories, 1993] mounted in a vertical configuration show that an 18 kW fire can ignite the PMMA sheet in less than two minutes. Once ignited, the PMMA continues to burn and propagate the flame across the sheet. Eventually, the PMMA melts and forms a pool fire burning with an intensity in excess of 400 kW. In summary, test data demonstrates that a small fire will ignite a PMMA panel and once ignited, the PMMA will self propagate the flame.

To help visualize the size fire needed to ignite the PMMA windows, an 18 kW fire, which was used as the ignition source in the previous experiments, is approximately equal to a small pile of burning paper (or several rags) or an 8 in. diameter oil spill fire. Since an 18 kW fire causes ignition of PMMA in less than two minutes, the longer ignition times in Table 7-1 suggest that an even smaller fire would also cause ignition (e.g., smaller fires require a greater exposure time to ignite the PMMA). It is expected that a fire involving the typical combustibles found in a glovebox is capable of igniting a PMMA panel. Using polycarbonate would make it more difficult to ignite the window panel but still would not negate the possibility of burn through and loss of containment.

7.3.2.2 Glovebox Fire History and Fire Tests

A serious glovebox fire occurred at Rocky Flats in 1969 resulting in an estimated $45 million in damages. The fire continued to burn for several hours before it was brought under control. Failure of the PMMA glovebox windows provided a means for plutonium oxide to escape and contaminate the building. The absence of fire suppression in both the gloveboxes and building contributed to the extent of fire spread [Patterson, 1970].

Since the occurrence of the Rocky Flats glovebox fire, there have been several experimental studies investigating the performance of various glovebox designs under fire conditions [Peatross, 1992; Williams, 1970; Domning, 1970; Domning and Woodward, 1970]. These glovebox fire tests consistently showed that acrylic windows burn through or melt and deform away from the glovebox frame during a fire. Polycarbonate windows tended to melt and

deform but did not burn as readily as the PMMA. It was observed in several of the tests that once the glovebox was breached due to burn through or deformation of the window, the intensity of the fire would typically increase due to the additional air supply. Where Pyrex, safety glass, and wired glass were used, the windows typically cracked but remained in place during the test fires. Only when the glass remained in place was the glovebox integrity maintained.

In general, tests indicate that when noncombustible window panels are used, glovebox fires typically burn themselves out without serious incident. However, where combustible plastic windows are used, containment is almost always lost and the window panels usually contribute to the fuel load resulting in a more serious fire.

The experimental data discussed above demonstrates that PMMA glovebox panels present a serious fire hazard. It has also been shown that combustibles typically found in gloveboxes are sufficient to ignite acrylic window panels. Polycarbonate windows provide some resistance to ignition and have a lower rate of energy release than PMMA under fire conditions. However, for a glovebox fire, polycarbonate windows can ignite and burn, potentially resulting in loss of containment. In general, it was found that where combustible plastic windows are used, adequate fire breaks and/or fire suppression systems are needed to offset the flammability of the window materials.

7.3.3 Automatic Fire Suppression

Controlling a fire before significant damage occurs can be achieved by an automatic fire suppression system. Currently there are three different types of existing automatic fire suppression systems used in PFP gloveboxes:

1. Total flooding Halon systems,
2. Dry chemical systems, and
3. Limited water bottle stations (LWBS).

In this section, the ability of a fire suppression system to respond to a fire and its effectiveness in controlling a fire is assessed based on the existing conditions of the 94-1 Process Line gloveboxes.

7.3.3.1 Suppression System Activation

In order for an automatic fire suppression system to be effective, it must actuate under the expected fire conditions in a glovebox. The systems currently used in the PFP gloveboxes and the systems recommended in the DGFPS are all heat actuated systems. Therefore, the heat generated by a fire must raise the temperature of a heat sensitive element above a preset threshold limit in order for the suppression system to respond. The heat sensitive element may be a fusible link, such as that of a sprinkler system, or a separate heat detector type device. In either case, there will be some lag time between the temperature in the glovebox and the temperature of the activating device. Issues such as fire intensity, size of the glovebox, location of the activating device, and ventilation flow rates will all affect the response time of a suppression system. In

order to determine the minimum fire size needed to activate a fire suppression system, a validated heat detector actuation model is used.

An analysis using DETACT-QS, as included in FPETOOL [Nelson, 1990], was conducted to estimate the response time of the fire suppression heat activating devices in the gloveboxes. DETACT solves heat transfer equations between the ceiling jet or plume and the heat sensitive activating device. The input parameters include the height and radial distance of the heat sensitive element above the fire, the actuation temperature and response time index (RTI) of the element, and the heat release rate of the fire. DETACT-QS assumes that the ceiling is unconfined which is ideal for large rooms. For smaller compartments, such as a glovebox, this will result in longer predicted actuation times since the heat transfer from the descending hot gas layer is not included. In a glovebox fire, the hot gas layer is expected to significantly affect the response time of the suppression system. Factors such as ventilation airflows and heat losses through openings make it difficult to model. As such, a conservative approach is taken using the unconfined ceiling model to provide worst case response times for the suppression system.

Table 7-2 provides a summary of the DETACT-QS results for various glovebox heights, fire locations, and detector RTI values. The reported heat release rates indicate the minimum quasi-steady fire size needed to cause actuation of the suppression system within 5 minutes. Although a 5 minute actuation time does not necessarily prevent significant glovebox damage, it allows a comparison of the minimum fire sizes using a representative response time for a glovebox. The glovebox heights used in the model generally correspond to the range of heights found in the 94-1 Process Line gloveboxes. The activation temperature of the activating device is taken as 93°C since this is the activation temperature of the existing Halon and dry chemical systems in the 94-1 gloveboxes. The two RTI values selected effectively cover the range of values expected of heat sensitive devices. The radial distance of the detector from the fire ranges from being directly above the fire (rad. dist. - 0.0 m) to 0.9 m from the fire, reflecting a nominal 1.5 m detector spacing. Again, these represent the expected range of values for the glovebox configuration.

Table 7-2. Minimum Fire Size Required for an Actuation Time of Less Than 5 Minutes

Glovebox Height (m)	Minimum Fire Size (kW) RTI=100 $(m/s)^{1/2}$		Minimum Fire Size (kW) RTI=300 $(m/s)^{1/2}$	
	rad. dist. - 0.0 m	rad. dist. - 0.9 m	rad. dist. - 0.0 m	rad. dist. - 0.9 m
0.75	5	30	7	65
1.00	10	45	15	90
1.50	25	80	35	140

As seen in Table 7-2, relatively small fires (i.e., ≤35 kW) directly under the slower heat sensitive device (i.e., RTI=300 $(m/s)^{1/2}$) will actuate the suppression system within 5 minutes.

This size fire is representative of transient fuel loads found in many of the gloveboxes. For fires along the edge of the glovebox (i.e., radial distance = 0.9 m), larger fires are required to activate the suppression system. However, a fire along the edge of the glovebox can ignite the acrylic window panel within several minutes. As seen in Table 7-1, PMMA burns at a very high rate of heat release. As such, this will provide, as a minimum, the necessary heat output required to activate the suppression system.

Based on the DETACT-QS results, small to moderate size fires are expected to activate the automatic suppression system within a glovebox. Again, it should be noted that conservative assumptions are used in the analysis to obtain bounding conditions. Depending on the size of the fire and its location, it is possible that acrylic and polycarbonate window panels will ignite prior to activation of the suppression system. However, due to the rapid increase in fire intensity associated with burning plastics, the suppression system is expected to activate quickly thereafter.

7.3.3.2 Suppression System Agent Effectiveness

The ability to control or extinguish a glovebox fire depends on the type of suppression system used and the extent of coverage provided. For the 94-1 Process Line, only partial coverage is provided using LWBS, Halon, and dry chemical systems. Regardless of the type of suppression system provided, it is necessary to confine a fire to the glovebox of origin in order to prevent fire spread through a process line or to connected gloveboxes.

Glovebox fire tests [Domning and Woodard, 1970] have shown that automatic sprinklers are effective in controlling a glovebox fire but may not completely extinguish it. Sprinklers maintain control of the fire by continuously wetting and cooling the combustibles in the glovebox, thereby preventing ignition and fire spread. Since the fire is not always extinguished by sprinklers, the continuous application of water is important.

The LWBS used in the PFP gloveboxes function the same as automatic sprinklers. However, only a limited water supply is available. The purpose of limiting the water supply is to prevent a criticality event in the glovebox. However, if a glovebox fire is not completely extinguished when the water supply is depleted, the fire may continue to grow and spread to other gloveboxes. Factory Mutual [Factory Mutual Research Corporation, 1967] and the DGFPS both recognize the use of LWBS; however, these systems have not been tested to verify their effectiveness.

A Halon system is installed throughout the gloveboxes along the HC-1 and HC-2 conveyor. The Halon is a total flooding system and extinguishes a fire by interrupting the combustion chain reaction. For this to occur, an effective concentration is required throughout the volume of the gloveboxes for a period of at least 10 minutes. An airlock between gloveboxes HC-2 and HC-3 is provided to allow the containment needed to maintain the required Halon concentration in the protected gloveboxes.

Dry chemical systems are installed (or will be installed) in several gloveboxes containing furnace operations in the 94-1 Process Line. The dry chemical may act as a total flooding or

local application system. If the system is total flooding, it must maintain the required fire extinguishing concentration of agent in the glovebox. Where a local application system is used, the nozzles must be arranged to discharge the agent directly onto the protected areas.

Dry chemical systems are effective in extinguishing fires involving ordinary combustibles, flammable liquids, plastics, and electrical components. In some cases, a fire involving the plastic window panels can potentially spread beyond the protected glovebox prior to actuation of the suppression system. As such, where openings between gloveboxes are not equipped with automatic dampers, local application of the dry chemical may be required. A dry chemical system should be designed and installed in accordance with the applicable NFPA standards.

7.3.4 Potential Fire Spread and Contamination

As experienced in the Rocky Flats glovebox fire [Patterson, 1970], fire propagation through a glovebox process line is a possibility. The fire at Rocky Flats originated in a glovebox having plastic window panels. Once the windows ignited, the fire quickly spread to the connected conveyor box. Since the conveyor was also lined with plastic windows, the fire was able to rapidly spread throughout the process line to other gloveboxes. With no fire suppression or fire separations, a fire in one of the 94-1 gloveboxes could potentially spread throughout the process line, similar to the Rocky Flats fire.

A small fire in one of the 94-1 gloveboxes would require only minutes to ignite the acrylic window panels. During this time, smoke and combustion products would begin to clog the HEPA filters in the exhaust system. Once the window panels ignited, assuming there is no suppression system in the glovebox, the fire would rapidly grow in size producing large quantities of smoke. As the HEPA filters clog, the negative pressure in the glovebox would be lost and a positive pressure would be created by the fire. In turn, contaminated smoke would begin to leak to the room since the room is at a lower pressure. As the fire grows in size, the window panels, combustible gloves, and HEPA filters between the glovebox and the room would begin to burn through. This would allow additional air into the glovebox and would provide an additional means for contamination to spread to the room. Since there are no fire stops or dampers to contain the fire, the fire could spread to adjacent gloveboxes through the unprotected openings. Likewise, the fire could spread through the entire glovebox process line consuming all of the combustibles along the way.

The fire that occurred at Rocky Flats in 1969 shows that this scenario is possible. Such a fire would result in significant damage to the gloveboxes and would require contamination cleanup of the rooms containing the process line as a minimum. Since the building is protected throughout by an automatic sprinkler system, significant thermal damage or fire spread to other rooms would not occur. However, if the sprinkler system failed, a maximum possible fire loss could spread beyond the rooms containing the gloveboxes.

Since the gloveboxes are no longer used for production purposes, losing part or all of the process line would not result in an impact on the "site mission". In the event of a significant fire, WHC personnel indicate that the stabilization process would likely be moved to another part of

the facility and the damaged gloveboxes would no longer be used. As such, there are minimal replacement costs associated with loss of the process line.

The cost of cleanup is based on the cost of the recent decontamination of Building 232-Z. The cost per square foot of room surface area was approximately $3.18 for the Change Room and $3.62 for the Process Room in Building 232-Z [McKinnis, 1996]. Although the cost is normalized with respect to room surface area, the values reflect the cleaning of the room and its associated equipment and contents. Although these areas were not highly contaminated, they were decontaminated completely. As a conservative estimate, a cleanup cost of $4.00 per square foot of room surface area is used in this analysis. This value is used for all levels of contamination and includes the cleaning of the room walls, floor, ceiling, and all contents within the room.

To evaluate the loss for a credible fire event, it is assumed that cleanup of the rooms would require decontamination of the walls, floors, ceilings, equipment, and other materials. A fire involving the entire 94-1 Process Line would potentially cause contamination in all of the rooms containing the damaged process line including: Room 227, Rooms 228A,B,C, Rooms 230A,B,C, Room 234A, Rooms 235A,B,C, Room 232 and Room 233. Based on a cleanup cost of $4.00 per square foot of surface area, a rough estimate of the floor, ceiling, and wall surface area in the potentially contaminated rooms yield an estimated cleanup cost of approximately $180,000 (~45,000 sq ft @ $4/sq ft).

Limiting smoke contamination to the rooms containing the process line assumes that the negative pressure in the rooms with respect to the corridor is maintained. A fire involving the acrylic window panels on the gloveboxes will produce large quantities of smoke and combustion products. Smoke from the fire could potentially clog the room exhaust HEPA filter boxes resulting in a positive room pressure. In this case, smoke would escape to the corridor where it would be drawn into other rooms at lower pressures. This would result in a much larger area of contamination and cleanup cost than that estimated above.

In addition to contamination cleanup, gloveboxes and equipment in the process rooms and adjacent spaces may be damaged from a fire. The maximum extent of fire propagation resulting from a fire in the glovebox process area is discussed in Section 6.3.3. It should be noted that for the 94-1 gloveboxes, the installation of a suppression system in the gloveboxes does not affect the MPFL.

7.4 RECOMMENDED FIRE PROTECTION FEATURES

Based on the analysis of the existing PFP gloveboxes, in particular those used for the 94-1 Thermal Stabilization Process, recommendations with respect to glovebox fire protection are provided for both active gloveboxes and gloveboxes removed from service (i.e., inactive gloveboxes).

It is recognized that the facility staff wishes to comply with the intent of the DGFPS and other applicable codes. However, it does not appear cost effective to retrofit all of the gloveboxes to comply with the DGFPS. Given the condition of the existing gloveboxes and extensive modifications necessary to comply with all of the applicable criteria, more practical methods of protection are considered. In this section, alternatives are presented which provide a specific level of fire protection for the gloveboxes consistent with the intent of the DGFPS. The alternative fire safety features presented in this section are intended to be applicable to all existing PFP gloveboxes.

Tables 7-3 and 7-4 provide a summary of the recommended fire protection features for *existing* active and inactive gloveboxes which are part of process lines in addition to those which are isolated from other gloveboxes.

The overall goal of the recommended protection strategies is to control the extent of burning from a fire to a single glovebox. Where contamination or operational concerns do not allow for the loss of a particular glovebox, including the loss of integrity of the glovebox and the spread of contamination to other gloveboxes or the room, additional fire protection features may be required.

Appendix F contains a cost/risk analysis of the potential glovebox fire hazards and protection options. The cost/risk assessment evaluates the relative benefit of several different protection options in terms of extent of damage and contamination spread. Based on the desired level of protection, an acceptable fire protection scheme can be implemented for the 94-1 gloveboxes.

7.4.1 Inactive Gloveboxes

In several areas, inactive gloveboxes (i.e., gloveboxes removed from service) are connected or adjacent to other active gloveboxes. Inactive gloveboxes are not utilized in any manner for storage, processing, transfer or other functions relating to a process occurring at the facility. Since many of these inactive gloveboxes will not be used again and will eventually be decontaminated and decommissioned, it is undesirable to install or maintain fire suppression and detection systems within them. However, these gloveboxes often still contain combustible materials and, like the 94-1 gloveboxes, many have acrylic and/or polycarbonate window panels. In addition, several of these gloveboxes are directly connected to active conveyor systems serving other active gloveboxes. As such, the existing fuel loading and potential fire spread hazard may not justify the absence or removal of automatic detection and suppression systems.

Consistent with the intent of the DGFPS, feasible protection options are presented which provide a level of protection sufficient to limit a fire to a single glovebox. Fire spread is limited by eliminating ignition sources and fuel loads, and by minimizing the potential for fire spread. Compliance with the stated conditions is required at all times in order to implement the alternative protection methods. Other existing features such as glovebox construction, ventilation arrangement, manual fire suppression, and glovebox operating procedures are assumed to remain unchanged.

Table 7-3. Process Line Gloveboxes — Recommended Fire Protection

Status	Plastic Windows (polycarbonate or acrylic)	Glass Windows
Inactive	• Automatic suppression or inerting system or • Separation; and remove all combustibles; and provide automatic detection or • Separation: and remove all combustibles; and remove ignition sources; and cap gloves	• Automatic suppression or inerting system or • Separation; and contents limited to ordinary combustibles; and provide automatic detection or • Remove all combustible contents; and remove ignition sources; and provide automatic detection or • Separation; and remove all combustibles; and remove ignition sources; and cap gloves
Active	• Automatic suppression or inerting system	• Automatic suppression or inerting system or • No flammable liquids; storage of combustible materials less than that required to activate suppression system; and combustible materials transported during supervised operation only; and provide automatic detection
Containing combustible or pyrophoric metals	• Gas inerting system or • Apply inactive/active glovebox criteriafor oxidation processes	• Gas inerting system or • Apply inactive/active glovebox criteriafor oxidation processes

Table 7-4. Stand Alone Glovebox - Recommended Fire Protection

Status	Plastic (polycarbonate or acrylic) and/or Glass Windows
Separated greater than 10 feet from other gloveboxes	• Automatic suppression or inerting system or • Automatic detection or • Remove all combustible contents; and remove ignition sources; and cap gloves
Separated less than 10 feet from other gloveboxes	• Must comply with Table 7-3 criteria; Physical separation complies with separation criteria specified in Table 7-4 or • Analysis demonstrates that the fire exposure to other gloveboxes within 10 feet does not cause fire spread

- **An inactive glovebox having acrylic or polycarbonate window panels and which is physically connected to at least one other active glovebox requires an automatic fire suppression or gas inerting system unless the following conditions are maintained:**

  1. *The inactive glovebox is completely separated from all other active gloveboxes by a permanent noncombustible fire wall or partition (note: any physical separation or spacing between gloveboxes meets this criteria); and*

  2. *All combustible materials (excluding plastic window panels and fixed gloves) are removed from the inactive glovebox, and*

  3. *Automatic fire detection is provided.*

Providing separation prevents fire spread between gloveboxes. This also inhibits the use of the inactive glovebox for temporary storage or other operations associated with the process line. Separation can be provided by either a permanent wall or partition or by physically separating the gloveboxes (e.g., a 1 foot spacing between gloveboxes). Removing the combustible materials from the glovebox eliminates most fuel load and potential ignition sources for the plastic window panels and combustible gloves. Combustible materials required to be removed include transient items such as rags,

plastics, paper, filters, insulation, and miscellaneous organic compounds. In addition, any hydraulic oil filled systems within the glovebox must be drained.

- **An inactive glovebox having solely glass window panels and which is connected to at least one other active glovebox requires an automatic fire suppression or gas inerting system unless the following conditions are maintained:**

  1. *The inactive glovebox is completely separated from all other active gloveboxes by a permanent noncombustible fire wall or partition, and the glovebox contents are limited to ordinary combustibles (i.e., no flammable liquids or combustible metals), and automatic fire detection is provided, <u>or</u>*

  2. *All combustible materials (excluding fixed gloves), electrical power, and other ignition sources are removed from the inactive glovebox, and automatic fire detection is provided.*

Glass window panels significantly reduce the fuel load and fire spread potential in the inactive glovebox. This is reflected in the less stringent criteria than that required for inactive gloveboxes having plastic windows. If separation is provided, a fire in the inactive glovebox will be contained by the noncombustible construction. Also, the separation prevents a fire in the active gloveboxes from spreading to the unprotected inactive glovebox. If separation is not provided and all of the combustibles and potential ignition sources are removed, this will prevent a fire from originating in the inactive glovebox. Likewise, removing all of the combustibles will minimize the potential fire spread from an adjacent active glovebox.

These requirements significantly reduce the fire hazard within the inactive glovebox, thereby, minimizing the need for automatic fire suppression. However, the combustible gloves, existing electrical equipment and wiring, and in some cases plastic windows, found in the inactive glovebox necessitate the need for an automatic fire detection system in the absence of an automatic suppression system.

- **An inactive glovebox having acrylic, polycarbonate, or glass window panels and which is connected to at least one other active glovebox requires an automatic fire detection system unless the following conditions are maintained:**

  1. *An automatic fire suppression or gas inerting system is provided, <u>or</u>*

  2. a. *The inactive glovebox is completely separated from all other active gloveboxes by a permanent noncombustible fire wall or partition, <u>and</u>*

b. *All combustible materials (excluding plastic window panels) are removed from the inactive glovebox, and*

c. *All gloves are removed from the inactive glovebox and replaced with covers or plugs, and*

d. *Electrical power and other ignition sources are removed from the inactive glovebox.*

Removing the gloves and electrical power further reduces the combustible fuel load and, in conjunction with the other requirements, eliminates all possible ignition sources from the glovebox. In addition, removing the gloves and electrical power further inhibits the use of the inactive glovebox for future process operations.

These protection requirements for inactive gloveboxes provide the means for deactivating existing detection and suppression systems. In addition, where automatic suppression systems may be required in active gloveboxes, the recommended alternatives provide a basis for not installing new systems within the unprotected, inactive gloveboxes. Implementing these fire protection features will require strict administrative controls to ensure that all of the conditions are maintained. Where only partial compliance is possible, the required fire protection features must meet the more stringent glovebox criteria or may be determined on a case-by-case basis.

7.4.2 Active Gloveboxes

Active gloveboxes include those used in the 94-1 Stabilization Process and any other PFP gloveboxes not meeting the conditions established in Section 7.4.1 for inactive gloveboxes. Although many of these are in a standby mode, their combustible loading and potential for fire spread require them to be treated as active gloveboxes. In this section, recommended fire protection features are provided for existing active PFP gloveboxes. The recommendations are consistent with the intent of the DGFPS and provide a level of protection sufficient to limit a fire to a single glovebox. Compliance with the stated conditions is required at all times in order to implement the alternative protection methods. As with the inactive gloveboxes, the recommendations in this section assume that other existing features such as glovebox construction, ventilation arrangement, manual fire suppression, and glovebox operating procedures remain unchanged.

- **An active glovebox having acrylic or polycarbonate window panels and which is connected to at least one other active glovebox requires an automatic fire suppression or gas inerting system.**

- **An active glovebox having solely glass window panels and which is connected to at least one other active glovebox requires an automatic fire suppression or gas inerting system unless the following conditions are maintained:**

  1. *The active glovebox is not used to handle flammable liquids, and*

2. *The amount of combustible materials stored in the active glovebox is less than that required to activate an automatic fire suppression system (see Section 7.3.3), and*

3. *Combustible materials (other than those permitted by number 2) which are transported or temporarily handled within the active glovebox are only permitted during supervised glovebox operations, and*

4. *Automatic fire detection is provided.*

- **A glovebox in which combustible or pyrophoric metals are in use must be equipped with an inert gas purging system.**

  Exception: Gloveboxes used for oxidizing combustible or pyrophoric metals (e.g., in muffle furnaces) should comply with the applicable glovebox criteria for gloveboxes not using combustible or pyrophoric metals.

A gas inerting system is necessary in these cases because the suppression systems described in Section 7.3.3.2 are not effective in extinguishing combustible or pyrophoric metal fires. In cases where the glovebox is used for oxidation processes, it is impractical to inert the glovebox since air (i.e., oxygen) is needed for the oxidation process. Given the small amounts of materials involved during the oxidation process, the glovebox detection and suppression criteria are expected to provide an acceptable level of protection. Where gas purging systems are used, they must be designed and installed in accordance with the applicable NFPA standards and the DGFPS.

Although the DGFPS recommends several fire protection features, all of which provide additional protection, automatic fire suppression is essential to controlling fire development and spread through the glovebox process line. For gloveboxes having only glass window panels, in some cases, a detection system may be used in lieu of a suppression system. However, if a suppression or inert purging system is provided, a separate fire detection system, unless used to activate the suppression system, is not required. Again, these criteria apply to all existing gloveboxes not meeting the conditions established in Section 7.4.1 for inactive gloveboxes.

7.4.3 Stand Alone Gloveboxes

In Sections 7.4.1 and 7.4.2, fire protection criteria is established for gloveboxes which are connected to other gloveboxes. However, many of the existing inactive and active gloveboxes in PFP are not connected to other gloveboxes. Rather, these stand alone gloveboxes are isolated and do not necessarily pose a fire spread hazard to other gloveboxes. For the purpose of this report, stand alone gloveboxes are defined as existing active or inactive gloveboxes which are not connected to other gloveboxes.

In order to prevent a fire in a stand alone glovebox from spreading to other gloveboxes, a safe separation distance is needed. The radiant heating from a fully involved stand alone

glovebox fire can ignite the gloves and/or window panels of nearby gloveboxes. Providing a separation distance of at least 10 feet between a stand alone glovebox and other gloveboxes minimizes the fire spread potential resulting from a stand alone glovebox fire. This separation distance is based on a conservative estimate of a glovebox fire radiating to another glovebox 10 feet away. The fire is approximated as a 10 feet wide by 10 feet high flame at 1000°C. The radiant heat flux to a point at mid-flame height located 10 feet away is less than 10 kW/m^2. This heat flux is less than the minimum heat flux required to ignite PMMA (see Table 7-1). In some cases, an analysis may demonstrate that a separation distance of less than 10 feet is sufficient to prevent fire spread to other gloveboxes.

For gloveboxes which are part of a process line, fire protection provisions are provided to contain fire involvement to a single glovebox. Since a fire in a stand alone glovebox cannot easily spread to other gloveboxes, this goal is expected to be maintained. Assuming that the room containing the glovebox is sprinklered, a fire in a stand alone glovebox may destroy the glovebox and its contents, but for a credible scenario, will not spread beyond the confines of the room. As such, regardless of the glovebox construction, stand alone gloveboxes do not require automatic fire suppression. However, since prompt response to a glovebox fire is desired, automatic fire detection is still recommended.

- **A stand alone glovebox separated from other gloveboxes by a distance of not less than 10 feet requires an automatic fire detection system unless the following conditions are maintained.**

  1. *An automatic fire suppression or gas inerting system is provided, <u>or</u>*

  2. a. *All combustible materials (excluding plastic window panels) are removed from the glovebox, <u>and</u>*

     b. *All gloves are removed from the glovebox and replaced with covers or plugs, <u>and</u>*

     c. *Electrical power and other ignition sources are removed from the glovebox.*

- **A stand alone glovebox located within 10 feet of another glovebox must comply with the criteria in Sections 7.4.1 or 7.4.2 for gloveboxes connected to other active gloveboxes unless an analysis can demonstrate that the fire exposure hazard to any glovebox within 10 feet is not sufficient to cause fire spread.**

Note: Any physical separation (e.g., 1 foot) complies with Section 7.4.1 criteria for separation of gloveboxes.

It is important to note that if loss of containment from a stand alone glovebox fire is not acceptable due to contamination, life safety, or operational concerns, automatic fire suppression or other protection features will be required.

7.4.4 Automatic Fire Suppression

Since automatic fire suppression is being relied upon to control a glovebox fire and prevent it from spreading to other gloveboxes, proper selection and installation of the suppression system is important. General guidelines are provided regarding the potential use and effectiveness of various suppression systems. However, the specific design and installation details depend on the fire suppression system ultimately chosen. Systems installed must be in accordance with the applicable design standards (e.g., NFPA).

Based on test data, automatic sprinkler protection provides the best means for controlling fires and is recommended where criticality is not a concern [Williams, 1970]. Installation of a sprinkler system must be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems* [1994], and the DGFPS.

The DGFPS and Factory Mutual [Factory Mutual Research Corporation, 1967] both recognize limited water bottle stations (LWBS) as an acceptable means of fire suppression. Currently there appears to be no fire test data to demonstrate the effectiveness of LWBS.

If criticality is a concern, using an automatic sprinkler system as the required fire suppression may not be desired. If so, a total flooding and/or local application dry chemical suppression system should be used. The system should be installed in accordance with NFPA 17, *Standard for Dry Chemical Extinguishing Systems* [1994], and the DGFPS. Unlike a sprinkler system, a dry chemical system does not continuously discharge the extinguishing agent. As such, it is important to design the dry chemical system to completely extinguish a glovebox fire during the limited discharge time. If pre-engineered systems are used, they should be installed in accordance with their listing and the manufacturer's installation manual.

Halon fixed fire suppression systems are being phased out of DOE facilities [DOE, 1993]. When feasible, existing Halon systems should be removed and replaced with either an automatic sprinkler or dry chemical suppression system. Where existing Halon systems are to be maintained, such as in some of the 94-1 gloveboxes, the design of the Halon system must be in accordance with *NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems [1992].*

SECTION 8 — PROTECTION OF ESSENTIAL SAFETY CLASS EQUIPMENT

"An engineered safety feature is a system, component, or structure that prevents and/or mitigates the consequences of all potential accidents including the design basis accidents" [DOE Order 5480.7A, 1993]. A Westinghouse Hanford Safety Class item is comparable to a DOE Order 6430.1A "safety class" item and provides protection of the offsite public and environment. Westinghouse Hanford also provides criteria for Safety Significant Items; however, these are not addressed as essential safety class systems.

Westinghouse Hanford's Safety Class system defines Safety Class as any system, component, or structure, including portions of process systems, whose failure could cause undue risk to the environment or the safety and health of the public. Safety Class items are subject to the appropriate higher quality design, fabrication, and industrial test standards and codes per DOE Order 6430.1A or to other comparable safety-related codes and standards that are appropriate for the system being designed. Safety Class items must be controlled by a comprehensive quality assurance program consistent with the requirements of *Quality Assurance Program Requirements for Nuclear Facilities* (ANSI/ASME NQA-1).

The only fire protection systems which are Safety Class items are the structural fire barriers (e.g., Stairs 1 and 2 in 234-5Z). A comprehensive list of PFP Safety Class items is documented in *PFP Safety Equipment List, WHC-SD-CP-TI-108, Rev. 15* [WHC, 1996]. There are 7 general categories of Safety Class items at the PFP. The categories are as follows:

(1) *Plutonium Building Structural Features* - Items in this group provide the final barrier to the environment. Loss of these barriers could potentially result in release of dispersible contaminated material during emergency conditions.

(2) *HEPA Filters, Secondary and Final Stage* - These items are part of the confinement safety boundary which is established to ensure that air from potentially contaminated and known contaminated areas within the PFP Complex is filtered by nuclear-grade HEPA filters before discharge to the environment. These HEPA filters maintain a protection envelope for off-site releases of radioactive materials from the PFP Complex.

(3) *Effluent Stack Air Monitors and Alarms* - The Effluent Stack Monitors ensure that the release of alpha emitting radionuclides to the environment via the building exhaust stacks is continuously monitored and alarms are initiated if the release exceeds identified limits.

(4) *HVAC Supply Fan Seismic Shutdown System* - A significant contamination spread could result from a 0.25g safe shutdown earthquake if the building were pressurized by the main supply fans while the exhaust fans no longer functioned. The seismic shutdown system ensures ventilation supply shutdown during an earthquake event.

(5) *Liquid Detector and Interlock in 26 in. Vacuum System* - Upon detection of liquid in the 26 in. vacuum header, this system must shutdown to preclude liquid from entering the geometrically unfavorable HEPA filters. This equipment provides a defined contingency in the double contingency principle of nuclear criticality. Components whose failure could result in the loss of double contingency protection for an accidental nuclear criticality independent of dose consequences are Safety Class.

(6) *Glovebox Criticality Design Features* - Items in this group consist primarily of glovebox criticality drains and screens. This equipment provides a defined contingency in the double contingency principle of nuclear criticality. Components whose failure could result in the loss of double contingency protection for an accidental nuclear criticality independent of dose consequences are Safety Class.

(7) *Plutonium Storage Arrays* - The plutonium storage arrays provide a defined contingency in the double contingency principle of nuclear criticality. Components whose failure could result in the loss of double contingency protection for an accidental nuclear criticality independent of dose consequences are Safety Class.

In general, Safety Class systems in the PFP are protected by one or more of the following: (1) automatic suppression systems, (2) automatic fire detection, (3) compartmentation/separation of hazards, (4) redundant safety systems, and (5) scheduled maintenance and testing. Potential damage of Safety Class systems is described in Section 6 for the applicable MPFL fire scenarios.

If the suppression systems in the buildings fail, scenarios exist that can cause damage to Safety Class Systems. PFP's Safety Equipment is described by classification of structures, components, and systems in the FSAR (Chapter 4, Section 4.4) [WHC-SD-CP-SAR-021]. The FSAR describes the equipment important to safety and necessary to control the operational risks that PFP imposes on the environs and on and off site personnel. WHC-SD-CP-OSR-010, "PFP Operating Safety Requirements," provides additional controls and information necessary for proper function of the equipment and operational responses and restrictions when the safety class equipment performance has degraded.

Based on FHA analyses, total failure of all Safety Class Systems is not possible as a result of any of the MPFL scenarios. Based on PFP staff input, failure of Safety Class equipment and subsequent consequences of their failure is addressed in the FSAR and bounds all possible scenarios in the FHA.

The following discusses the effects of failure of individual safety class equipment and systems as specified by PFP staff:

- Total failure of Plutonium Building Structural Features and HEPA Filters Safety Class systems is addressed in Chapter 9 PFP FSAR [WHC-SD-CP-SAR-021]

which accepts total shutdown of all safety systems in the most severe case, the design basis earthquake. The maximum release of radioactive materials out of the facility is within the limits specified by DOE. The analysis includes loss of containment through building structure failure. PFP has designed the ventilation system to shut down in the event of an earthquake. Seismically induced concurrent criticality and fire events have also been analyzed and do not produce an unacceptable release. The two stages of the HEPA Filters are located in different locations within the facility. The Primary Filter System located in room 308 is not expected to become involved in the MPFL scenario which prevents total loss of filtration. The alternative exists to manually shut down the system without resulting in unacceptable consequences. Thus, the total loss of this safety class equipment has been addressed and the resultant consequences deemed acceptable by facility staff.

- The Effluent Stack Air Monitors are located on the stacks with common alarm equipment located in rooms outside of those areas affected in MPFL scenarios. Due to the various locations of the equipment, and the stack structures being remote from the building and noncombustible, total failure is not addressed.

- Both the HVAC Supply Fan Seismic Shutdown System and Liquid Detection/Interlock In 26" Vacuum System have been designed with fail safe modes that shut down both systems with any disruption to the power supply.

- Glovebox Criticality Design Features Systems are located through out the facility. These systems were designed as passive safety features that will perform as needed in any fire scenario.

- The Plutonium Storage Arrays are not addressed in MPFL scenarios because of lack of fire potential. These systems were designed as passive safety features that will perform as needed in any fire scenario.

SECTION 9 – LIFE SAFETY CONSIDERATIONS

9.1 OCCUPANCY TYPE

For the purposes of this Fire Hazard Analysis, each of the structures evaluated is classified according to a specific occupancy type as defined by NFPA 101 *Life Safety Code* [NFPA, 1994]. The buildings addressed fall into one or more of the following occupancy classifications: business, general and special purpose industrial, storage, and mixed use occupancy. A mixed use occupancy classification covers structures whose primary functions include more than one occupancy type.

The specific occupancy type of each structure is presented in Table 9-1

Table 9-1. Building Occupancy Classifications

Building	Occupancy Classification
232-Z Building	Special Purpose and General Industrial
234-5Z Complex	Mixed Use - Business, Storage, Special Purpose and General Industrial
236-Z Building	Special Purpose and General Industrial
241-Z Building	Mixed Use - Storage, Special Purpose and General Industrial
242-Z Building	Mixed Use - Storage, Special Purpose and General Industrial
243-Z Building	Special Purpose and General Industrial
291-Z Building	Special Purpose and General Industrial
2721-Z Building	Special Purpose and General Industrial
2736-Z Complex	Storage

In order to meet the requirements of the code, each building must meet the requirements for the applicable occupancy type. Where two or more occupancy types occur in the same building or structure and are so intermingled that separate safeguards are impracticable, the installed safeguards must comply with the most restrictive requirements for the occupancies involved.

9.2 MEANS OF EGRESS

All of the buildings have exit capacity and numbers exceeding that required. Only Buildings 232-Z, 234-Z, and 236-Z have more than one-story which require exits from above

grade. The majority of these exits are provided by stairs. The only exceptions are the installation of ladders on the west end of 234-5Z Building and the roof access ladders in 236-Z Building.

Ladders are permitted for use as exits if (see Section 5-2.9.1):

1. They provide access to unoccupied roof spaces, and
2. They provide a secondary means of egress from towers, elevated platforms, boiler rooms, and similar spaces which are subject to occupancy by only able bodied adults, totaling more than three in number.

Both of these spaces meet these requirements and are therefore in compliance with the code.

Some of the exit doors in the facilities (e.g., door no. 8 in Building 2736-Z) require multiple actions in order to open. Section 5-2.1.5.3 requires that a latch or other fastening device on a door shall be provided with a knob, handle, panic bar, or other simple type of releasing device having an obvious method of operation under all lighting conditions. Doors shall be operable with no more than one releasing operation.

9.3 EXIT CAPACITY

The *Life Safety Code* mandates that all structures provide a minimum amount of exit capacity. The required exit capacity is a function of the actual maximum anticipated occupancy (number of persons). In order to ensure adequate exiting ability, the code established minimums based on the occupiable space (area) available. For the occupancy classifications listed in Table 9-1, the occupant load factor is one person for every 100 ft^2 of building footprint area. Table 9-2 indicates the *Life Safety Code* minimum number of occupants for whom exits must be provided, the number of exits, doors and or stairs, and the estimated exit capacity. In all cases, the exit capacity provided by existing exits exceeds the minimum code requirements.

Table 9-2. Exit Capacity

Building	Minimum Exit Capacity	Number of Exits	Estimated Exit Capacity
232-Z Building	20 Each Floor	2 - 1st floor 1 - 2nd floor	360 180
234-5Z Building	696 Each Occupied Floor	18 - 1st floor 5 - duct level 6 - 2nd floor	3240 900 900
236-Z Building	58 1st floor 48 2nd floor 6 5th and 6th floor	9 3 1	1620 540 180
241-Z Building	15	2	360
242-Z Building	13	2	360
243-Z Building	15	5	900
291-Z Building	95	2	360
2721-Z Building	9	2	360
2736-Z Building	150	5	900

9.4 NUMBER OF MEANS OF EGRESS

The *Life Safety Code* requires two means of egress from every floor except in the industrial occupancies where the travel distance is less than 50 feet. All of the areas listed in Table 9-2 as having only one exit are in industrial occupancies and have travel distances significantly less than 50 ft.

9.5 ARRANGEMENT OF MEANS OF EGRESS

Where two exits are provided, they must be remote from each other (NFPA 101, Section 5-5.1.3). Further, no common path of travel or dead-end can exceed the distance specified in Table 9-3. Over the years, special life safety features have been implemented in the PFP buildings in order to facilitate occupant egress. In addition to exit signage, all exit doors have been painted green so that they are easily identified in an emergency. In the duct level, the exit routes are identified by a painted path on the floor. During the site survey, there were no arrangement of means of egress deficiencies identified for the PFP facilities.

Table 9-3. Dead End and Common Path of Travel Criteria

Occupancy Classification	Dead-End Limitation	Common Path of Travel Limitation (Sprinklered Facility Criteria)
Business	50 ft (27-2.5.2)	75 ft (100 ft)
Storage	50 ft (29-2.5.3) 100 ft in sprinklered facility	50 ft (100 ft)
Industrial	50 ft (28-2.5.2)	50 ft (100 ft)

9.6 TRAVEL DISTANCE

In order to ensure prompt access to exits, the *Life Safety Code* has maximum allowable distance persons are allowed to travel before reaching an exit. This distance is limited as specified in Table 9-4.

Table 9-4. Travel Distance Criteria

Occupancy Classification	Travel Distance without Sprinklers	Travel Distance with Sprinklers
Business	200 ft (27-2.6)	300 ft (27-2.6 Ex.)
Storage	200 ft (29-2.6)	400 ft (29-2.6 Ex. No. 1)
Industrial	200 ft (28-2.6.1)	250 ft (28-2.6.1 Ex. No. 1)

DOE 6430.1A provides additional criteria for areas where an accidental breach of a primary confinement could expose personnel to radioactive material (e.g., the 94-1 glovebox areas). In these areas, the travel distance is limited to 75 feet to reach an exit access route in a different air zone. None of the buildings or areas contained within the scope of this study are in violation of the travel distance provisions of NFPA 101 or DOE 6430.1A.

9.7 PROTECTION OF VERTICAL OPENINGS

The exit stairs and elevator in Building 234-5Z and the stairs in Building 236-Z appear to be enclosed in fire resistance rated construction. Penetration of the stairs for conduit or other devices exists. In addition, emergency cabinets that contain supplies for emergency contamination conditions are stored in the stairs of 236-Z. The cabinets do not block the path of the stairwell and must remain in their present location to facilitate emergency response at all levels of PRF.

The hydraulic elevator pump for the PRF elevator is located on the first floor level in Stair No. 1. However, since this stair is not a required exit stair, there is no deficiency related to the elevator equipment.

Exit stairs are required to be enclosed in rated construction (Sections 27-3.1, 28-3.1 and 29-3.1). Sealed existing penetrations are allowed to remain.

9.8 EMERGENCY LIGHTING AND EXIT SIGNS

Battery pack emergency lights are provided in most rooms and along the primary exit paths. Illuminated exit signs are installed at exit doors. Based on facility staff input, the emergency lighting system in the plant has known deficiencies which are being evaluated. It is recommended that a complete evaluation of the emergency lighting system be conducted. If deficiencies are found, they should be addressed with work packages or corrective actions to ensure compliance with NFPA 101 for emergency lighting and exit signage. (See NFPA 101, Section 5-5, 5-9, and 5-10).

9.9 INTERIOR FINISH

Interior finish in Industrial Occupancies is required to have a maximum flame spread rating of 200 and a maximum smoke developed rating of 450 based on NFPA 101 criteria (Sections 28-3.3.1 and 6-5.3.2). However, DOE-RL [RLID 5480.7, Section 8.2.e] provides more restrictive criteria for nuclear facilities and laboratories. In these areas, interior finish materials (e.g., decorations, furnishings, and exposed wall or insulating materials) are required to have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, except for acoustical materials, which shall have a smoke developed rating of 100 or less. In Building 234-5Z, there are several areas which do not comply with these criteria (e.g., Room 303L - foam rubber, 303 - plywood, 306 - wood paneling). However, since these areas are limited to the second floor office spaces of a fully sprinklered building and not nuclear areas or laboratories as specified in DOE-RL, it is not recommended that actions be taken to correct the deficiencies.

The interior finish in Building 242-Z is known as "Butvar" (trademark of Monsanto Company). Since there are several different types of Butvar available and detailed information regarding the type was not available from facility staff, the flame spread rating and smoke development properties of this material are unknown. However, based on the facility being unoccupied, sprinkler protection being provided, and the fuel load specified by facility staff, the interior finish is not a concern.

SECTION 10 – CRITICAL PROCESS EQUIPMENT

Critical process equipment is not clearly defined in the applicable DOE order, DOE 5480.7A. For this Fire Hazard Analysis critical process equipment is defined as equipment that is considered necessary to the Hanford Site mission. Based on this definition and input from facility staff, there are no critical process equipment designated for the PFP facilities.

SECTION 11 — HIGH VALUE PROPERTY

High value property for purposes of this analysis is defined as property or equipment with replacement costs estimated in excess of $1 million as identified in the RL Property System (Appendix E). The RL high value property/equipment and associated replacement costs for the PFP facilities are identified in Table 11-1. Damage to some of the high value property/equipment is possible based on the postulated fire scenarios as discussed in Sections 6.0 and 12.0. In some areas, such as Room 132 in Building 234-5Z, where the mass spectrometer is located, additional fire protection (e.g., smoke detectors) is installed to protect the high value property. However, in most areas, high value property is protected to the same level as the building in which it is located. Based on the identified high value items and existing level of protection, no additional fire protection systems are recommended for the high value property.

Table 11-1. High Value Property (RL Property System)

Room	Property/Equipment	Property Number	RL Replacement Costs (dollars)
Building 234-5Z			
--	Power Wiring	F174335	2,362,005
--	General System Equipment	F174866	14,377,501
--	General System Equipment	F175343	1,162,584
--	Piping	F227418	9,147,096
--	Fire Alarm Equipment	F258335	5,437,134
--	Monitoring System	F262090	1,632,871
--	Piping	F262536	1,149,854
Perimeter Fence	Detection System	F264301	2,735,911
132	Mass Spectrometer	WB10697	1,278,644
228	Hood/Equipment	--	2,455,021
233	Hood/Equipment	--	2,176,580
321	Fans/Equipment	--	2,844,500
Building 236-Z			
--	Piping	F221925	2,605,140
--	Instrumentation	F226233	1,415,772
--	Process Cell Equip	F226235	1,556,570
35	Piping	F269057	1,321,337
41	Hood/Equipment	--	1,090,604
Building 241-Z			
--	Piping	F269100	6,078,162

Table 11-1. High Value Property (Continued)

Room	Property/Equipment	Property Number	RL Replacement Costs (dollars)
Building 242-Z			
--	Piping	F226491	1,332,003
Building 243-Z			
--	Piping	F269061	2,100,878
Building 2736-Z			
--	Building Storage	F256107	1,585,456
Building 2736-ZB			
--	Building Storage	F264613	6,188,389
637	Lab Equipment	--	1,471,803
Building 291-Z			
--	Power Wiring	F264421	1,047,300
--	Piping	F268561	1,018,384

SECTION 12 — DAMAGE POTENTIAL

Estimates of damage potential are based on the worst-case fire events in each of the facilities. Cost estimates include loss of contents, structural damage to the buildings, and contamination cleanup. Based on facility direction, loss of production or program continuity is not a monetary concern in this analysis because operations can be relocated. Based on DOE Order 5480.7A, estimates of the MPFL assume that one automatic suppression system will malfunction. Manual firefighting efforts are also ignored for determination of the MPFL. Estimates of the MCFL are based on the assumption that the fire protection features, including automatic sprinkler systems, function as designed. Table 12-1 provides a summary of the MPFL and MCFL cost estimates for each of the PFP facilities.

Table 12-1. Summary of MPFL and MCFL Estimates for PFP Facilities

Building	MPFL	MCFL
234-5Z fire (first floor)	$14,000,000	$1,300,000
234-5Z fire (second floor)	$13,000,000	$3,000,000
242-Z	$5,300,000	$16,000
236-Z	$1,800,000	$1,800,000
291-Z	$530,000	$530,000
2736-ZB	$2,227,000	$2,227,000
2736-Z	$800,000	$800,000
2721-Z	$1,000,000	$500,000
232-Z	$100,000	$100,000
241-Z	$250,000	$250,000
243-Z	$500,000	< $500,000
Compressed Gas Storage Areas	<$1,000,000	<$1,000,000
Hazardous Product and Waste Exterior Lay Down Areas	$980,000	$980,000

Replacement costs of building contents and the structure are based on RL Property Systems cost breakdown as provided by WHC. A copy of the cost breakdown by room for each of the PFP facilities is included in Appendix E. Cost of contamination cleanup is based on the

recent cleanup efforts in Building 232-Z. A fixed rate of $4.00 per square foot of surface area is used as a conservative cleanup estimate [McKinnis, 1996].

In accordance with DOE Order 5480.7A, facilities having a MPFL in excess of $1,000,000 require an automatic suppression system designed in accordance with the applicable NFPA standards. When the MPFL exceeds $50 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, will limit the loss to $50 million. When the MPFL exceeds $150 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $150 million.

12.1 BUILDING 234-5Z

12.1.1 First Floor

12.1.1.1 Maximum Possible Fire Loss (MPFL)

The MPFL for a fire on the first floor occurs for the office/laboratory fire in the analytical labs. Damage results from complete burnout of the analytical labs, instruments Shop, and office and lab spaces located in the south center portion of the first floor. As a result of potential HEPA filter clogging in the E-3 filter banks, contamination of the entire 234-5Z facility is possible. There is no significant structural damage to the building; however, the areas of the first floor directly involved in the fire will have to be reconstructed.

The replacement cost for loss of all contents in the burned area (e.g., room nos. 126-170) is approximately $8,200,000. The reconstruction cost is estimated based on Means Facilities Cost Data [1994] for office reconstruction (office occupancies have the highest reconstruction cost) and is based on a fixed rate of $915 per square meter of floor area ($85.00 per square foot). The total burnout area on the first floor is approximately 455 m^2 (4900 ft^2). This yields a reconstruction cost of approximately $416,500. The contamination cleanup cost, based on the contaminated areas identified in Table 6-5 is approximately $5,380,000 (1,345,000 ft^2 x $4.00/$ft^2$). This yields a total MPFL of approximately $14 million.

12.1.1.2 Maximum Credible Fire Loss (MCFL)

The MCFL for a fire on the first floor occurs for the office/laboratory fire in the analytical labs. The automatic sprinkler system is expected to contain the fire to a single lab space. As a worst case event, it is assumed that the fire occurs in the area having the most expensive equipment. A fire in Room 131 results in a loss of contents which have the maximum replacement cost of approximately $1,278,644. This includes two mass spectrometers and related equipment.

12.1.2 Second Floor

12.1.2.1 Maximum Possible Fire Loss (MPFL)

The MPFL for a fire on the second floor results from a hydraulic oil spill in room 321. Unprotected structural steel members which are directly exposed to the fire will exceed maximum temperature criteria and are assumed to result in collapse of the roof assembly in the main fan room. With the exception of the 2-hour fire barrier enclosing the Plastics Shop, wall partitions on the second floor are not sufficient to prevent fire spread. Therefore, the fire can spread from the main fan room laterally throughout the front side offices and storage areas (e.g., room nos. 300-303, 321-329). Exposed structural members in these areas will exceed maximum temperature criteria and are assumed to result in collapse of the roof assembly.

Due to the large number of columns and beams which fail the maximum temperature criteria on the second floor, it is assumed that all second floor interior partitions and the entire roof assembly collapses. Since the roof assembly can potentially collapse for this fire scenario, contamination has a direct route to the exterior. The fire is primarily contained to the front side (which is not contaminated) because there are limited combustibles on the back side to allow fire spread. However, since the partition walls separating the front and back sides may collapse during the fire exposure, it is assumed that the two E-4 filter banks (i.e., room nos. 309 and 310) are exposed to the fire. The other filter rooms, which serve the E-3 ventilation system, are relatively uncontaminated compared to the E-4 filter rooms. It is unlikely that any of the filter rooms would become involved in the fire since they are separated from areas containing combustible materials. However, the E-4 filter rooms are the closest source of contamination to the fire on the front side. Therefore, it is assumed that their entire plutonium inventory is dispersed in the fire to the outside. This provides a worst case cleanup scenario.

The filter boxes on the backside of the second floor (e.g., room no. 308) are also contaminated. However, they are further from the fire than the filter rooms and there are no combustibles to allow fire propagation to the filter boxes. Therefore, while structural collapse of the roof assembly may breach and expose the filter boxes, their contents are not expected to become involved in the fire.

The total MPFL includes loss of all contents on the second floor, contamination of the entire second floor, contamination to the outside, and reconstruction of the entire second floor. The replacement cost for loss of all contents is approximately $6,000,000. The reconstruction cost is estimated based on Means Facilities Cost Data [1994] for office reconstruction (office occupancies have the highest reconstruction cost) and is based on a fixed rate of $915 per square meter of floor area ($85.00 per square foot). The total area of the second floor is approximately 6,720 m^2 (4,900 ft^2). This yields a reconstruction cost of approximately $6,150,000

The contamination cleanup cost for the second floor, based on the contaminated areas identified in Section 6.3.4.3, is approximately $700,000 (163,650 ft^2 x $4.00/$ft^2$). The contamination cleanup required outside of the PFP is based on the area determined in Section 15.2. The cleanup cost is based on actual cleanup costs of soil contaminated by low level

uranium waste [Myott, 1995]. The cost includes samples and surveys which are to characterize the waste and assumes that the waste is stockpiled according to present policy and not buried. The actual cost of the 25 acre soil cleanup was approximately $550,000. This equates to a cost of $5.44 per square meter ($0.51 per square foot). Based on this cleanup cost value for contaminated accessible soil, the cost of the PFP contamination to the outside is approximately $53,500 (9,825 m^2 x $5.44/$m^2$).

This total MPFL for the second floor is approximately $13 million.

12.1.2.2 Maximum Credible Fire Loss (MCFL)

Sprinkler activation resulting from the hydraulic oil spill fire in Room 321 is expected to prevent fire spread into adjacent areas. In addition, the cooling effect from the water will limit structural damage to areas in the immediate vicinity of the pool fire. However, since the sprinklers will not necessarily extinguish the liquid pool fire (and may actually spread it out over a greater area), thermal damage can still occur in the main fan room. Therefore, the MCFL for this scenario involves the loss of all contents in Room 321. Since this area is not contaminated, there is no cleanup associated with the MCFL. The replacement cost of all contents is approximately $3,000,000. This is expected to be a conservative estimate of the MCFL since it is unlikely that all contents would be damaged during the fire exposure.

12.1.3 General

The MPFL and MCFL in Building 234-5Z is approximately $14 million and $3 million, respectively. In this case, the MPFL occurs for a fire in the analytical labs on the first floor and the MCFL results from a fire in the second floor fan room. Since the MPFL is greater than $1 million, DOE 5480.7A requires an automatic sprinkler system. However, since the MPFL is less than $50 million, redundant protection and additional fire protection features are not required.

With a few exceptions, Building 234-5Z is protected throughout by an automatic sprinkler system and automatic fire detection system (providing redundant protection). Therefore, with the exception of several areas which are not protected by sprinklers (vaults, filter rooms, etc.), Building 234-5Z is in compliance with DOE 5480.7A loss limitations (see Section 5.2.1).

12.2 BUILDING 242-Z

12.2.1 Maximum Possible Fire Loss (MPFL)

The worst case fire event for Building 242-Z is an exposure hazard resulting from a fire in the storage annex. A fire in this space can compromise the west wall of the 242-Z facility and potentially spread throughout the 242-Z Building and into 234-5Z. Assuming total loss of the 242-Z structure and all equipment results in a MPFL of approximately $4,000,000. The sprinkler system in 234-5Z, an independent system from 242-Z, is expected to limit fire damage to the MCFL limits for 234-5Z first floor (i.e., $1.3 million, see Section 12.1). In addition, fire involvement of the 242-Z Building will result in a release to the exterior. The level of

contamination which will require cleanup efforts is not easily quantified since the contents of the facility are unknown. Therefore, this cost is not included in the MPFL.

The 242-Z Building and the storage annex are equipped with automatic sprinkler systems. Therefore, assuming that contamination cleanup does not cause the MPFL to exceed $50 million, Building 242-Z is in compliance with the criteria of DOE 5480.7A.

12.2.2 Maximum Credible Fire Loss (MCFL)

The automatic sprinkler system in the storage annex is expected to control the fire and prevent fire spread to the 242-Z facility. Damage resulting from the fire includes loss of the storage contents in the annex building. The MCFL for the facility (i.e, the replacement cost for the contents) is approximately $15,750.

12.3 BUILDING 236-Z

12.3.1 Maximum Possible Fire Loss (MPFL)

The MPFL for Building 236-Z results from a glovebox fire in the MT Process Room . The fire is expected to be contained to the MT room; however, contamination of the entire facility is possible. The concrete structure is not expected to be damaged.

The replacement cost for loss of all contents in room no. 41 (i.e., the MT room) is approximately $1,100,000. The contamination cleanup, based on the contaminated areas identified in Section 6.5.2, is approximately $720,000 (180,000 ft^2 x $4.00/$ft^2$). This yields a total MPFL of approximately $1,800,000. The 236-Z Building is protected throughout by an automatic sprinkler system, except in the canyon. Therefore, the facility is in compliance with DOE 5480.7A.

12.3.2 Maximum Credible Fire Loss (MCFL)

Since this fire scenario involves a fire within the MT gloveboxes, which are not equipped with an automatic suppression system, the fire can spread throughout the gloveboxes. Therefore, all of the gloveboxes and the contents within them, can be damaged by the fire. Also, while the sprinklers in the room will prevent fire spread to other areas, smoke and contamination can still spread throughout the facility. Since the fire is contained to within the MT room for the MPFL scenario, the extent of damage to the building is not reduced by activation of the sprinkler system in the MT glovebox room. For this scenario, the MCFL is equal to the MPFL, which is $1,800,000.

12.4 BUILDING 291-Z

12.4.1 Maximum Possible Fire Loss (MPFL)

The worst case fire event for Building 291-Z is a transformer oil spill fire in Room 500. The MPFL for this scenario includes the loss of all contents in Rooms 500 and 501. There is no contamination potential associated with a fire in this facility and the fire is expected to be contained to within the building. As such, the total cost includes the replacement cost of the two transformers, and the compressor and vacuum pumps in Room 501. The total damage resulting from this fire scenario is approximately $530,000. Since the MPFL is less than $1 million, DOE 5480.7A does not require an automatic sprinkler system.

12.4.2 Maximum Credible Fire Loss (MCFL)

The only suppression system in Building 291-Z is the automatic deluge system protecting the transformers in Room 500. The deluge system is not expected to control the fire or significantly reduce the subsequent damage potential. Therefore, the MCFL is the same as the MPFL, which is $530,000.

12.5 BUILDING 2736-ZB

12.5.1 Maximum Possible Fire Loss (MPFL)

The maximum possible fire event in the 2736-ZB Building results from a fire in the NDA Lab. Fire spread includes the NDA Lab and back side office spaces. Damage results from loss of contents in the lab and office spaces and contamination of the facility. The concrete structure is not expected to be damaged.

The replacement cost for the contents of the NDA Lab and back side office spaces is approximately $1,900,000. The contamination cleanup, based on the contaminated areas identified in Section 6.7.2, is approximately $370,000 (91,500 ft^2 x $4.00/$ft^2$). This yields a total MPFL of approximately $2,270,000. The 2736-ZB Building is protected throughout by an automatic sprinkler system. Therefore, the facility is in compliance with DOE 5480.7A.

12.5.2 Maximum Credible Fire Loss (MCFL)

A fire in the NDA Lab is expected to be contained within the Lab room based on the limited fuel load, sprinkler protection, and fire resistive construction. While sprinkler activation will reduce the fire spread within the room, smoke and heat damage to equipment can still occur. In addition, water from the sprinklers may damage some of the sensitive equipment in the Lab. Therefore, even with sprinkler activation, all of the contents in the NDA Lab are expected to be damaged. In addition, contamination resulting from the fire can potentially spread throughout the facility even with sprinkler protection. As such, for this scenario, the MCFL is equal to the MPFL.

12.6 BUILDING 2736-Z

12.6.1 Maximum Possible Fire Loss (MPFL)

A maximum possible fire event in Building 2736-Z is an electrical fire damaging the surveillance and security equipment in the vaults. Assuming that all alarm equipment and instrumentation are damaged, the MPFL for the facility is approximately $800,000. Since the MPFL is less than $1 million, DOE 5480.7A does not require an automatic sprinkler system.

12.6.2 Maximum Credible Fire Loss (MCFL)

There are no automatic suppression systems in the vaults of Building 2736-Z. Although the corridor has automatic sprinklers, a small electrical fire is not expected to activate the suppression system prior to causing thermal damage. Therefore, the MCFL is equal to the MPFL, which is $800,000.

12.7 BUILDING 2721-Z

12.7.1 Maximum Possible Fire Loss (MPFL)

The worst case fire event in Building 2721-Z is a diesel fuel spill fire. The MPFL for the facility assumes that the structure and all equipment in the building are damaged since there are no separations to control the spread of fire. This includes the loss of three diesel generators, the control panel, and other building service equipment. The MPFL for the building is approximately $1,000,000. Building 2721-Z is equipped with an automatic dry pipe sprinkler system. Therefore, Building 2721-Z is in compliance with the requirements DOE 5480.7A.

12.7.2 Maximum Credible Fire Loss (MCFL)

The automatic dry-pipe sprinkler system in the Building 2721-Z is not expected to significantly reduce the damage to the building contents. However, the cooling effect of the water will likely prevent any significant damage to the structure. The MCFL is approximately $500,000.

12.8 BUILDING 232-Z

12.8.1 Maximum Possible Fire Loss (MPFL)

The worst case fire event for Building 232-Z is a fire involving transient combustibles in the Process Area. Such a fire will not cause damage to the structure. Equipment and contents in the vicinity of the fire will be damaged. Since the facility is entering a decontamination and decommissioning (D&D) phase, the building and its contents have no value. Therefore, the only cost associated with the fire is decontamination cleanup. Based on the recent cleanup efforts in this facility, the MPFL (i.e., cleanup cost) is less than $100,000.

12.8.2 Maximum Credible Fire Loss (MCFL)

There are no automatic suppression systems in Building 232-Z. Therefore, the MCFL is equal to the MPFL, which is less than $100,000.

12.9 BUILDING 241-Z

12.9.1 Maximum Possible Fire Loss (MPFL)

The worst case fire event in Building 241-Z is a small fire involving transient combustibles. Such a fire will not cause damage to the structure and is not expected to damage the pump and tank equipment. As a conservative estimate, it is assumed that the fire damages the electrical wiring and alarm system equipment in the facility. The MPFL for this scenario is less than $250,000. Since the MPFL is less than $1 million, DOE 5480.7A does not require an automatic suppression system.

12.9.2 Maximum Credible Fire Loss (MCFL)

There are no automatic suppression systems in Building 241-Z. Therefore, the MCFL is equal to the MPFL.

12.10 BUILDING 243-Z

12.10.1 Maximum Possible Fire Loss (MPFL)

The worst case fire event for Building 243-Z is a fire involving transient combustibles in the space. Such a fire will not cause damage to the structure or piping equipment. Electrical equipment and contents in the vicinity of the fire are expected to be damaged. Conservatively assuming that all of the power wiring in the facility is damaged results in a MPFL of approximately $500,000. Building 243-Z is equipped with an automatic sprinkler system. Since the MPFL is less than $1 million, DOE 5480.7A does not require an automatic suppression system.

12.10.2 Maximum Credible Fire Loss (MCFL)

The automatic sprinkler system in the Building 243-Z will reduce the thermal damage to equipment in the facility. The MCFL is less than $500,000.

12.11 COMPRESSED GAS STORAGE AREAS

12.11.1 Maximum Possible Fire Loss (MPFL)

There are no accident scenarios for the Compressed Gas Storage Areas which present a fire hazard to the PFP facilities. Scenarios involving a flaming jet from one of the propane cylinders can result in loss of a single storage shed and may damage other gas cylinders. The

MPFL is limited to the replacement cost of the gas cylinders and storage shed, approximately $25,000. An explosion from a propane leak would damage the buildings and surrounding structure. Damage is expected to be limited to less than $1 million.

12.11.2 Maximum Credible Fire Loss (MCFL)

There are no automatic suppression systems protecting the Compressed Gas Storage Areas. Therefore, the MCFL is equal to the MPFL.

12.12 HAZARDOUS PRODUCT AND WASTE EXTERIOR LAY DOWN AREAS

12.12.1 Maximum Possible Fire Loss (MPFL)

The MPFL for the Hazardous Product and Waste Exterior Lay Down Areas results from a diesel spill fire engulfing 55-gallon drum storage containers. The pool fire breaches a maximum of 128 drums containing TRU waste materials (see Section 6.14.2). Because the drum contents have no monetary value, the cost associated with this scenario is based solely on the contamination cleanup resulting from the burning contents in the 128 drums.

The maximum contaminated area determined in Section 15.3 is 180,068 m^2. The cleanup cost is based on actual cleanup costs of soil contaminated by low level uranium waste [Myott, 1995]. The cost includes samples and surveys which characterize the waste and assumes that the waste is stockpiled according to present policy and not buried. The actual cost of the 25 acre soil cleanup was approximately $550,000. This equates to a cost of $5.44 per square meter ($0.51 per square foot). Based on this cleanup cost value for contaminated accessible soil, the cost of the burning drum contents scenario is approximately $979,570.

12.12.2 Maximum Credible Fire Loss (MCFL)

There are no automatic suppression systems protecting the Hazardous Product and Waste Exterior Lay Down Areas. Therefore, the MCFL is equal to the MPFL.

SECTION 13 – FIRE DEPARTMENT/BRIGADE RESPONSE

The Hanford Fire Department (HFD) consists of four fire stations covering the 560 square mile area of the Hanford site. These stations are strategically located across the site to ensure minimum response time to all facilities. Front-line engines are aerial device/pumpers in all stations with regular pumpers as back-up/reserve. The HFD maintains a fleet of 39 vehicles with a diversified range of capabilities. Of these, 29 are fire/emergency response apparatus. Of the 29 emergency response apparatus, 24 are considered first-line equipment. The remainder are fully maintained reserves.

The 200 area station is the closest to PFP. This station is located between the 200W and 200E areas. The estimated response time for apparatus to arrive on the scene of an incident is expected to be four to five minutes after notification from the dispatch/communications center. This estimate assumes the firefighters are in the 200 area fire station and normal road and traveling conditions. The HFD response time for fire alarm trouble (i.e., supervisory) signals is limited to 30 minutes.

The present operating procedure for a Hanford Site Emergency Response is to dispatch an ambulance and single aerial device/pumper from the closest station and a second aerial device/pumper from the next closest station. This provides a two "engine" response with additional manpower/medical capabilities. The first apparatus due on scene constitutes what is termed "Initial Attack Response Capability."

The HFD has an established mutual/automatic aid agreement with the surrounding jurisdictions. The agreement enables the HFD to augment its own fire and emergency medical resources in the event of a major incident. This agreement is known as the "Tri-Cities Mutual Aid Agreement" and has been in existence since 1985. Participating agencies include the cities of Richland, Kenwick, and Pasco, and the Fire Protection Districts of Benton County #1, Benton County #2, Benton County #3, Benton County #4, Benton County #5, Benton County #6, Franklin County #3, and Walla Walla County #5. Participation in the agreement is delivered utilizing existing manpower and equipment.

Facility pre-fire plans were reviewed for this FHA. All of the plans were up-to-date. Procedures exist to obtain fire department access to the site through the security requirements [Campbell, 1996]. Future changes to the HFD include closing Station 1 during the night. This will have no impact on fire department services to the PFP.

SECTION 14 — RECOVERY POTENTIAL

Table 14-1 identifies the primary consequences and recovery potential, as provided by PFP facility staff, for the fire scenarios presented in Section 6.0 which involve active PFP facilities.

Table 14-1. Effects of Fire Scenarios on PFP Operations

Scenario Description	Recovery Potential and Consequences
Building 234-5Z: First floor fire including loss of analytical labs, offices and other lab areas, and storage rooms.	The PFP would utilize the R&D Lab and redirect the overflow of work to one of the other labs located on the Hanford site. Additional equipment could be purchased for the R&D labs to handle the additional work. Operations would be delayed, but not greatly impacted, because of job priorities at other labs.
Building 234-5Z: First floor fire including loss of entire 94-1 Thermal Stabilization Process Line	The 94-1 Stabilization project would be temporarily shut down. Process line equipment and gloveboxes would be required to be relocated to a different part of the facility to allow 94-1 project to continue its efforts. This would cause a delay of approximately 6 months for some 94-1 project operations.
Building 234-5Z: Second floor fire including complete loss of supply fans and equipment	Loss of the supply fans would have an impact on the facility causing all radiological work to stop until the supply system could be replaced. PFP could maintain negative confined pressure in the facility by continued use of the exhaust fans. This would cause a down time of about one month before temporary supply fans could be installed and one year before permanent supply fan replacement.
Building 291-Z: Including loss of transformers, compressor, dryers and vacuum pumps	Loss of the transformers would be a temporary power loss until the power could be switched to a different power source. Loss of the compressor, dryer and reservoir would be temporary until portable equipment, which is on site, could be setup. There would be a down time of approximately two weeks. Loss of the exhaust fans would have a major impact on the facility causing all radiological work to stop until the exhaust system could be replaced. However, there are no credible fire scenarios which could potentially damage all of the exhaust fans simultaneously.
Building 2721-Z: Loss of emergency generators	The generators are not emergency generators but are considered standby generators. If these generators were lost due to fire, uninterrupted power supplies (UPS) are in place to support the needed areas of concern. Loss of operations would not be effected because of the UPS and emergency generators that would start up. Needed power feeds would be re-routed to other generators. The damaged generators would not be replaced.
Building 2736-ZB: Including complete loss of the NDA Lab	The PFP would utilize the analytical, R&D, or any of the other labs located on the Hanford site to process any needed tests or materials. There would be no operational loss to the PFP.

Table 14-1. Effects of Fire Scenarios on PFP Operations (Continued)

Scenario Description	Recovery Potential and Consequences
Building 2736-Z: Fire involving loss of security equipment in storage vaults	Patrol would man security stations as they currently do. Only limited access would be allowed into the vaults. Each vault being entered would have a security guard stationed outside the vault door to survey everyone leaving the vault until the security systems were brought back on line. Loss of operations would be minimal since administrative procedures would be put in place to secure the area until new systems could be purchased and installed. Equipment would be purchased and installed within three weeks.

SECTION 15 — POTENTIAL FOR A TOXICOLOGICAL, BIOLOGICAL, AND/OR RADIOLOGICAL INCIDENT DUE TO A FIRE

This section addresses special fire hazards resulting from chemicals, radioactive materials, and toxic materials and the potential for their release to the site or the public. A release to the environment can create a health hazard and also result in contamination of both on and off site areas. The health hazards associated with toxicological, biological, and/or radiological materials are addressed in the FSAR [WHC, 1995]. In this section, the analysis focuses on the extent of contamination and maximum cleanup costs resulting from the MPFL fire scenarios developed in Section 6.0. Although a toxicological incident due to fire can also occur in some of the PFP areas (e.g., 236-Z Chem Prep Room 40), the FHA addresses worst case events, and involving a toxicological incident rather than radiological does not change the MPFL scenario results.

Contamination within the PFP facilities occurs for several of the fire scenarios considered in this analysis. Since the buildings are maintained at a negative pressure with respect to the outside, most of the fire scenarios do not result in a release to the environment. A release from the building to the outside can occur if any of the following occur:

(1) The building is intentionally vented;

(2) The building is exposed to an abnormal event such as an earthquake which could lead to loss of building perimeter integrity;

(3) An explosion occurs which violates the integrity of the exterior walls;

(4) Fire products escape through building openings (e.g., roof or door); or

(5) Fire products escape through building openings created by structural collapse due to fire.

There are two MPFL fire scenarios which can potentially result in a release to the outside: (1) second floor hydraulic oil spill fire and (2) exterior TRU drum storage fire. The fire damage resulting from these scenarios is discussed in Section 6.0. In the following sections, the maximum onsite and offsite contamination is determined.

15.1 CONTAMINATION DISPERSION MODEL

The contamination to the outside is estimated using a model developed by Himes [1994]. In the model, the dispersion of radioactively contaminated particles is calculated using classical plume equations. The model assumes no containment effect by the structure and is considered to be a conservative estimate of the actual dispersion. In developing the model, assumptions regarding the maximum heat release per unit area and environmental conditions are consistent with the context of this analysis. The end result of the model yields a maximum downwind

extent of the contour and the corresponding area relating to a minimum contamination level. The maximum downwind extent, X_l, is given by,

$$X_l = \left(64.9 \frac{I}{C} A_f^{0.8407}\right)^{-1/m} \tag{15-1}$$

where

$$m = -(0.02940 \ln A_f + 3.248) \tag{15-2}$$

and I is the total radioactive inventory consumed in the fire (Ci),
C is the minimum contamination level (Ci/m^2), and
A_f is the burn area of the contaminated area involved in the fire (m^2).

The area of the minimum contamination level contour is given by,

$$A_c = 0.0724 \sqrt{-m}\, X_l^{1.903} \tag{15-3}$$

The minimum contamination level, C, is determined from the *WHC Environmental Compliance Manual* [WHC-CM-7-5, Rev. 2]. Specifically, Table 6-2 specifies the accessible soil concentration limits for specific isotopic nuclides in pCi/g. The author of the dispersion model (i.e., Himes) stated that it is common practice to assume a soil depth of 1 cm and an average soil density of 1.6 g/cm^3 when converting the units of the contamination values in Table 6-2 to Ci/m^2. With this assumption, the conversion factor is 1 pCi/g = 1.6 x 10-8 Ci/m^2.

Using this model, the maximum contamination resulting from the design base fire scenarios is estimated. The area of ground contamination is significant both as a life safety concern and of determining the MPFL of the fire scenario.

15.2 SECOND FLOOR HYDRAULIC OIL SPILL FIRE

The design base fire scenario on the second floor can potentially result in collapse of the roof assembly, thus providing a direct route for combustion products to escape to the exterior. While the fire is primarily contained to the front side of the second floor (which is not contaminated), thermal failure of the structural members (i.e., columns, beams, roof) can collapse interior partition walls. Since the partition walls separating the front and back sides may collapse during the fire exposure, it is assumed that the two E-4 filter banks (e.g., room nos. 309 and 310) are exposed to the fire. These other filter rooms, which serve the E-3 ventilation system, are

relatively uncontaminated compared to the E-4 filter rooms. Therefore, their involvement in the fire is not considered.

It is unlikely that any of the filter rooms would become involved in the fire since they are separated from areas containing combustible materials. However, the E-4 filter rooms are the closest source of contamination to the fire on the front side. Therefore, it is assumed that their entire plutonium inventory is dispersed in the fire to the outside. This provides a worst case cleanup scenario.

The filter boxes on the backside of the second floor (e.g., room no. 308) are also contaminated. However, they are further from the fire than the filter rooms and there are no combustibles to allow fire propagation to the filter boxes. Therefore, while structural collapse of the roof assembly may breach and expose the filter boxes, their contents are not expected to become involved in the fire.

The total radioactive inventory in the filter banks is estimated based on maximum plutonium content values presented in the FSAR. Each E-4 filter bank contains a maximum of 0.1 g of plutonium in the HEPA filters. As a worst case, it is assumed that the entire inventory is consumed in the fire and dispersed to the outside via the roof openings.

The isotopic breakdown of the plutonium content in the E-4 filter banks is based on the mass weighted average and 90th percentile plutonium breakdown for PFP materials presented in the FSAR. Table 15-1 provides the mass weighted isotopic values for PFP materials and the total activity for the E-4 filter banks based on the mass weighted breakdown.

Table 15-1. Mass-Weighted Isotopic Values for E-4 Filter Banks

Isotope	Percent Pu (%)	Specific Activity (Ci/g)	E-4 Filter Banks Mass (mg)	E-4 Filter Banks Activity (Ci)
^{238}Pu	0.13	17.4	0.26	0.00452
^{239}Pu	86.59	0.0615	173.18	0.01065
^{240}Pu	11.99	0.227	23.98	0.00544
^{241}Pu	0.89	114.0	1.78	0.20292
^{242}Pu	0.40	0.004	0.80	0.00000
^{241}Am	1.49	3.24	2.98	0.00966
Total	101.49*	–	202.98	0.23320

* The percent Pu is calculated on a per gram plutonium basis. The total is greater than 100% because of the contribution of the ^{241}Am mass.

In order to provide a conservative estimate of the total activity for the plutonium inventory, values for the 90th percentile Pu materials used at the PFP are used rather than mass-weighted values. Based on the FSAR, the activity for the 90th percentile Pu materials is approximately 3 times greater than that for the mass-weighted average. Therefore, in this analysis, the total radioactive inventory identified in Table 15-1 for the E-4 filter rooms is tripled so that it reflects the activity of the 90th percentile materials used at the PFP. This yields a total radioactive inventory of 0.70 Ci for the two E-4 filter banks. Again, it is conservatively assumed that the entire inventory is consumed in the fire.

The minimum allowable soil contamination level is based on the specific isotopic breakdown of the PFP materials in accordance with Section 6.5.2 and Table 6-2 of the *WHC Environmental Compliance Manual*. The minimum accessible soil contamination level for the Pu material in the E-4 filter banks is 3.03×10^{-6} Ci/m^2.

The fire area of the contaminated area is estimated based on the total floor area of the two E-4 filter banks. The total burn area for this scenario is approximately 50 m^2.

Solving Equations 15-1 through 15-3 yields a maximum downwind contamination distance of approximately 362 m (1190 ft) and a maximum contamination area of approximately 9,825 m^2 (105,700 ft^2). The closest site boundary from the PFP is approximately 12.5 km to the west. Therefore, this level of dispersion will not contaminate any offsite areas.

15.3 EXTERIOR TRU DRUM STORAGE FIRE

The maximum damage resulting from this scenario involves breaching and burning the contents of 128 drums (see Section 6.14) within the fenced yard area of the PFP. Each 55-gallon drum contains a maximum TRU content of 15 g ^{239}Pu equivalent based on nuclear-criticality safety control limits presented in the FSAR. Assuming that all 128 drums contain the maximum TRU content, this yields a total plutonium mass of 1920 g ^{239}Pu equivalent. The specific activity of ^{239}Pu is 0.0615 Ci/g [Wick, 1988]. This yields a total radioactive inventory of approximately 120 Ci for the contents of the 128 55-gallon drums involved in the fire scenario.

The minimum allowable soil contamination level is based on the value for ^{239}Pu in Table 6-2 of the *WHC Environmental Compliance Manual*. The minimum accessible soil contamination level is 3.04×10^{-6} Ci/m^2. The burn area of the drum contents is approximately equal to the area of the liquid spill fire determined in Section 6.14 (i.e., 39.7 m^2). Since some trash contents may be expelled from the drums during the fire exposure, the burn area is estimated as 50 m^2 in order to calculate the maximum contamination area.

Solving Equations 15-1 through 15-3 with I=120 Ci, C=3.04 x 10-6 Ci/m^2, and A=50 m^2, yields a maximum downwind extent of approximately 1,669 m (5,475 ft) and a maximum contamination area of approximately 180,068 m^2 (1,937,530 ft^2). The closest site boundary from the PFP is approximately 12.5 km to the west. Therefore, this level of dispersion will not contaminate any offsite areas.

15.4 HEPA FILTER CLOGGING

A series of experiments was conducted at Lawrence Livermore National Laboratory (LLNL) which investigated smoke aerosol exposure to HEPA filters [Alvares et al.]. The study included plugging of the HEPA filter. The plugging tests involved smoke generation from a variety of fuels in different configurations. The material of interest for our analysis is smoke generation from wood. Based on the test results, the minimum quantity of fuel required to burn in order to cause a fifty percent reduction in airflow is determined. A fifty percent reduction in airflow is defined as failure by clogging of the HEPA filter in the LLNL study.

Based on the analysis of the LLNL test data, 25 kg (55 lb) of wood can potentially clog (i.e., reduce the airflow by fifty percent) a 61 cm x 61 cm (24 in. x 24 in.) HEPA filter [Beyler and Iqbal, 1995]. The 234-5Z Building ventilation exhaust system filters air from Zones 3 and 3a (i.e., the contaminated areas) through a single stage of testable HEPA filters that are located in seven filter rooms (i.e., room 311 through 316 and 318); any three of which may be in normal service with the remainder in standby. Each filter room contains 112 HEPA filters (61 cm x 61 cm x 29 cm), yielding a total of 784 HEPA filters in the E-3 exhaust system.

Assuming that all of the HEPA filters in all seven of the E-3 filter rooms must clog in order to lose negative pressure in the facility, a total fuel mass of approximately 19,600 kg (43,120 lb) must be burned. Based on the maximum estimated fuel load developed in Section 6.3.2.3 for an office or lab space (i.e., 511 kg), a fire must spread and consume all of the fuel in over 38 office or lab spaces in order to clog the E-3 exhaust system. The maximum fire spread determined in Section 6.3.2.5.3 involves approximately 40 to 45 office and lab spaces in the southeast corner of the first floor. Although every office and lab space does not contain the maximum fuel load, the total fuel consumed in the fire is in the range of that required to clog the HEPA filters. Therefore, both a loss of negative pressure in the building and a radiological release could occur.

As the negative pressure in the facility may be lost, radiological release to the exterior is expected to be minimal. First, the total quantity of fuel required to clog the E-3 filter banks is approximately equal to the total amount of fuel consumed in the worst case fire scenarios. Since conservative estimates are made regarding fuel load, the degree of HEPA clogging may not reduce the airflow to an extent required for complete loss of negative pressure. In addition, the only openings to the exterior are doors which are normally kept closed and small cracks/leaks in the exterior walls. Therefore, while some level of contamination may be dispersed to the exterior, if there is no structural damage to the building, most of the contamination dispersed during a fire is expected to be contained within the facility.

15.5 LIQUID RUN OFF

Liquid runoff resulting from fire protection water (e.g., automatic sprinklers, fire department hose streams) provide an additional means for contamination to spread from the facility to the outside. In order to prevent the liquid runoff from spreading off-site, the facilities

within PFP are provided with sink and process drains (see Figure 15-1). The drains which have a potential for containing contaminated runoff are piped through manholes to 243-Z Building.

Based on the total water supply for fire protection requirements for the PFP complex as defined in Section 5, Table 5.2 and the hydraulic calculations found in Appendix A of the FHA, liquid run off will not exceed the capacity of Pump Station No 1. The flow of the automatic sprinklers and hose stream (approximately 700 gpm) for 20 minutes is within the capacity of the pump station tank capacity. Contaminated liquid run-off may escape the building causing ground contamination and cleanup. However, the release to the soil will not impact the dose consequences addressed in Chapter 9, Section 9.2.4A.8.3 of the FSAR analysis.

Rainfall adds water to Pump Station No 1 via the storm drains. The average rainfall for Hanford Area is 6.26 inches per year based on a 30 year average from 1961 to 1991 according to Pacific Northwest Laboratory Weather Forecaster. The drains have been flow tested at up to 695 gpm without exceeding capacity.

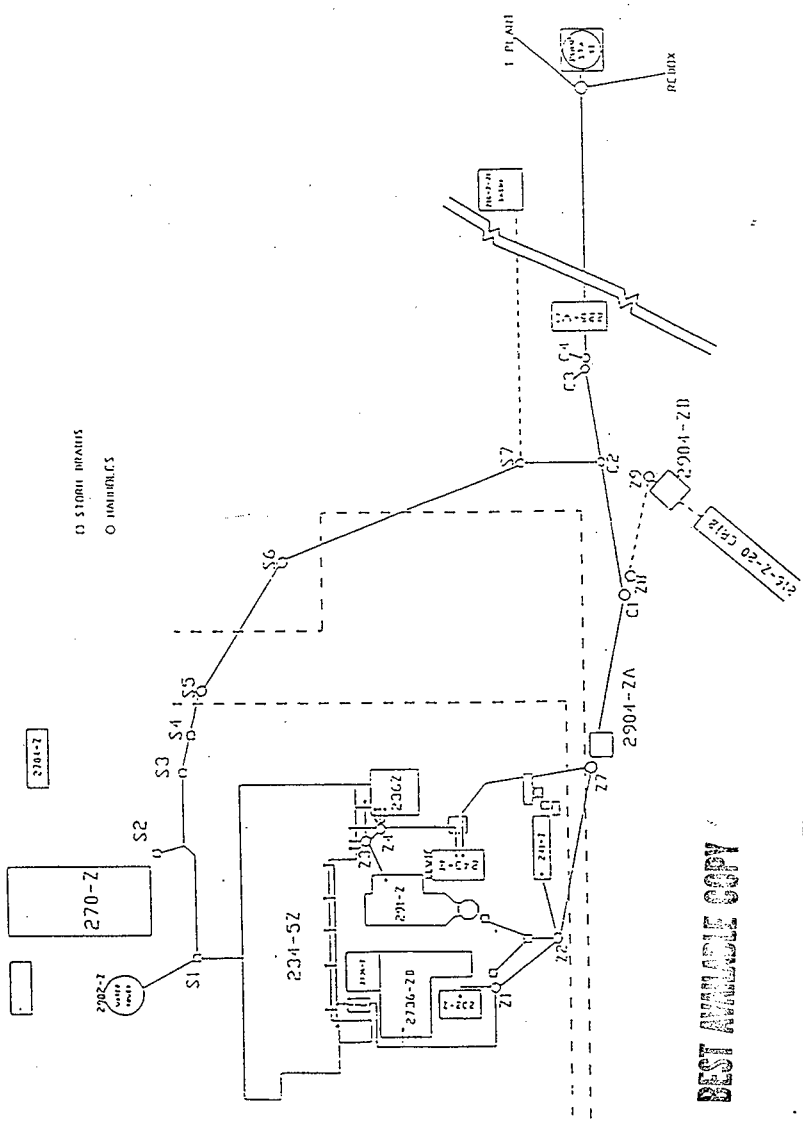


Figure 15-1. RFP

SECTION 16 — EMERGENCY PLANNING

Several prefire plans have been developed by the fire department and PFP staff for the Complex. The primary tactic selected for manual firefighting is a direct interior attack unless conditions prevent such a strategy. The PFP Complex does not maintain a fire brigade. In most situations, the personnel are instructed to activate the building fire alarm system and notify personnel within the immediate area. In some cases, there are plant operating procedures which address specific responses to fire (e.g., Z0-200-010, "Respond to Plutonium Metal Sump Fires"). Other plant documents, such as WHC-IP-1054-PFP, "PFP Emergency Response Guides," and WHC-IP-0263-PFP, "Building Emergency Plant for the PFP Complex," Part 7.2.4, Fire and Explosion, provide additional specific emergency planning procedures for the PFP facilities.

The PFP Complex is included in the site-wide emergency plan and WHC-CM-5-8 [WHC-CM-5-8, Volume 1, 1996]. Fire incidents are reported to the fire department by the fire alarm system or use of the phone. Water flow alarm from the sprinkler system is also transmitted to the fire department. A local fire alarm bell is installed outside the building to provide notification of a fire incident.

SECTION 17 – SECURITY AND SAFEGUARDS CONSIDERATIONS RELATED TO FIRE PROTECTION

Access to the PFP facility is restricted to authorized or escorted personnel. There are no special security considerations identified in the PFP Complex that were judged to impact the fire hazard analysis. Most doors are operable for egress, without lockout or cipher locks. In addition, site security plans do not inhibit access to the building for fire department personnel and apparatus. Operating procedures should minimize fire department response time and provide access to the facilities as quickly as reasonably achievable.

SECTION 18 — NATURAL HAZARDS IMPACT ON FIRE SAFETY

The impact of floods, tornadoes, and earthquakes on the PFP Complex have been previously analyzed and is presented below.

18.1 FLOODS

The Columbia River probable maximum flood (PMF) (the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions reasonably possible in the region) would produce a flow of 40,793 m^3/s (1,440,000 ft^3/s). This flood would not affect the central part of the site (the plateau of the 200 East and West Areas) including the PFP facilities. Likewise, waters of a 100-yr flood (13,000 m^3/s (459,000 ft^3/s)) would have no effect on the PFP facilities. [WHC]

Since credible floods from the Columbia and Yakima Rivers have no impact on the PFP facilities, no further analysis is considered.

18.2 TORNADOES

The Pacific Northwest is one of the areas of the country with the lowest frequency of tornadoes. The entire state of Washington has an average tornado frequency of less than one per year. An analysis of the Hanford Site concludes that the probability of a tornado hitting any particular on-site facility is six chances in a million during any one year.

The 234-5Z facility is qualified to withstand an extreme wind condition of 90 miles per hour. The extreme wind analyses and strength evaluations are included in *Extreme Wind Analysis PFP Structures 236-Z, 291-Z, and 234-5Z Buildings* [Giller]. The PFP facilities are not designed for tornado conditions [WHC].

18.3 EARTHQUAKE

A 0.2 g (maximum) acceleration level at the ground surface in the site area is assigned as the design basis earthquake [DOE-RL]. The 234-5Z Building, as is, could resist the design basis earthquake motions without collapse; however, some buildings in the PFP Complex are not designed to withstand a seismic event. For some buildings in the Complex, interior walls, exterior wall panels, gloveboxes, filerboxes, and exhaust ducts may fail during a seismic event. As a result, radiological contamination within the building and potentially airborne contamination can occur. A detailed analysis of the seismic event is presented in the FSAR. Fire hazards associated with the seismic event which are greater than the MPFL fire scenarios could result if the concrete walls or first floor plaster ceiling fail as a result of the earthquake and a fire is initiated. Results of fire following an earthquake could include loss of building structure due to potential fire spread and breach of structural fire protection (e.g., ceiling and column plaster protection).

SECTION 19 — EXPOSURE FIRE POTENTIAL

Piloted ignition of adjacent structures can occur due to flame radiation from fully developed fires. Minimum separation distances between structures are determined based on the construction and dimensions of the perimeter walls, building heights, potential fire severity, and the number of unprotected openings.

Minimum separation distances for adjacent structures are estimated based on procedures provided in NFPA 80A, *Recommended Practice for Fire Protection of Buildings from Exterior Fire Exposures* [NFPA 80A]. NFPA 80A is used to determine the minimum separation distance required between the PFP facilities in the scope of this study and other buildings which pose a potential exposure hazard. Table 19-1 provides a summary of the potential exposure hazards to the buildings, their location with respect to specific structures, and the required separation distance according to NFPA 80A.

Table 19-1. Required Separation per NFPA 80A for PFP Facilities

Building	Approximate Distance (m)	Required Separation (m)	Comments
BUILDING 234-5Z			
242-Z	Attached	0	Protected by an automatic sprinkler system
236-Z	Attached via 242-Z	0	Protected by an automatic sprinkler system
234-5ZA	Attached	0	Protected by an automatic sprinkler system
291-Z	Attached by plenum; structure is 11 m away	0	Underground structure
2736-Z	8	4	NFPA 80A, Table 2-3
2736-ZA	3	0	Protected by an automatic sprinkler system
2736-ZB	4	0	Protected by an automatic sprinkler system
2721-Z	11	0	Protected by an automatic sprinkler system
252-Z Electrical Substation Transformers	2	0	Protected by an automatic deluge system
2731-Z	6	5.4	Table 2-3; all exposed wall openings are closed with material equivalent to the wall

Table 19-1. Required Separation per NFPA 80A for PFP Facilities (Continued)

Building	Approximate Distance (m)	Required Separation (m)	Comments
BUILDING 242-Z			
234-5Z	Attached	0	Protected by automatic sprinkler systems
236-Z	Attached	0	Protected by an automatic sprinkler system
Storage Annex	Attached	0	Protected by an automatic sprinkler system
BUILDING 236-Z			
242-Z	Attached	0	Protected by an automatic sprinkler system
234-5Z	Attached via 242-Z	0	Protected by automatic sprinkler systems
2727-Z	1	0	Exterior walls of 236-Z provide a minimum 3-hour fire resistive rating
Building 291-Z			
243-Z	7	0	Protected by an automatic sprinkler system
2736-ZB	8	0	Protected by an automatic sprinkler system
2731-Z	2	--	Limited exposure and loss potential (see text)
234-5Z	Attached by plenum; structure is 11 m away	0	Protected by automatic sprinkler systems
Building 2736-ZB			
2736-Z	Attached	0	Separated by a 3-hour fire wall
232-Z	4	0	Protected by an automatic sprinkler system
2721-Z	8	0	Protected by an automatic sprinkler system
Building 2736-Z			
2736-ZB	Attached	0	Separated by a 3-hour fire wall
2736-ZA	1.5	0	Protected by an automatic sprinkler system
234-5Z	8	0	Protected by automatic sprinkler systems
2736-ZC	3	4.8	Table 2-3; all exposed wall openings are closed with material equivalent to the wall
Building 2721-Z			
2736-ZB	8	0	Protected by an automatic sprinkler system
Building 232-Z			
2731-ZA	4.6	4.9	Table 2-3; all exposed wall openings are closed with material equivalent to the wall
2736-ZC	2.5	4.8	Table 2-3; all exposed wall openings are closed with material equivalent to the wall
2736-ZB	4	0	Protected by an automatic sprinkler system

Table 19-1. Required Separation per NFPA 80A for PFP Facilities (Continued)

Building	Approximate Distance (m)	Required Separation (m)	Comments
Building 241-Z			
241-ZG	1.5	--	Limited exposure and loss potential (see text)
241-ZA	2	--	Limited exposure and loss potential (see text)
Building 243-Z			
291-Z	7	0	Underground structure

Buildings 234-5Z, 242-Z (including the adjacent storage annex), 236-Z, 243-Z, 232-Z, 234-5ZA, 2736-ZA, 2736-ZB, and 2721-Z are protected throughout by an automatic sprinkler system and the 252-Z Electrical Substation Transformers are protected by an automatic deluge system. In accordance with NFPA 80A (Section 4-4), where the exposing building or structure is protected throughout by an automatic suppression system, no exposure hazard is considered to exist. Therefore, these buildings do not present an exposure hazard to other facilities.

Buildings 2736-Z, 2731-Z, and 2727-Z are not protected by an automatic sprinkler system and are located within 6 m (20 ft) of Building 234-5Z. For these buildings, the method outlined in NFPA 80A is used to determine the minimum separation distance.

Building 2727-Z is located approximately 2 m west of Building 236-Z. The building is of noncombustible construction and has nominal dimensions of 5 m wide by 10 m long. The exterior walls of Building 236-Z are constructed of 20 cm (8 in.) thick concrete having a fire resistance rating of at least 6 hours. NFPA 80A allows a separation reduction to 0 m where the exposed wall is of noncombustible construction with a minimum fire resistance rating of 3-hours (Section 4-2.3). Therefore, there are no separation requirements for this facility.

Building 2736-Z is located approximately 8 m (26 ft) south of the 234-5Z Building. The exterior walls of 2736-Z are constructed of 30 cm (12 in.) thick concrete with a single door opening along the exposing wall. In accordance with Section 2.2.3, the wall of Building 2736-Z facing Building 234-5Z is treated as having 20 percent openings. The width and height of the exposing wall are approximately 20 m and 4 m, respectively. The severity of the exposing fire is taken as light based on the low fuel loading in the facility and the non-combustible construction of the exterior wall. Using NFPA 80A, Table 2-3 yields a guide number of 0.51. In accordance with Section 2-3, the minimum separation distance is calculated by multiplying the minimum of the height and width of the exposing building by the guide number and adding 1.5 m (5 ft). A minimum separation distance of approximately 4 m (12 ft) is calculated. Since the building is located 8 m away, the separation distance is in compliance with NFPA 80A.

Building 2731-Z is located approximately 6 m south of the 234-5Z Building. The exterior walls and roof of 2731-Z are constructed of noncombustible corrugated metal. In accordance with Section 2-2.3, the wall of Building 2731-Z facing Building 234-5Z is treated as having 100 percent openings because it does not have the ability to withstand fire penetration for more than 20 minutes. The width and height of the exposing wall are approximately 5.5 m and 4.0 m, respectively. The severity of the exposing fire is taken as moderate based on the fuel load in Building 2731-Z in accordance with NFPA 80A Table 2-2.4(a). Using NFPA 80A, Table 2-3 yields a guide number of 2.30. In accordance with Section 2-3, the minimum separation distance is calculated by multiplying the minimum of the height and width of the exposing building by the guide number and adding 1.5 m (5 ft). A minimum separation distance of approximately 10.7 m (35 ft) is calculated. NFPA 80A Section 4-2.3 allows a separation reduction of 50 percent where the exposed wall is of noncombustible construction and where all wall openings are closed with materials equivalent to the wall. Therefore, the required separation distance is reduced to 5.4 m (18 ft). Since the building is located 6 m (20 ft) away, the separation distance is in compliance with NFPA 80A.

Building 2731-ZA is located approximately 4.6 m west of 232-Z and 3 m south of 2736-ZB. The peaked roof structure is noncombustible construction and, based on facility input, has a moderate fuel load. The width and height of the non-sprinklered facility is approximately 7.6 m and 3.0 m, respectively. Following NFPA 80A criteria, a minimum separation distance of 9.8 m was calculated. Since all exposed wall openings are closed with materials equivalent to the wall, the minimum separation distance can be reduced to 4.9 m. Although 2731-ZA is within 4.9 m of 232-Z and 2736-ZB, automatic sprinkler protection in 232-Z and 2736-ZB substantially reduces the exposure hazard. Therefore, no recommendations are provided to protect or mitigate the exposure hazard.

A similar situation exists for 2736-ZC which is located approximately 2.5 m east of 232-Z. The facility is used for storage and has a light fuel loading. The building is of noncombustible construction and has a width and height of approximately 7.6 m and 4.6 m, respectively. Based on NFPA 80A criteria, a minimum separation distance of 4.8 m was calculated. Since 232-Z is provided with automatic sprinkler protection, the exposure potential is considered to be minimal, and therefore, no recommendations are provided.

NFPA 80A does not address all of the potential exposure hazard at PFP. Other small buildings and storage areas present potential exposure hazards to the main facilities and are not included in Table 19-1. The 2734-Z series gas storage shed are located in various areas of the yard. Some of these storage sheds are attached to 234-5Z and are sometimes used for flammable gas storage. The 2734-Z storage sheds are addressed in Section 6.13 and are not considered to be an exposure hazard. In addition to the storage sheds, several connex units are to the north of 234-5Z. The connex units are used for storage and are constructed of combustible materials. Since the boxes are stored at least 6 m (20 ft) away from the facility, they do not present an exposure hazard.

Building 291-Z is an underground structure with a concrete block roof. However, the urethane foam coating the exterior of the roof is combustible. The only building which is a

potential exposure hazard is 2731-Z, which is located approximately 2 m (6 ft) west of 291-Z. Likewise, the combustible roof coating of 291-Z is a potential exposure hazard to 2731-Z. However, since a fire on the roof will not penetrate the 291-Z concrete structure and given the limited value of the 2731-Z contents and structure, no recommendation is provided to correct or protect the exposure hazard.

Several ancillary building expose the 241-Z facility. For example, 241-ZA and 241-ZG are located within 2 m of the 241 building. Although neither the exposed buildings nor 241-Z are protected by automatic sprinkler systems, the exposure hazard is considered to be minimal based on the noncombustible construction and limited fuel load. The primary use of 241-Z is to house the underground storage tanks. There are almost no combustible contents within the facility. Therefore, the existing separation distances do not present an exposure hazard.

SECTION 20 — RECOMMENDATIONS

20.1 GENERAL RECOMMENDATIONS

- Maintain all existing automatic sprinkler systems installed in the PFP facilities.
- Maintain existing housekeeping efforts in the PFP facilities.
- Provide automatic fire suppression and fire detection in gloveboxes in accordance with the recommendations presented in Section 7.0 or, based on glovebox specific evaluation, provide cost effective protection.
- Document fire resistance rating of fire barriers on facility drawings.

20.2 BUILDING 234-5Z

- Limit the combustible loading in offices, labs, storage rooms, and process areas to existing levels with a maximum fuel load as discussed in Section 6. Increased fuel loads will result in longer fire durations and can potentially increase the MPFL for the building.
- Do not allow the storage of combustible materials in the duct level. The floor/ceiling assembly for the first floor may not prevent fire spread to the duct level if combustibles materials are stored on the duct level floor. Fire spread to the duct level will increase the MPFL for the building.
- Do not store combustible materials in the corridors except in designated storage areas (e.g., second floor near elevator). During the site survey, corridors were generally free of combustibles; however, in some areas, the corridors were used for temporary storage (e.g., laundry bags, cardboard boxes). Combustible materials in the corridor provide a means for fire spread throughout the facility and could result in a greater MPFL for the building.
- Maintain the integrity of the first floor ceiling assembly. The plaster ceiling is heavily relied upon to maintain structural integrity of the building. Existing penetrations and unprotected openings do not violate the passive fire resistance of the plaster ceiling for the design basis fire scenarios. Future unprotected penetrations or openings should not be permitted.
- Maintain a minimum 1-hour fire resistance rating for the fire barrier separating 234-5Z and 234-5ZA. The 2-hour fire resistance rating of the 234-5ZA roof assembly is not required and should not be maintained.

- Deactivate or abandon in place the manual fire alarm station located in the corridor 4B airlock (i.e., no. 27-50) and provide a sign indicating that the device is not or may not be operational.

- Deactivate or abandon in place the heat detector located in the corridor 4B airlock (i.e., no. 27-49) and provide a sign indicating that the device is not or may not be operational.

- Continue to store combustible and flammable liquids in approved flammable liquid cabinets.

- Conduct a complete evaluation of the emergency lighting system. If deficiencies are found, they should be addressed with work packages or corrective actions.

- Automatic sprinkler protection is not required in the filter rooms or plutonium storage vaults based on the limited fuel load and criticality concerns. However, all other areas of the building which do not have sprinklers should be provided with automatic sprinkler protection (e.g., Rooms 194, 334, and 335).

- Provide a diked area around the hydraulic elevator pump in room no. 321 (i.e., fan room) in accordance with NFPA 30, *Flammable and Combustible Liquids Code*. The automatic sprinkler system on the second floor is expected to control and limit damage resulting from a fire involving ordinary combustibles. However, a combustible liquid fire may not be controlled by the sprinkler system; therefore, the exposed structural steel members on the second floor may be exposed to such a fire and result in structural failure of the roof assembly. As such, limiting the maximum fire size of a hydraulic oil spill will minimize the potential damage to the facility.

- Maintain the water spray deluge system protecting the oil filled transformers (i.e., Station 252-ZI). The water spray system is required since the transformers provide an exposure hazard to the 234-5Z facility.

20.3 BUILDING 242-Z

- Deactivate or abandon in place the fire alarm equipment that cannot be accessed for testing and is not necessary based on this analysis. In addition, post a sign upon entering the facility indicating that the fire alarm equipment is not or may not be operational.

- Remove the plastic rolls from TC-66 or enclose them in noncombustible containers.

20.4 BUILDING 236-Z

- There are no recommendations for this facility.

20.5 BUILDING 291-Z

- Maintain the water spray deluge system protecting the oil filled transformers in Room 500.
- Fill all penetrations and maintain a minimum 3-hour fire resistance rating for the wall separating Room 500 and the fan room.
- Fill all penetrations and maintain a minimum 1-hour fire resistance rating for the wall separating Rooms 500 and 501.

20.6 BUILDING 2736-ZB

- Relocate the designated fire wall to along the south wall of the NDA Lab. This will allow the door serving the NDA Lab to remain open while maintaining adequate separation between the office and lab/storage areas.

20.7 BUILDING 2736-Z

- Provide door no. 8, which serves as an exit, with a knob, handle, panic bar, or other simple type of releasing device which opens with no more than one releasing operation. Currently, this door requires multiple actions to open.

20.8 BUILDING 2721-Z

- There are no recommendations for this facility.

20.9 BUILDING 232-Z

- There are no recommendations for this facility.

20.10 BUILDING 241-Z

- There are no recommendations for this facility.

20.11 BUILDING 243-Z

- There are no recommendations for this facility.

20.12 COMPRESSED GAS STORAGE AREAS

- Replace the combustible wood storage shed with a structure constructed of noncombustible materials in accordance with NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders.*

20.13 HAZARDOUS PRODUCT AND WASTE EXTERIOR LAY DOWN AREAS

- There are no recommendations for this facility.

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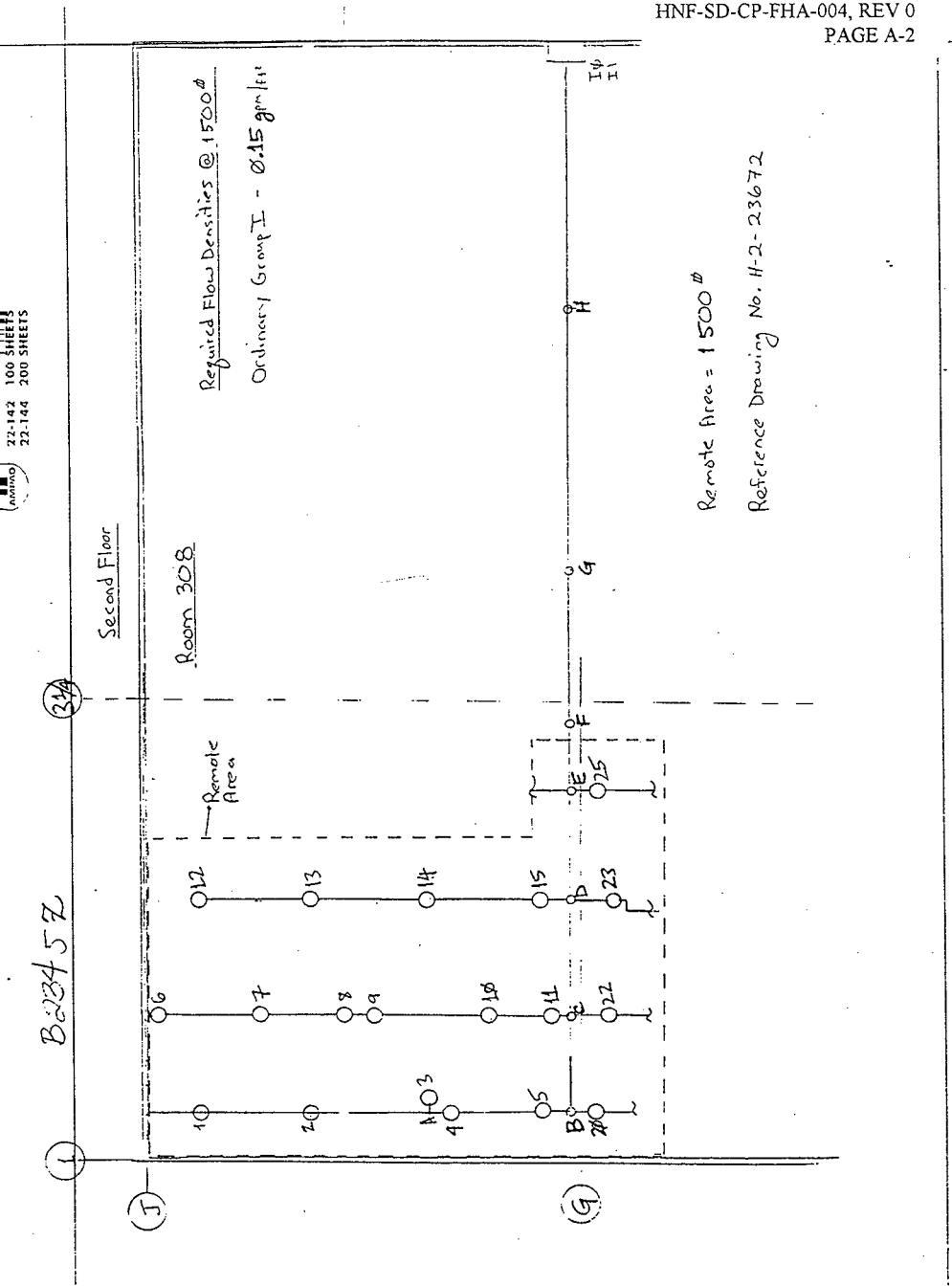
This document was too large to scan as a single document; therefore, it has been divided into smaller sections.

Section 2 of 2

Document Information			
Document #	SD-CP-FHA-004	Revision	0
Title	FIRE HAZARD ANALYSIS FOR PFP PROJECT		
Date	10/07/98		
Originator	MCKINNIS DL	Originator Co.	BWHC
Recipient		Recipient Co.	
References	EDT-700527		
Keywords	MAXIMUM POSSIBLE FIRE LOSS,MAXIMUM CREDITABLE FIRE LOSS		
Projects	PFP		
Other Information			

APPENDIX A

Hydraulic Calculations


Required Flow Densities @ 1500#
Ordinary Group I - 0.15 gpm/ft²
Remote Area = 1500#
Reference Drawing No. H-2-23672
Second Floor
Room 308
Remote Area
B234 5Z
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File: B2345Z-A.THE "THE" Sprinkler Program by FPE Software, Inc. Page: 1

NODE	PRESSURE (PSI)	FLOW (GPM)	ELEVATION (FEET)	K-FACTOR	AREA (SQ.FT.)	DENSITY (GPM/SQ.FT.)
A	18.59	0.00	718			
B	25.59	0.00	718			
C	26.33	0.00	718			
D	27.55	0.00	718			
E	29.71	0.00	718			
F	31.32	0.00	718			
G	33.13	0.00	718			
H	34.76	0.00	718			
I0	36.93	0.00	717.25			
I1	38.02	0.00	714			
J	41.34	0.00	713.17			
K0	42.68	0.00	713.17			
K1	41.60	0.00	716			
L	43.17	0.00	715.5			
M	43.52	0.00	715			
N	27.18	0.00	718			
BR	62.30	718.23	671.92	SOURCE		
1	12.13	19.50	718	5.6	130	0.150
2	13.49	20.57	718	5.6	111	0.185
3	17.40	23.36	718	5.6	111	0.210
4	18.97	24.39	718	5.6	75	0.325
5	21.30	25.85	718	5.6	96	0.269
6	12.82	20.05	718	5.6	106	0.189
7	14.10	21.03	718	5.6	106	0.198
8	17.79	23.62	718	5.6	82	0.288
9	18.85	24.31	718	5.6	120	0.203
10	21.66	26.06	718	5.6	120	0.217
11	24.33	27.62	718	5.6	71	0.389
12	13.54	20.61	718	5.6	120	0.172
13	15.05	21.73	718	5.6	120	0.181
14	20.78	25.53	718	5.6	120	0.213
15	24.39	27.66	718	5.6	120	0.230
16	29.71	0.00	718	0.0		
17	29.71	0.00	718	0.0		
18	29.71	0.00	718	0.0		
19	29.71	0.00	718	0.0		
20	25.48	28.27	718	5.6	60	0.471
21	25.48	0.00	718	0.0		
22	26.00	28.55	718	5.6	120	0.238
23	27.18	29.20	718	5.6	65	0.449
24	27.18	0.00	718	0.0		
25	29.34	30.33	718	5.6	115.5	0.263

- 234-5Z
- Ordinary Hazard Group II

END NODE	FLOW (GPM)	DIAMETER (INCHES)	TYPE	FITTINGS	LENGTH (FEET)	EQV LENGTH (FEET)	TOT LENGTH (FEET)	FRICTION (PSI/FT.)	C-VALUE	Pe (PSI)	Pf (PSI)	VELOCITY (FT/SEC)
M	468.23	8.249	10	E	43	18.00	61.00	0.002	120	18.67	0.12	2.81
L	468.23	8.249	10	T	33.5	35.00	68.50	0.002	120	0.22	0.13	2.81
K1	468.23	6.065	40	3EFT	77.67	79.00	156.67	0.009	120	0.22	1.35	5.20
K0	468.23	6.065	40	E	2.83	14.00	16.83	0.009	120	-1.23	0.15	5.20
J	468.23	6.065	40	E	141	14.00	155.00	0.009	120	0.00	1.34	5.20
I0	468.23	5.047	40	2E	100.83	24.00	124.83	0.021	120	1.77	2.64	7.51
I1	468.23	5.047	40	E	3.25	12.00	15.25	0.021	120	-1.41	0.32	7.51
H	468.23	5.047	40	3E	35.83	36.00	71.83	0.021	120	1.73	1.52	7.51
G	468.23	4.026	40		25.75	0.00	25.75	0.064	120	0.00	1.64	11.80
F	468.23	3.548	40		15.34	0.00	15.34	0.118	120	0.00	1.80	15.19
E	468.23	3.068	40		6.75	0.00	6.75	0.239	120	0.00	1.61	20.32
E	0.00	1.610	40	T	8.25	8.00	16.25	0.000	120	0.00	0.00	0.00
19	0.00	1.380	40		10.83	0.00	10.83	0.000	120	0.00	0.00	0.00
18	0.00	1.049	40	4E	16.5	8.00	24.50	0.000	120	0.00	0.00	0.00
17	0.00	1.049	40		9.58	0.00	9.58	0.000	120	0.00	0.00	0.00
D	437.90	3.068	40		10.25	0.00	10.25	0.211	120	0.00	2.16	19.00
15	95.52	1.610	40	T	2.83	8.00	10.83	0.291	120	0.00	3.16	15.05
14	67.86	1.380	40		11	0.00	11.00	0.328	120	0.00	3.61	14.56
13	42.33	1.049	40		11	0.00	11.00	0.521	120	0.00	5.73	15.72
12	20.61	1.049	40		11	0.00	11.00	0.138	120	0.00	1.51	7.65
C	313.19	3.068	40		10.75	0.00	10.75	0.113	120	0.00	1.22	13.59
11	142.70	2.067	40	T	1	10.00	11.00	0.181	120	0.00	2.00	13.64
10	115.07	1.610	40		6.5	0.00	6.50	0.411	120	0.00	2.67	18.14
9	89.01	1.610	40		11	0.00	11.00	0.256	120	0.00	2.81	14.03
8	64.70	1.380	40		3.5	0.00	3.50	0.300	120	0.00	1.05	13.88
7	41.08	1.049	40		7.5	0.00	7.50	0.493	120	0.00	3.70	15.25
6	20.05	1.049	40		9.75	0.00	9.75	0.131	120	0.00	1.28	7.44
B	141.94	2.469	40		9.75	0.00	9.75	0.076	120	0.00	0.74	9.51
5	113.67	1.610	40	T	2.67	8.00	10.67	0.402	120	0.00	4.29	17.91
4	87.82	1.610	40		9.33	0.00	9.33	0.250	120	0.00	2.33	13.84
A	63.43	1.380	40		1.33	0.00	1.33	0.290	120	0.00	0.39	13.61
3	23.36	1.049	40	T	1.83	5.00	6.83	0.173	120	0.00	1.18	8.67
2	40.07	1.049	40		10.83	0.00	10.83	0.471	120	0.00	5.10	14.87
1	19.50	1.049	40		11	0.00	11.00	0.124	120	0.00	1.37	7.24
21	0.00	1.610	40		6	0.00	6.00	0.000	120	0.00	0.00	0.00
20	28.27	2.067	40	T	2	10.00	12.00	0.009	120	0.00	0.11	2.70
22	28.55	1.610	40	T	2.58	8.00	10.58	0.031	120	0.00	0.33	4.50
24	0.00	1.049	40	T	0.5	5.00	5.50	0.000	120	0.00	0.00	0.00
N	0.00	1.610	40	3E	7.17	12.00	19.17	0.000	120	0.00	0.00	0.00
23	29.20	1.610	40	T	3.25	8.00	11.25	0.033	120	0.00	0.37	4.60
25	30.33	1.610	40	T	2.58	8.00	10.58	0.035	120	0.00	0.37	4.78

H Y D R A U L I C S U M M A R Y

WATER SUPPLY INFORMATION

Static: 124.00 psi.
Residual: 80.00 psi. @ 1170.00 gpm.
Hose: 250.00 gpm.

System requires: 62.30 psi. @ 718.23 gpm. (including Hose Allowance)
Supply available: 106.16 psi.

Safety Margin: 43.86 psi.

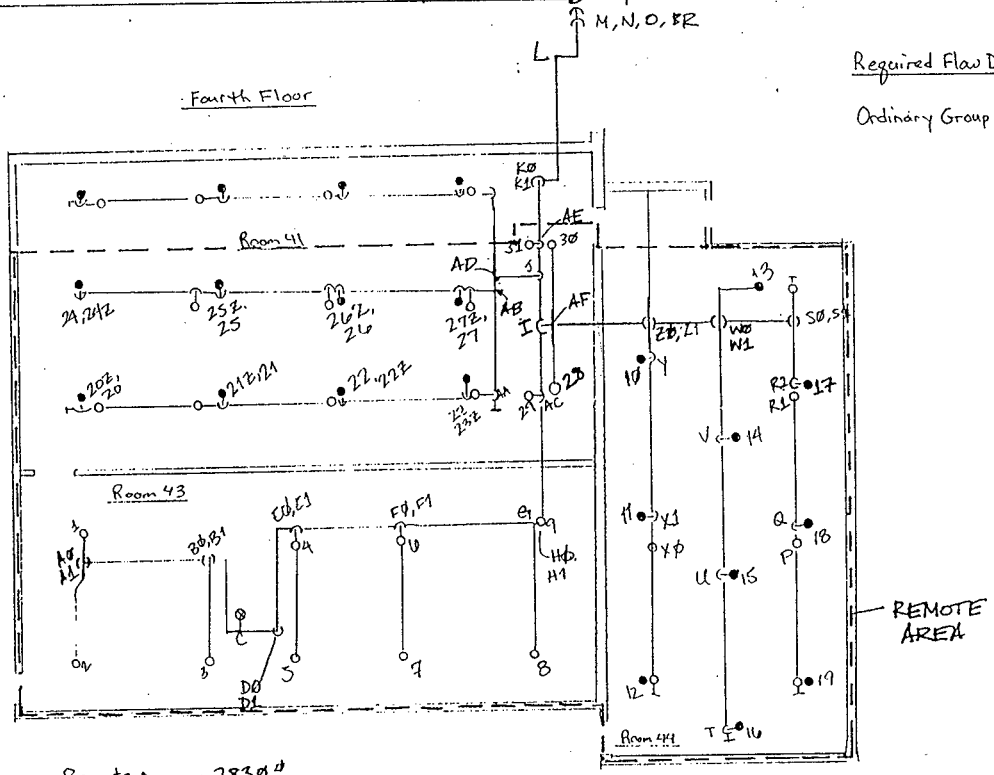
Maximum velocity in the system is 20.32 ft/sec.

Continuity at all nodes satisfied to 0.01 gpm.

FITTING LEGEND	PIPE TYPE LEGEND
F = 45 DEGREE ELBOW	40 = SCHEDULE 40
E = 90 DEGREE ELBOW	10 = SCHEDULE 10
L = 90 DEGREE LONG TURN ELBOW	30 = SCHEDULE 30
T = TEE OR CROSS	AD = ACTUAL DIAMETER
B = BUTTERFLY VALVE	CK = COPPER TYPE K
G = GATE VALVE	CL = COPPER TYPE L
C = CHECK VALVE	CM = COPPER TYPE M
A = ALARM VALVE	PB = POLYBUTYLENE - IRON PIPE SIZE
=	CP = CPVC
=	=

NOTES:

PFP BLDG B236-Z



Required Flow Densities @ 2830 ft²

Ordinary Group I - 0.125 gpm/ft²

Remote Area = 2830 ft²

Reference Drawing No. H-2-26911

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- ORDINARY HAZARD GROUP 1
- 236-Z

NODE	PRESSURE (PSI)	FLOW (GPM)	ELEVATION (FEET)	K-FACTOR	AREA (SQ.FT.)	DENSITY (GPM/SQ.FT.)
BR	51.93	854.00	-30.5	SOURCE		
O	49.14	0.00	-24.90			
N	45.27	0.00	-18.62			
M	30.06	0.00	7.58			
L	27.31	0.00	7.62			
X0	23.16	0.00	7.69			
X1	21.15	0.00	9.54			
J	19.61	0.00	9.56			
I	19.22	0.00	9.58			
H0	17.41	0.00	9.62			
H1	16.14	0.00	10.91			
G	15.16	0.00	10.92			
F0	14.52	0.00	10.94			
F1	12.39	0.00	11.33			
E0	14.25	0.00	10.96			
E1	12.15	0.00	11.33			
D1	14.04	0.00	11.00			
D0	14.49	0.00	9.75			
C	14.39	0.00	9.75			
B0	13.57	0.00	9.77			
B1	12.73	0.00	10.25			
A0	12.61	0.00	9.79			
A1	10.50	0.00	10.25			
P	13.82	0.00	11.92			
Q	13.87	0.00	11.92			
R1	14.56	0.00	11.83			
R2	14.62	0.00	11.83			
S1	15.19	0.00	11.83			
S0	15.80	0.00	11.33			
T	6.66	0.00	11.92			
U	7.72	0.00	11.83			
V	10.81	0.00	11.82			
W0	16.01	0.00	11.33			
W1	13.63	0.00	11.80			
X0	14.22	0.00	12.19			
X1	14.30	0.00	12.19			
Y	15.07	0.00	12.18			
Z0	16.35	0.00	11.31			
Z1	15.56	0.00	12.18			
20Z	12.10	0.00	12			
21Z	13.56	0.00	12			
22Z	14.13	0.00	12			
23Z	14.50	0.00	12			
24Z	12.58	0.00	12			
25Z	14.09	0.00	12			
26Z	14.68	0.00	12			
27Z	15.06	0.00	12			
AA	16.56	0.00	10.17			
AB	17.16	0.00	10.17			
AC	18.50	0.00	9.58			
AD	18.44	0.00	10.17			

PRESSURE (PSI)	FLOW (GPM)	ELEVATION (FEET)	K-FACTOR	AREA (SQ.FT.)	DENSITY (GPM/SQ.FT.)
19.81	0.00	9.57			
13.85	0.00	11.9			
9.48	17.25	10.92	5.6	112	0.154
8.91	16.72	10.58	5.6	112	0.149
10.94	18.52	10.92	5.6	112	0.165
9.89	17.61	11.67	5.6	85	0.207
8.82	16.63	12.08	5.6	85	0.196
10.10	17.79	11.67	5.6	108	0.165
8.93	16.74	12.25	5.6	108	0.155
12.95	20.15	11.33	5.6	115	0.175
15.13	21.78	11.33	5.6	115	0.189
14.46	21.29	9	5.6	115	0.185
13.78	20.79	9	5.6	124	0.168
12.10	19.48	9	5.6	115	0.169
12.57	19.85	9	5.6	70	0.284
10.67	18.29	9	5.6	70	0.261
7.91	15.75	9	5.6	78	0.202
7.00	14.82	9	5.6	78	0.190
13.95	20.92	9	5.6	65	0.322
13.32	20.44	9	5.6	75	0.273
11.72	19.17	9	5.6	75	0.256
11.83	19.26	9	5.6	132	0.146
13.12	20.29	9	5.6	110	0.184
13.63	20.68	9	5.6	110	0.188
13.96	20.92	9	5.6	110	0.190
12.25	19.60	9	5.6	113	0.173
13.59	20.65	9	5.6	94	0.220
14.12	21.04	9	5.6	94	0.224
14.46	21.29	9	5.6	94	0.227
12.48	19.78	11.9	5.6	104	0.190
16.84	22.98	10.17	5.6	104	0.221
12.42	19.74	11.9	5.6	72	0.274
18.03	23.78	10.17	5.6	48	0.495

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BEGIN NODE	END NODE	FLOW (GPM)	DIAMETER (INCHES)	TYPE	FITTINGS	LENGTH (FEET)	EQV LENGTH (FEET)	TOT LENGTH (FEET)	FRICTION (PSI/FT.)	C-VALUE	Pe (PSI)	Pf (PSI)	VELOCITY (FT/SEC)
A1	2	16.72	1.049	40	T2F	8.5	7.00	15.50	0.093	120	0.14	1.45	6.21
A1	1	17.25	1.049	40	T	2.33	5.00	7.33	0.099	120	0.29	0.73	6.40
A0	A1	33.96	1.049	40	T	0.5	5.00	5.50	0.347	120	0.20	1.91	12.61
B0	A0	33.96	1.380	40		10.5	0.00	10.50	0.091	120	0.01	0.96	7.28
B1	3	18.52	1.049	40	T	8.33	5.00	13.33	0.113	120	0.29	1.50	6.87
B0	B1	18.52	1.049	40	T	0.6	5.00	5.60	0.113	120	0.21	0.63	6.87
C	B0	52.48	1.610	40		8.45	0.00	8.45	0.096	120	0.01	0.81	8.27
D0	C	52.48	2.469	40	E	2.13	6.00	8.13	0.012	120	0.00	0.10	3.52
D1	D0	52.48	2.469	40	E	1.25	6.00	7.25	0.012	120	-0.54	0.09	3.52
E0	D1	52.48	2.469	40	E	10.16	6.00	16.16	0.012	120	0.02	0.19	3.52
4	5	16.63	1.049	40		9.71	0.00	9.71	0.092	120	0.18	0.90	6.17
E1	4	34.24	1.049	40	T	1	5.00	6.00	0.352	120	0.15	2.11	12.71
E0	E1	34.24	1.049	40	T	0.5	5.00	5.50	0.352	120	0.16	1.94	12.71
F0	E0	86.72	2.469	40		8.75	0.00	8.75	0.030	120	0.01	0.27	5.81
6	7	16.74	1.049	40		9.71	0.00	9.71	0.094	120	0.25	0.91	6.21
F1	6	34.53	1.049	40	T	1	5.00	6.00	0.357	120	0.15	2.14	12.82
F0	F1	34.53	1.049	40	T	0.5	5.00	5.50	0.357	120	0.17	1.97	12.82
G	F0	121.26	2.469	40		11.08	0.00	11.08	0.056	120	0.01	0.63	8.13
G	8	20.15	1.049	40	T	10.37	5.00	15.37	0.132	120	0.18	2.03	7.48
H1	G	141.41	2.469	40	T	1	12.00	13.00	0.075	120	0.00	0.98	9.48
H1	9	21.78	1.049	40	T	0.4	5.00	5.40	0.152	120	0.18	0.82	8.09
H0	H1	163.19	2.469	40	E	1.3	6.00	7.30	0.098	120	0.56	0.71	10.94
AC	H0	163.19	2.469	40		10.96	0.00	10.96	0.098	120	0.02	1.07	10.94
I	AC	186.17	2.469	40		5.75	0.00	5.75	0.125	120	0.00	0.72	12.48
J	I	416.49	3.548	40		4	0.00	4.00	0.095	120	0.01	0.38	13.52
AE	J	580.22	4.026	40		2.25	0.00	2.25	0.095	120	-0.00	0.21	14.62
K1	AE	604.00	4.026	40	E	3	10.00	13.00	0.102	120	0.01	1.32	15.22
K0	K1	604.00	4.026	40	E	1.85	10.00	11.85	0.102	120	0.80	1.21	15.22
L	K0	604.00	4.026	40	E	30.5	10.00	40.50	0.102	120	0.03	4.12	15.22
AE	31	23.78	1.049	40	ET	1.5	7.00	8.50	0.179	120	0.26	1.52	8.83
M	L	604.00	4.026	40	2E	6.84	20.00	26.84	0.102	120	0.02	2.73	15.22
N	M	604.00	4.026	40	4F	21.88	16.00	37.88	0.102	120	11.35	3.86	15.22
O	N	604.00	5.047	40	2FE	11.93	22.00	33.93	0.034	120	2.72	1.15	9.69
ER	O	604.00	6.065	40	2F	12.05	14.00	26.05	0.014	120	2.43	0.36	6.71
P	19	19.17	1.049	40	E2T	16	12.00	28.00	0.120	120	-1.27	3.37	7.12
Q	P	19.17	1.380	40		1.58	0.00	1.58	0.032	120	0.00	0.05	4.11
Q	18	20.44	1.049	40	2ET	4.42	9.00	13.42	0.135	120	-1.27	1.82	7.59
R1	Q	39.61	1.610	40		11.42	0.00	11.42	0.057	120	0.04	0.65	6.24
R2	R1	39.61	1.610	40		1	0.00	1.00	0.057	120	0.00	0.06	6.24
R2	17	20.92	1.049	40	2ET	4.42	9.00	13.42	0.141	120	-1.23	1.90	7.76
S1	R2	60.52	2.067	40	T	5.33	10.00	15.33	0.037	120	0.00	0.57	5.79
S0	S1	60.52	2.067	40	T	0.5	10.00	10.50	0.037	120	0.22	0.39	5.79
W0	S0	60.52	2.067	40		5.67	0.00	5.67	0.037	120	0.00	0.21	5.79
W1	13	19.85	1.049	40	2ET	8.75	9.00	17.75	0.128	120	-1.21	2.28	7.37
T	16	14.82	1.049	40	2ET	3.33	9.00	12.33	0.075	120	-1.27	0.92	5.50
U	T	14.82	1.049	40		13.67	0.00	13.67	0.075	120	0.04	1.02	5.50
U	15	15.75	1.049	40	2ET	3.33	9.00	12.33	0.084	120	-1.23	1.03	5.85
V	U	30.57	1.049	40		10.83	0.00	10.83	0.285	120	0.00	3.09	11.35
V	14	18.29	1.049	40	2ET	3.33	9.00	12.33	0.110	120	-1.22	1.36	6.79
W1	V	48.86	1.380	40	T	9.75	6.00	15.75	0.179	120	0.01	2.81	10.48
W0	W1	68.71	1.380	40	T	0.47	6.00	6.47	0.336	120	0.20	2.17	14.74

END NODE	FLOW (GPM)	DIAMETER (INCHES)	TYPE	FITTINGS	LENGTH (FEET)	EQV LENGTH (FEET)	TOT LENGTH (FEET)	FRICTION (PSI/FT.)	C-VALUE	Pe (PSI)	Pf (PSI)	VELOCITY (FT/SEC)
W0	129.24	2.469	40		5.33	0.00	5.33	0.064	120	0.01	0.34	8.66
12	19.48	1.049	40	E2T	16.2	12.00	28.20	0.124	120	-1.38	3.50	7.23
X0	19.48	1.380	40		2.5	0.00	2.50	0.033	120	0.00	0.08	4.18
11	20.79	1.049	40	2ET	4.62	9.00	13.62	0.140	120	-1.38	1.90	7.72
X1	40.27	1.610	40		13	0.00	13.00	0.059	120	0.00	0.77	6.35
10	21.29	1.049	40	2ET	4.62	9.00	13.62	0.146	120	-1.38	1.99	7.90
Y	61.56	2.067	40	T	2.84	10.00	12.84	0.038	120	0.00	0.49	5.89
Z1	61.56	2.067	40	T	0.87	10.00	10.87	0.038	120	0.38	0.42	5.89
Z0	190.80	3.068	40	3ET	10.59	36.00	46.59	0.045	120	0.75	2.11	8.28
29	22.98	1.049	40	ET	1.33	7.00	8.33	0.168	120	0.26	1.40	8.53
24	19.60	1.049	40	2ET	4	9.00	13.00	0.125	120	-1.30	1.63	7.28
25	20.65	1.049	40	2ET	4	9.00	13.00	0.138	120	-1.30	1.79	7.66
26	21.04	1.049	40	2ET	4	9.00	13.00	0.143	120	-1.30	1.86	7.81
27	21.29	1.049	40	2ET	4	9.00	13.00	0.146	120	-1.30	1.90	7.90
20	19.26	1.049	40	2ET	4	9.00	13.00	0.121	120	-1.30	1.58	7.15
21	20.29	1.049	40	2ET	4	9.00	13.00	0.134	120	-1.30	1.74	7.53
22	20.68	1.049	40	2ET	4	9.00	13.00	0.138	120	-1.30	1.80	7.68
23	20.92	1.049	40	2ET	4	9.00	13.00	0.141	120	-1.30	1.84	7.77
20Z	19.26	1.049	40		12	0.00	12.00	0.121	120	0.00	1.46	7.15
21Z	39.54	1.610	40		10	0.00	10.00	0.057	120	0.00	0.57	6.23
22Z	60.22	2.067	40		10	0.00	10.00	0.037	120	0.00	0.37	5.76
23Z	81.14	2.067	40	ET	4.92	15.00	19.92	0.064	120	0.79	1.27	7.76
24Z	19.60	1.049	40		12	0.00	12.00	0.125	120	0.00	1.50	7.28
25Z	40.25	1.610	40		10	0.00	10.00	0.059	120	0.00	0.59	6.34
26Z	61.29	2.067	40		10	0.00	10.00	0.038	120	0.00	0.38	5.86
27Z	82.58	2.067	40	ET	4.92	15.00	19.92	0.066	120	0.79	1.31	7.90
AA	81.14	2.067	40		9.42	0.00	9.42	0.064	120	0.00	0.60	7.76
AB	163.73	2.469	40	T	0.92	12.00	12.92	0.098	120	0.00	1.27	10.97
AD	163.73	3.068	40	ET	4.5	22.00	26.50	0.034	120	0.26	0.91	7.11
30	19.74	1.049	40	T	6.25	5.00	11.25	0.127	120	0.00	1.43	7.33
28	19.78	1.049	40	T	5.75	5.00	10.75	0.128	120	0.00	1.37	7.34
AF	39.52	1.049	40	ET	2.5	7.00	9.50	0.459	120	1.01	4.36	14.67

H Y D R A U L I C S U M M A R Y

WATER SUPPLY INFORMATION

Static: 124.00 psi.
Residual: 80.00 psi. @ 1170.00 gpm.
Hose: 250.00 gpm.

System requires: 51.93 psi. @ 854.00 gpm. (including Hose Allowance)
Supply available: 99.42 psi.

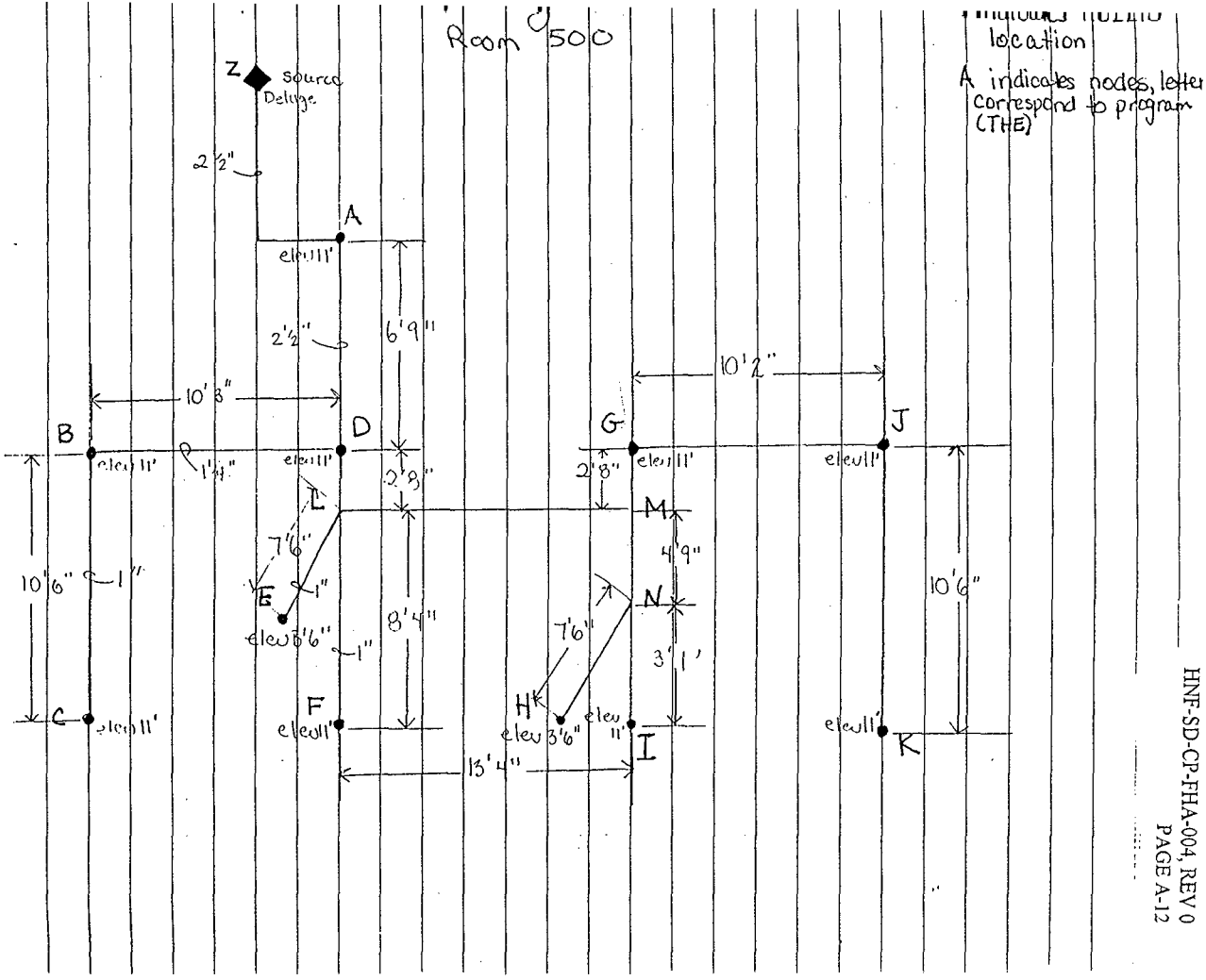
Safety Margin: 47.49 psi.

Maximum velocity in the system is 15.22 ft/sec.

Continuity at all nodes satisfied to 0.01 gpm.

FITTING LEGEND	PIPE TYPE LEGEND
F = 45 DEGREE ELBOW	40 = SCHEDULE 40
E = 90 DEGREE ELBOW	10 = SCHEDULE 10
L = 90 DEGREE LONG TURN ELBOW	30 = SCHEDULE 30
T = TEE OR CROSS	AD = ACTUAL DIAMETER
B = BUTTERFLY VALVE	CK = COPPER TYPE K
G = GATE VALVE	CL = COPPER TYPE L
C = CHECK VALVE	CM = COPPER TYPE M
A = ALARM VALVE	PB = POLYBUTYLENE - IRON PIPE SIZE
=	CP = CPVC
=	=

NOTES:


Room 500
location
A indicates nodes, letter correspond to program (THE)
Z
Source
Deluge
2'2"
A
elev 11'
6'9"
2'2"
10'3"
10'2"
B
elev 11'
1'4"
D
elev 11'
G
elev 11'
J
elev 11'
2'8"
2'3"
L
M
7'6"
4'9"
10'6"
1"
E
1"
N
elev 6'6"
1"
8'4"
7'6"
3'1"
10'6"
C
elev 11'
F
elev 11'
H
elev 3'6"
elev 11'
I
elev 11'
K
13'4"

H Y D R A U L I C S U M M A R Y

WATER SUPPLY INFORMATION

Static: 124.00 psi.
Residual: 80.00 psi. @ 1170.00 gpm.
Hose: 250.00 gpm.

System requires: 91.59 psi. @ 630.86 gpm. (including Hose Allowance)
Supply available: 109.97 psi.

Safety Margin: 18.37 psi.

Maximum velocity in the system is 26.49 ft/sec.

Continuity at all nodes satisfied to 0.01 gpm.

FITTING LEGEND

F = 45 DEGREE ELBOW
E = 90 DEGREE ELBOW
L = 90 DEGREE LONG TURN ELBOW
T = TEE OR CROSS
B = BUTTERFLY VALVE
G = GATE VALVE
C = CHECK VALVE
A = ALARM VALVE
D = DELUGE VALVE
=

PIPE TYPE LEGEND

40 = SCHEDULE 40
10 = SCHEDULE 10
30 = SCHEDULE 30
AD = ACTUAL DIAMETER
= COPPER TYPE K
= COPPER TYPE L
= COPPER TYPE M
= POLYBUTYLENE - IRON PIPE SIZE
= CPVC
=

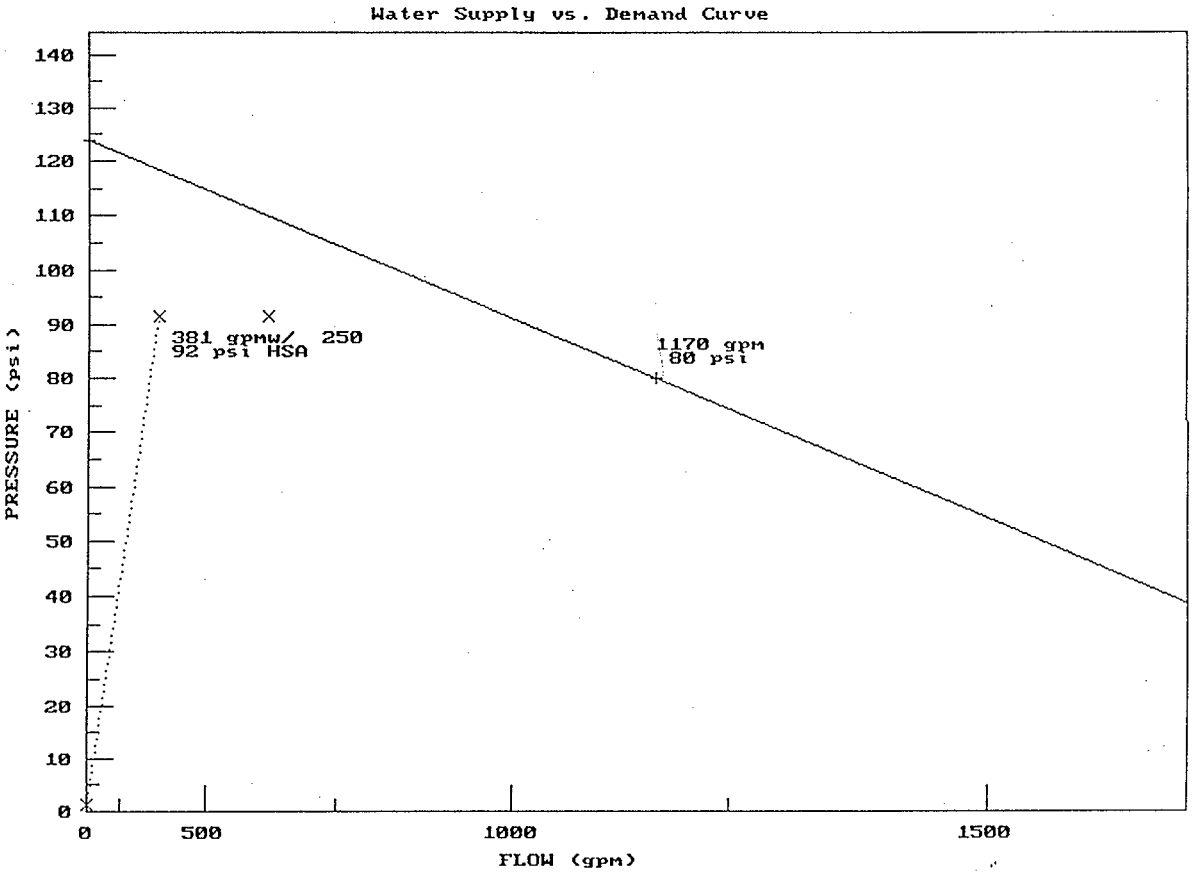
NOTES:
high areas requested, worst case scenario. area overestimated, but useful because line is incorporated, needed due to uncertainty with spray pattern and dimension (conservative, but still within boundaries)

Building 291-Z, Room 500

E	PRESSURE (PSI)	FLOW (GPM)	ELEVATION (FEET)	K-FACTOR	AREA (SQ.FT.)	DENSITY (GPM/SQ.FT.)
	73.40	42.84	11	5.0	100	0.428
	57.42	37.89	11	5.0	100	0.379
	52.04	36.07	11	5.0	100	0.361
	66.76	40.85	11	5.0	100	0.409
	61.50	39.21	3.5	5.0	120	0.327
	58.03	38.09	11	5.0	100	0.381
	37.98	30.81	11	5.0	100	0.308
	35.99	30.00	3.5	5.0	120	0.250
	34.17	29.23	11	5.0	100	0.292
	32.73	28.60	11	5.0	100	0.286
	29.76	27.28	11	5.0	100	0.273
	62.54	0.00	11			
	40.62	0.00	11			
	35.35	0.00	11			
	91.59	630.86	7.75	SOURCE		

ile: TRANS.THE "THE" Sprinkler Program by FPE S

EGIN ODE	END NODE	FLOW (GPM)	DIAMETER (INCHES)	TYPE	FITTINGS	LENGTH (FEET)	EQV LENGTH (FEET)	TOT L (FEE
	D	338.02	2.500	40	T	6.75	12.00	18.
	B	73.96	1.250	40	E	11	4.00	15.
	C	36.07	1.000	40		11	0.00	11.
	L	223.21	2.000	40	T	2.667	6.00	8.6
	F	38.09	1.000	40		8.33	0.00	8.3
	M	145.92	1.500	40	T	14.33	10.00	24.
	G	86.69	1.500	40	E	2.667	5.00	7.6
	J	55.88	1.250	40	E	10.167	4.00	14.1
	K	27.28	1.000	40		10.167	0.00	10.1
	I	29.23	1.000	40		3.58	0.00	3.5
	E	39.21	1.000	40		7.5	0.00	7.5
	H	30.00	1.000	40		7.5	0.00	7.5
	N	59.22	1.250	40	T	4.75	8.00	12.
	A	380.86	2.500	40	G E T	19	19.00	38.


Water Supply vs. Demand Curve
PRESSURE (psi)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
381 gpmw/ 250
92 psi HSA
1170 gpm
80 psi
0
500
1000
1500
FLOW (gpm)

Node	Elevation	K-Factor	Area
A	11	5.0	100
B	11	5.0	100
C	11	5.0	100
D	11	5.0	100
E	3.5	5.0	120
F	11	5.0	100
G	11	5.0	100
H	3.5	5.0	120
I	11	5.0	100
J	11	5.0	100
K	11	5.0	100
L	11		
M	11		
N	11		
Z	7.75	SOURCE	

Building 291-Z, Room 500

Begin Node	End Node	Length	Diam	Type	Fitting Description	C-Value
	D	6.75	E	40	T	120
	B	11	C	40	E	120
	C	11	A	40		120
	L	2.667	B	40	T	120
	F	8.33	A	40		120
	M	14.33	D	40	T	120
	G	2.667	D	40	E	120
	J	10.167	C	40	E	120
	K	10.167	A	40		120
	I	3.58	A	40		120
	E	7.5	A	40		120
	H	7.5	A	40		120
	N	4.75	C	40	T	120
	A	19	E	40	G E T	120

Node	Static	Residual	@	Flow	Hose
Z	124	80		1170	250

HYDRAULIC SUMMARY

ER SUPPLY INFORMATION

tic: 124.00 psi.
idual: 80.00 psi. @ 1170.00 gpm.
e: 250.00 gpm.

stem requires: 51.61 psi. @ 532.80 gpm. (including Hose Allowance)
pply available: 113.73 psi.
---
fety Margin: 62.12 psi.

ximum velocity in the system is 19.63 ft/sec.

ntinuity at all nodes satisfied to 0.01 gpm.

FITTING LEGEND	PIPE TYPE LEGEND
= 45 DEGREE ELBOW	40 = SCHEDULE 40
= 90 DEGREE ELBOW	10 = SCHEDULE 10
= 90 DEGREE LONG TURN ELBOW	30 = SCHEDULE 30
= TEE OR CROSS	AD = ACTUAL DIAMETER
= BUTTERFLY VALVE	= COPPER TYPE K
= GATE VALVE	= COPPER TYPE L
= CHECK VALVE	= COPPER TYPE M
= ALARM VALVE	= POLYBUTYLENE - IRON PIPE SIZE
= DELUGE VALVE	= CPVC
=	=

S:

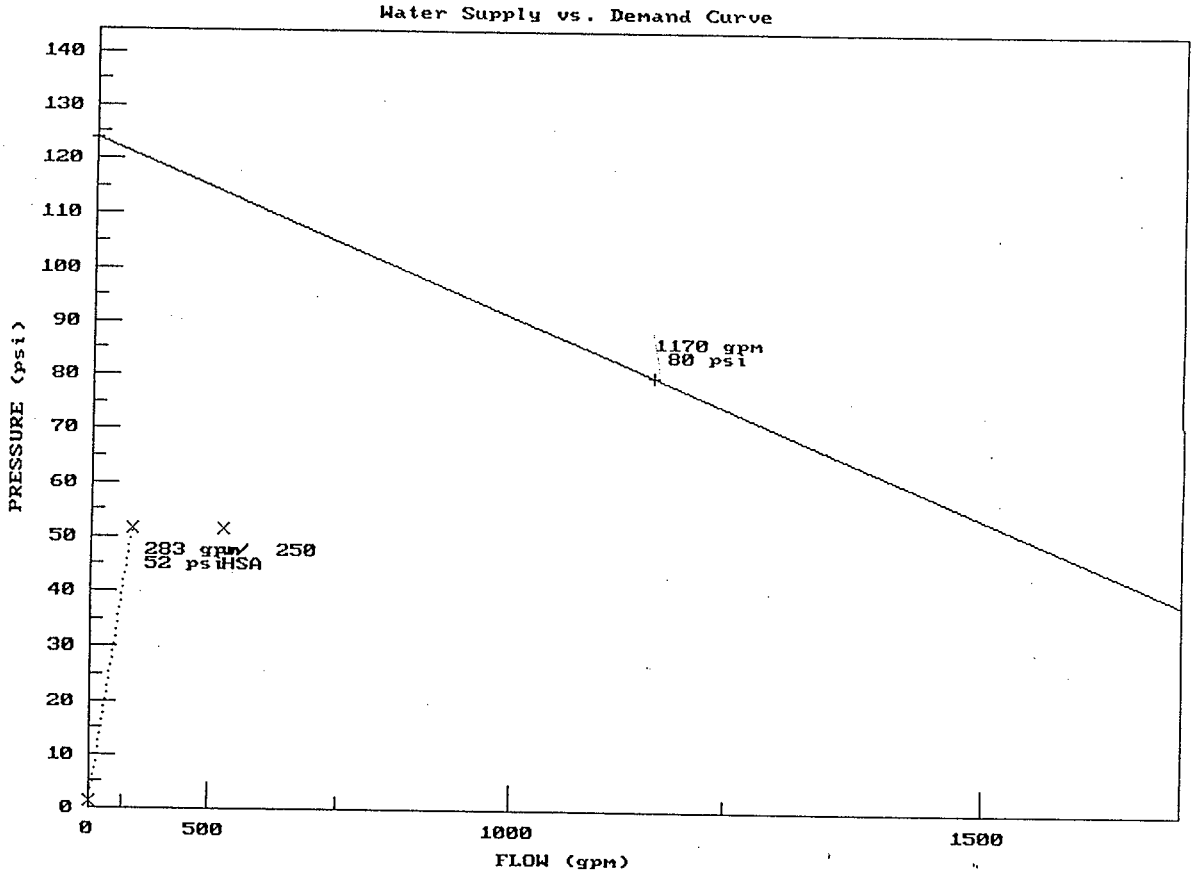
ndle reasonable estimate of
ea, may not account for
ncertainties with transformer
minsar + nozzle specs

Building 291-Z, Room 506

File: TRANS.THE "THE" Sprinkler Program by FPE Software, Inc. Page: 1

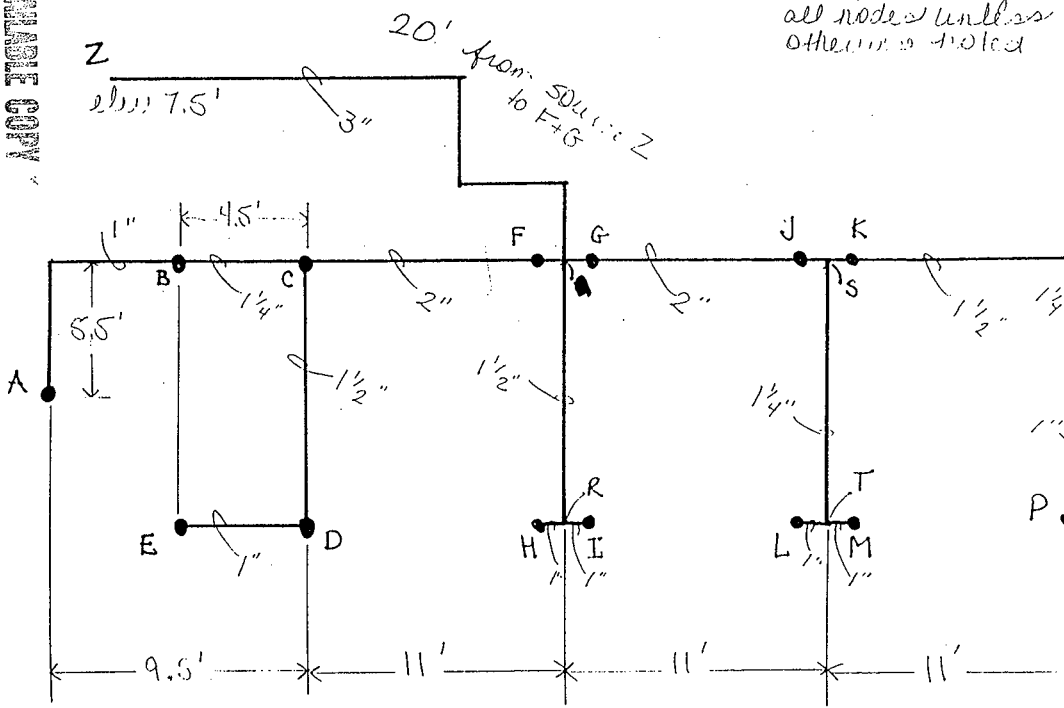
NODE	PRESSURE (PSI)	FLOW (GPM)	ELEVATION (FEET)	K-FACTOR	AREA (SQ.FT.)	DENSITY (GPM/SQ.FT.)
A	40.53	31.83	11	5.0	80	0.398
B	31.59	28.10	11	5.0	80	0.351
C	28.64	26.76	11	5.0	80	0.334
D	36.70	30.29	11	5.0	60	0.505
E	34.97	29.57	3.5	5.0	60	0.493
F	31.69	28.14	11	5.0	60	0.469
G	20.69	22.75	11	5.0	60	0.379
H	20.79	22.80	3.5	5.0	60	0.380
I	18.53	21.52	11	5.0	60	0.359
J	17.72	21.05	11	5.0	80	0.263
K	16.00	20.00	11	5.0	80	0.250
L	34.26	0.00	11			
M	22.19	0.00	11			
N	19.11	0.00	11			
Z	51.61	532.80	7.75	SOURCE		

END NODE	FLOW (GPM)	DIAMETER (INCHES)	TYPE	FITTINGS	LENGTH (FEET)	EQV LENGTH (FEET)	TOT LENGTH (FEET)	FRICTION (PSI/FT.)	C-VALUE	Pe (PSI)	Pf (PSI)	VELOCITY (FT/SEC)
D	250.97	2.500	40	T	6.75	12.00	18.75	0.204	120	0.00	3.83	16.40
B	54.86	1.250	40	E	10.25	4.00	14.25	0.358	120	0.00	5.11	14.34
C	26.75	1.000	40		10.5	0.00	10.50	0.281	120	0.00	2.96	10.93
L	165.83	2.000	40	T	2.667	6.00	8.67	0.281	120	0.00	2.44	16.94
F	28.14	1.000	40		8.33	0.00	8.33	0.309	120	0.00	2.57	11.50
M	108.12	1.500	40	T	13.33	10.00	23.33	0.517	120	0.00	12.07	19.63
G	63.80	1.500	40	E	2.667	5.00	7.67	0.195	120	0.00	1.50	11.58
J	41.05	1.250	40	E	10.167	4.00	14.17	0.210	120	0.00	2.97	10.73
K	20.00	1.000	40		10.5	0.00	10.50	0.164	120	0.00	1.72	8.17
I	21.52	1.000	40		3.08	0.00	3.08	0.188	120	0.00	0.58	8.79
E	29.57	1.000	40		7.5	0.00	7.50	0.339	120	-3.25	2.54	12.08
H	22.80	1.000	40		7.5	0.00	7.50	0.209	120	-3.25	1.57	9.31
N	44.32	1.250	40	T	4.75	8.00	12.75	0.242	120	0.00	3.08	11.59
A	282.80	2.500	40	G E T	19	19.00	38.00	0.255	120	1.41	9.68	18.48


Water Supply vs. Demand Curve
PRESSURE (psi)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
500
1000
1500
FLOW (gpm)
1170 gpm
80 psi
283 gpm
52 psi
250
HSA

Station 152-21

elev 14' throughout all nodes unless otherwise noted



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HUGHES ASSOCIATES, INC. FIRE SCIENCE & ENGINEERING			ENGINEERING CALCULATIONS
TITLE	DATE	SHEET NO.	
DESCRIPTION	CALC. BY	APPROVED BY	

H Y D R A U L I C S U M M A R Y

WATER SUPPLY INFORMATION

Static: 124.00 psi.
Residual: 80.00 psi. @ 1170.00 gpm.
Hose: 250.00 gpm.

System requires: 52.23 psi. @ 697.82 gpm. (including Hose Allowance)
Supply available: 107.09 psi.

Safety Margin: 54.86 psi.

Maximum velocity in the system is 20.33 ft/sec.

Continuity at all nodes satisfied to 0.01 gpm.

FITTING LEGEND	PIPE TYPE LEGEND
F = 45 DEGREE ELBOW	40 = SCHEDULE 40
E = 90 DEGREE ELBOW	10 = SCHEDULE 10
L = 90 DEGREE LONG TURN ELBOW	30 = SCHEDULE 30
T = TEE OR CROSS	AD = ACTUAL DIAMETER
B = BUTTERFLY VALVE	= COPPER TYPE K
G = GATE VALVE	= COPPER TYPE L
C = CHECK VALVE	= COPPER TYPE M
A = ALARM VALVE	= POLYBUTYLENE - IRON PIPE SIZE
=	= CPVC
=	=

NOTES:

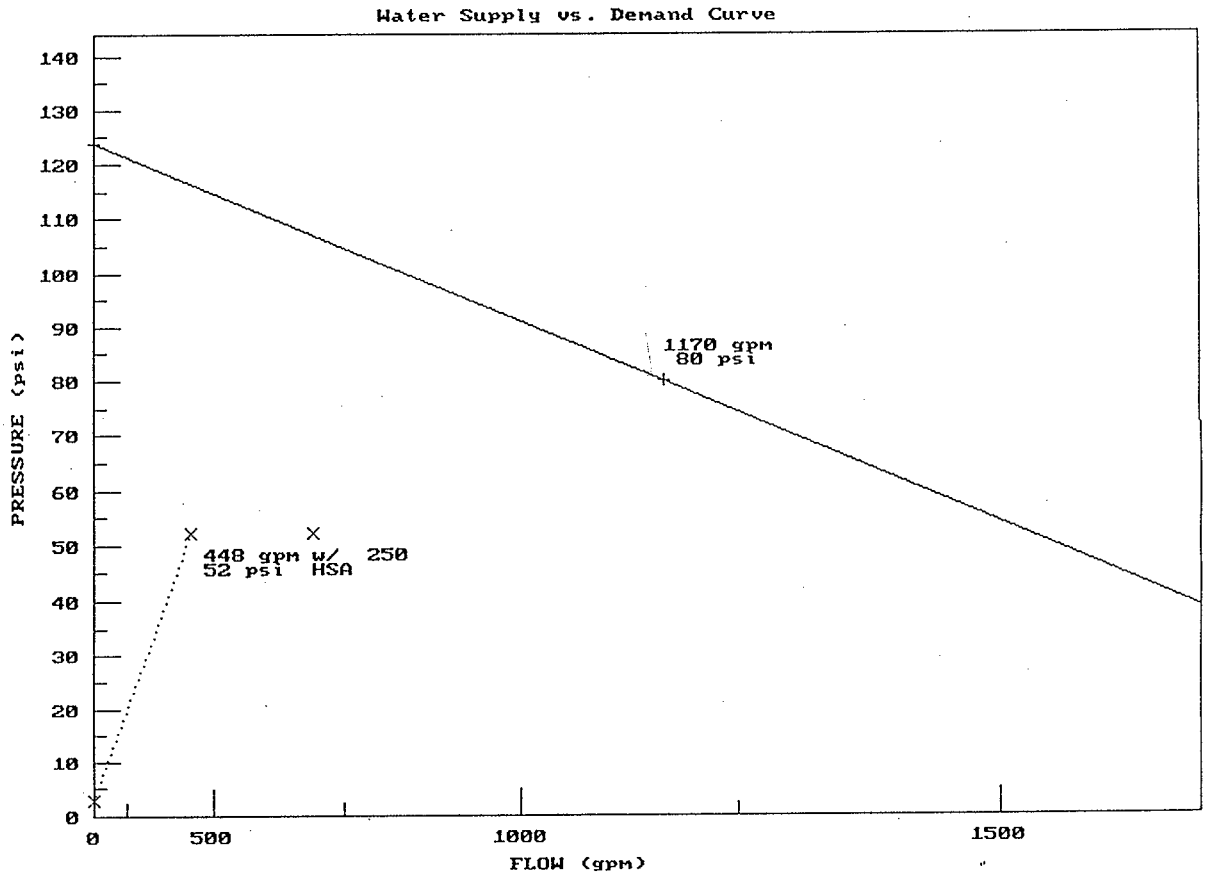
Station 252-ZI

TRANS2.THE "THE" Sprinkler Program by FPE Software, Inc. Page: 1

PRESSURE (PSI)	FLOW (GPM)	ELEVATION (FEET)	K-FACTOR	AREA (SQ.FT.)	DENSITY (GPM/SQ.FT.)
29.51	27.16	14	5	100	0.272
33.13	28.78	14	5	100	0.288
34.80	29.50	14	5	100	0.295
32.33	28.43	14	5	100	0.284
30.97	27.82	14	5	100	0.278
38.38	30.97	14	5	100	0.310
38.19	30.90	14	5	100	0.309
34.68	29.44	14	5	100	0.294
34.68	29.44	14	5	100	0.294
32.34	28.44	14	5	100	0.284
32.34	28.44	14	5	100	0.284
26.35	25.67	14	5	100	0.257
26.35	25.67	14	5	100	0.257
28.07	26.49	14	5	100	0.265
26.37	25.67	14	5	100	0.257
25.00	25.00	14	5	100	0.250
34.85	0.00	14			
32.50	0.00	14			
26.48	0.00	14			
52.23	697.82	7.5	SOURCE		

File: TRANS2.THE "THE" Sprinkler Program by FPE Software, Inc. Page:

BEGIN NODE	END NODE	FLOW (GPM)	DIAMETER (INCHES)	TYPE	FITTINGS	LENGTH (FEET)	EQV LENGTH (FEET)	TOT LENGTH (FEET)	FRICTION (PSI/FT.)	C-VALUE	Pe (PSI)	Pf (PSI)	VELOCITY (FT/SEC)
E	F	447.82	3.000	40	E E T G	20	25.00	45.00	0.245	120	2.82	11.04	20.33
F	C	141.69	2.000	40	T	11	6.00	17.00	0.210	120	0.00	3.57	14.47
C	B	55.94	1.250	40		4.5	0.00	4.50	0.372	120	0.00	1.67	14.63
B	A	27.16	1.000	40	E	10.5	2.00	12.50	0.289	120	0.00	3.62	11.10
C	D	56.25	1.500	40	E	11	5.00	16.00	0.154	120	0.00	2.47	10.21
D	E	27.82	1.000	40		4.5	0.00	4.50	0.303	120	0.00	1.36	11.37
F	R	58.89	1.500	40	T	11	10.00	21.00	0.168	120	0.00	3.53	10.69
F	S	185.37	2.000	40	T	11	6.00	17.00	0.346	120	0.00	5.87	18.93
S	T	51.33	1.250	40	T	11	8.00	19.00	0.317	120	0.00	6.02	13.42
S	N	77.16	1.500	40	E	11	5.00	16.00	0.277	120	0.00	4.44	14.01
N	O	50.67	1.250	40		5.5	0.00	5.50	0.309	120	0.00	1.70	13.25
O	P	25.00	1.000	40		5.5	0.00	5.50	0.248	120	0.00	1.37	10.21
F	G	30.90	1.000	40		.5	0.00	0.50	0.367	120	0.00	0.18	12.62
R	H	29.44	1.000	40		.5	0.00	0.50	0.336	120	0.00	0.17	12.03
R	I	29.44	1.000	40		.5	0.00	0.50	0.336	120	0.00	0.17	12.03
S	J	28.44	1.000	40		.5	0.00	0.50	0.315	120	0.00	0.16	11.62
S	K	28.44	1.000	40		.5	0.00	0.50	0.315	120	0.00	0.16	11.62
T	L	25.67	1.000	40		.5	0.00	0.50	0.261	120	0.00	0.13	10.48
T	M	25.67	1.000	40		.5	0.00	0.50	0.261	120	0.00	0.13	10.48


Water Supply vs. Demand Curve
PRESSURE (psi)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1170 gpm
80 psi
448 gpm w/ 250
52 psi HSA
0
500
1000
1500
FLOW (gpm)

Begin Node	End Node	Length	Diam	Fitting Type	Fitting Description	C-Value
Z	F	20	E	40	E E T G	120
F	C	11	B	40	T	120
C	B	4.5	C	40		120
B	A	10.5	A	40	E	120
C	D	11	D	40	E	120
D	E	4.5	A	40		120
F	R	11	D	40	T	120
F	S	11	B	40	T	120
S	T	11	C	40	T	120
S	N	11	D	40	E	120
N	O	5.5	C	40		120
O	P	5.5	A	40		120
F	G	.5	A	40		120
R	H	.5	A	40		120
R	I	.5	A	40		120
S	J	.5	A	40		120
S	K	.5	A	40		120
T	L	.5	A	40		120
T	M	.5	A	40		120

Station 252-ZI

Elevation	K-Factor	Area
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14	5	100
14		
14		
14		
7.5	SOURCE	

Node	Static	Residual	@	Flow	Hose
[illegible]	124	80		1170	250

APPENDIX B

Analysis of Propane Cylinder Leak

Appendix B — Analysis of Propane Cylinder Leak

Westinghouse Hanford Company has determined that the following proposed scenario depicting the leak of a 1-lb propane bottle is not a credible event [Rodgers, 1996]. The MPFL scenarios were developed and integrated with the PFP SAR based on the requirements of RLID 5480.7A (1/17/94) and WHC-SD-GN-FHA-30001, Rev 0 [WHC, 1994] as directed by WHC [Bucci, 1996]. Since the propane deflagration scenario is not a credible event, it is not considered to be a MPFL fire scenario. The analysis in this section describes the consequences of a worst case propane deflagration and does not consider the probability of such an event.

Hazards associated with the use of liquid propane gas (LPG) in DOT 39 cylinders are divided into two general areas: slow leaks (e.g., releases through the normal discharge orifices) and catastrophic container failures. The latter, catastrophic cylinder failures, is defined as a rupture in which virtually all of the LPG escapes instantaneously. Mechanisms that might cause a catastrophic failure include dropping a full cylinder, crushing a full cylinder, or exposure of a full cylinder to a fire. These catastrophic container failure scenarios are addressed in detail in the FSAR [WHC, 1995]. As such, the remainder of this analysis focuses on slow LPG leaks.

Figure B-1 shows a typical DOT 39 LPG cylinder and its associated features. The cylinders are constructed of two cylindrical sections of cold-drawn, malleable sheet steel having a minimum thickness of 0.635 mm (0.025 in.). The two halves are welded together, and the entire cylinder is completely annealed. Nozzles that attach to the connection are available with shutoff valves having two orifice diameters:

(1) 0.11 mm, which at the maximum flow rate will discharge an initially full container in 20 hours, and

(2) 0.23 mm, which at the maximum flow rate will discharge an initially full container in 6 hours.

All LPG cylinders are equipped with a safety relief valve (SRV) having a diameter of 2.2 mm. At a normal temperature of 30°C, the internal tank pressure is 150 psig. The SRV is designed to open if the internal pressure exceeds 350 psig and reclose if the pressure falls below 350 psig. If the SRV remains open, a full container will discharge in less than 20 seconds.

A previous assessment examined the consequences of a small orifice discharge from a single LPG cylinder [Fauske, 1993]. The analysis primarily considers high momentum turbulent jets resulting from an unconfined LPG discharge. It is shown that the concentration of propane in the jet near the discharge point exceeds the upper flammability limit, and as dilution occurs, the propane concentration enters the flammable range and subsequently falls below the lower flammability limit. As such, an unconfined turbulent propane jet has a limited region within the flammable limits. An uncontrolled discharge through the 2.2 mm diameter SRV was shown to bound the slow leak unconfined turbulent jet scenarios. A deflagration under these conditions in an unventilated 30 m^3 room, which is smaller than any PFP process room, yields a peak

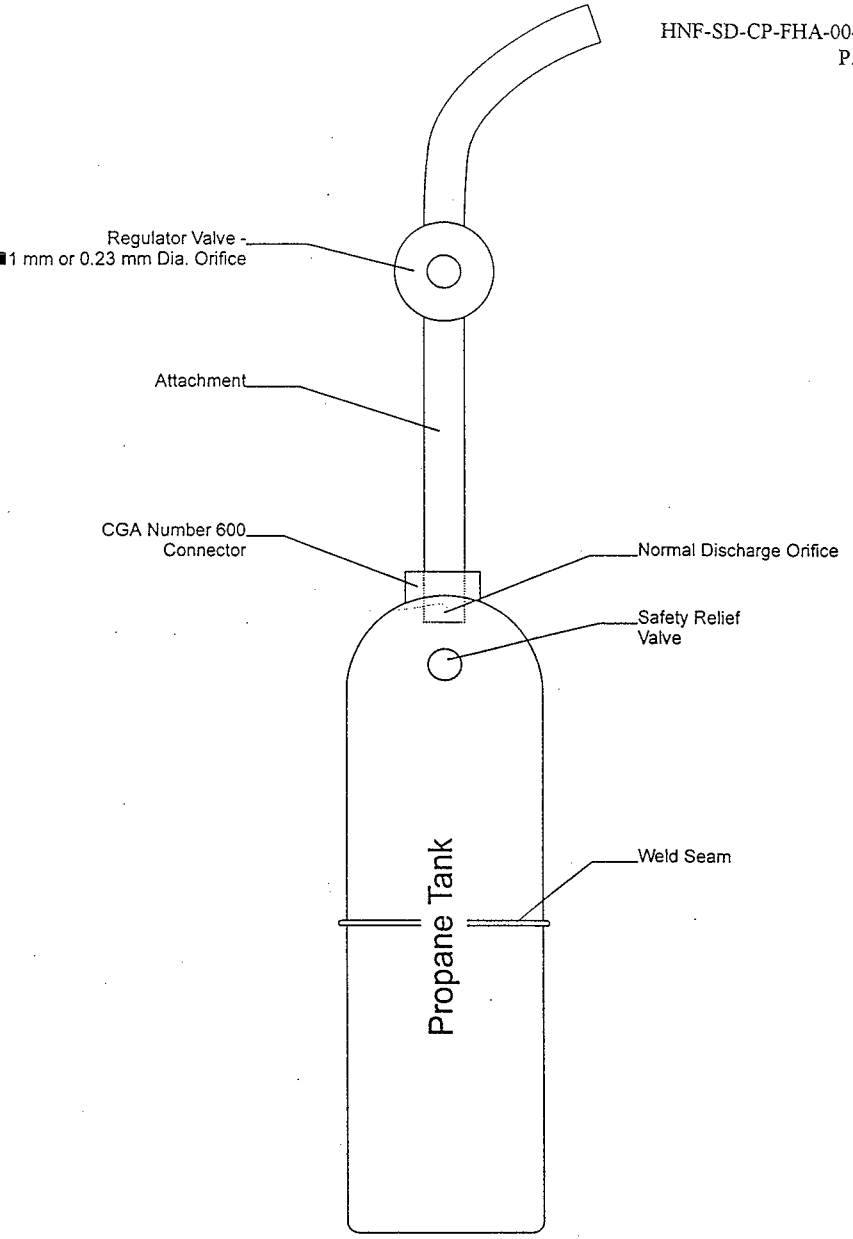


Figure B-1 Typical DOT 39 LPG cylinder

pressure rise of 0.34 psig [WHC, 1995]. *PFP 234-5Z Building Wall Panel Testing* [WHC, 1989] shows that simulated PFP wall panels can survive a maximum pressure rise of 0.49 psig. As such, damage resulting from the deflagration is limited to within the room containing the LPG cylinder.

In the event of an uncontrolled LPG discharge, if the turbulent propane jet is obstructed or confined within the jet region which is at or above the lower flammable limit, it is possible to generate a flammable vapor cloud. Figure B-2 shows a propane cylinder discharge to an area near the corner of a room. This illustrates one example of a confined turbulent jet in which the entrainment of air to the propane jet is reduced to an extent which allows the formation of a flammable gas mixture. Since the density of propane is greater than air, the propane will accumulate along the floor with minimal diffusion to the air above. If the propane concentration in the vapor cloud is above the upper flammable limit, the propane can burn as a diffusion flame at the propane-air interface. If the concentration is within the flammable range, the propane-air mixture can result in a flammable premixed vapor cloud. The maximum pressure rise resulting from the deflagration of a propane-air vapor cloud occurs for a stoichiometric propane concentration in air (i.e., 4.0% volume).

As a bounding scenario, this analysis considers a propane discharge through the 2.2 mm SRV. It is assumed that the turbulent jet is obstructed by an object within the flammable region of the jet and a propane-air mixture having a propane concentration of 4.0% by volume (i.e., the stoichiometric propane-air mixture) forms along the floor. The maximum pressure at the completion of combustion for the propane-air mixture is estimated using Equation 6-7 in Section 6.3.5.

The adiabatic flame temperature for a stoichiometric propane-air mixture is approximately 2300 K [Zalosh, 1988]. For an initial room temperature of 295 K, Equation 6-7 yields a maximum pressure to initial pressure ratio of 7.8. This result estimates the maximum pressure in a space completely filled with a stoichiometric propane-air mixture at the completion of combustion. Since a stoichiometric propane-air mixture resulting from a 465 gram container will not occupy the entire volume of the compartment, the resulting pressure rise in the space will be less than that predicted by Equation 6-7.

The maximum pressure rise in the compartment is determined using the following equation [Zalosh, 1988]:

$$\Delta P_{rm} = P_o \left(\frac{P_m}{P_o} - 1 \right) \frac{m_b}{m_{rm,st}} \qquad \text{(B-1)}$$

where ΔP_{rm} = maximum pressure rise in the compartment,
m_b = mass of propane actually burned (0.465 kg), and
$m_{rm,st}$ = stoichiometric mass of propane which would occupy the entire enclosure.

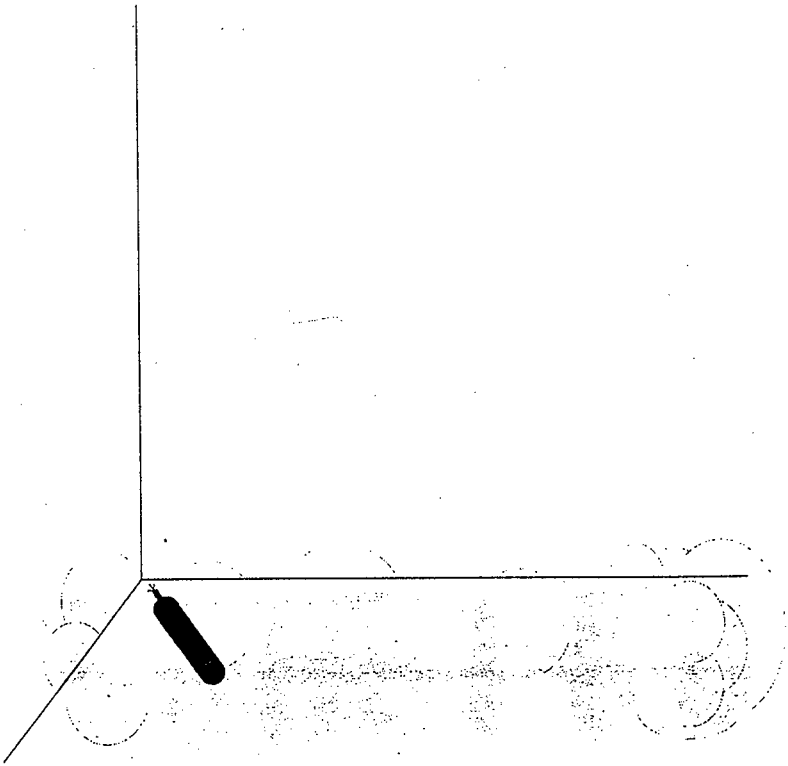


Figure B-2 Flammable vapor cloud formation

The mass of propane actually burned is simply the mass of propane discharged from the cylinder (i.e., 0.465 kg). The stoichiometric mass of propane which would occupy the enclosure is given by

$$m_{rm,st} = Y_{p,st}\ \rho_a\ V_{rm} \tag{B-2}$$

where $m_{rm,st}$ = stoichiometric mass of propane which would occupy enclosure,
ρ_a = density of air at 295 K and 100 kPa (1.2 kg/m^3),
$Y_{p,st}$ = stoichiometric propane-air mass fraction (0.06 g C_3H_8/g air),
V_{rm} = volume of room enclosure.

For a 30 m^3 room enclosure, solving Equations 6-7, B-1, and B-2 yields a maximum pressure rise of 146 kPa or 21.5 psig. The PFP exterior wall panels can only withstand a maximum pressure rise of 0.49 psig. Clearly, the pressure rise resulting from a stoichiometric propane vapor cloud deflagration would cause structural damage to a 30 m^3 room. As the volume of the room increases, the maximum pressure rise will decrease. The smallest size compartment which would yield a maximum pressure rise less than 0.49 psig is a room having a volume of 1,320 m^3. This is larger than almost all of the rooms in the PFP.

Whereas catastrophic cylinder failures and unconfined/unobstructed turbulent jet discharges do not pose a fire hazard (that is a fire hazard greater than the other fire scenarios considered in this study), the analysis identifies scenarios which can potentially cause structural damage to the building. Premixed propane vapor clouds can form when the propane jet discharge is obstructed or confined within the flammable jet region. If such an event occurs in an area along the perimeter of the building or on the second floor such that the room ceiling is part of the building roof assembly, it is possible to breach the structure and release contamination to the atmosphere.

In Sections 6.3.2 and 6.3.3, the integrity of the first floor plaster ceiling assembly is heavily relied upon to limit fire spread and prevent structural damage to the facility. In the event of a propane deflagration, room over pressures as high as 146 kPa (21.5 psig) can result. These pressures can not only blow out wall panels but can also destroy the plaster protection on the ceiling assembly. As a worst case scenario, the propane deflagration can occur in an area along the perimeter such that both the exterior wall and ceiling assembly are compromised. The burning of the vapor cloud can result in simultaneous ignition of combustibles in the areas affected by the blast. The fire spread in this case follows that described in Sections 6.3.2 and 6.3.3. However, since the deflagration is assumed to destroy the plaster ceiling protection, the structural members (e.g., beams, joists, metal deck) will be directly exposed to the first floor fire.

The burning duration of the fires is on the order of 30 minutes based on the analyses of the existing PFP fuel loads (see Sections 6.3.2 and 6.3.3). Direct flame impingement to the ceiling structural members in the area of the blast for this period will result in temperatures which exceed the failure criteria. In addition, flames entering the breached ceiling assembly will spread laterally within the ceiling assembly thus exposing adjacent structural members. As the ceiling

assembly starts to collapse in the area directly exposed to the fire, the plaster protection on the ceiling in adjacent spaces can be compromised along with the partitions between the spaces. Since the fire will spread through these spaces, this can result in additional ceiling structural members being directly exposed to the fire.

The fire spread and resulting ceiling failure can potentially continue until there is no additional fuel load or the fire is extinguished. The maximum fire extent is described in Sections 6.3.2 and 6.3.3 for the first floor. Losing the structural members in the ceiling assembly for these areas can potentially result in catastrophic structural failure of the building. If this were to occur, fire spread could continue throughout the facility provided there is sufficient fuel loading. As a worst case event, the fire spread and structural failure would entail the entire facility.

In addition to damaging the facility and all of its contents, this scenario can potentially result in an airborne contamination release. The level of contamination will depend on the amount of radiological material directly involved in the fire and the extent of structural damage to the building.

IMPACT OF AUTOMATIC SPRINKLER SYSTEM

Because of the rapid nature of a deflagration resulting from a premixed vapor cloud ignition, automatic sprinkler protection will not prevent the immediate damage caused to the building. Also, the sudden pressure rise in the room can damage the sprinkler system. Therefore, automatic suppression will provide little to no benefit in the area of the deflagration. Sprinkler protection in adjacent zones will likely remain intact and will limit the fire spread in the building. However, fire spread and structural damage throughout an entire sprinkler zone can still occur. Therefore, catastrophic structural failure of the building can not be precluded, even with automatic sprinkler protection.

APPENDIX C

CFAST Input Files

```
          234-5Z
VERSN    1Glove02.in   Fans: On  Hall Doors:  Open
TIMES   5000  25   25   25    0
TAMB   298.  101300.    0.
EAMB   298.  101300.    0.
HI/F    0.00
WIDTH   23.0
DEPTH   6.58
HEIGH   4.88
HVENT  1  2  1   2.14  2.13   0.00
HVENT  1  2  2   2.14  2.13   0.00
HVENT  1  2  3   1.07  2.13   0.00
HVENT  1  2  4   1.07  2.13   0.00
MVOPN  1  1 V  4.40  2.00
MVOPN  2  3 V  4.40  2.00
MVDCT  1  2  0.1  2.00  0.002   0.00 2.000 0.00 2.0000
MVFAN  2  3  0.0  300.0  8.97
INELV. 1  2.1   2  4.4   3  4.4
CEILI GYPSUM
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.    0.   12.0    38400000.  300. 400.   0.
LFBO   1
LFBT   2
FPOS   3.3   3.3  0.0
FTIME   100  200  300. 400. 500.  600.  700.  800. 900. 5000.
FHIGH   0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
FAREA   2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5
FQDOT   0.0  469E3  1876E3 4221E3 7504E3 11725E3 16884E3 22981E3 30000E3
37989E3 37989E3
CJET OFF
DUMPR glove02a.hi
WINDOW      0    0  -100  1280  1024   1100
GRAPH   1  120.  300.    0.  600.  920.   10. 5 TIME  METERS
GRAPH   2  740.  300.    0.  1220. 920.   10. 5 TIME  CELSIUS
INTER   0 0 0 0 1   1 U
TEMPERA 0 0 0 0 2   1 U
TEMPERA 0 0 0 0 2   1 L
TEMPERA 0 0 0 0 2   2 L
```

234-5Z

```
VERSN   1Glove08.in   Fans: On   Hall Doors:  Closed
TIMES   5000  25   25   25   0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F   0.00
WIDTH   23.0
DEPTH   6.58
HEIGH   4.88
HVENT  1  2  1   1.07  2.13   0.00
HVENT  1  2  2   1.07  2.13   0.00
MVOPN  1  1 V  4.40  2.00
MVOPN  2  3 V  4.40  2.00
MVDCT  1  2  0.1  2.00  0.002   0.00 2.000 0.00 2.0000
MVFAN  2  3  0.0  300.0  8.97
INELV  1  2.1  2  4.4  3  4.4
CEILI GYPSUM
WALLS CONCRETE
FLOOR CONCRETE
CHEMI   0.   0.   12.0   38400000.  300. 400.  0.
LFBO  1
LFBT  2
FPOS  3.3   3.3  0.0
FTIME  100  200  300. 400. 500.  600.  700.  800. 5000.
FHIGH  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
FAREA  2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5
FQDOT  0.0  469E3  1876E3 4221E3 7504E3 11725E3 16884E3 22981E3 30000E3
30000E3
CJET OFF
DUMPR glove08a.hi
WINDOW      0    0  -100  1280  1024   1100
GRAPH  1  120.  300.   0.  600.  920.   10. 5 TIME  METERS
GRAPH  2  740.  300.   0.  1220. 920.   10. 5 TIME  CELSIUS
INTER  0 0 0 0 1   1 U
TEMPERA 0 0 0 0 2   1 U
TEMPERA 0 0 0 0 2   1 L
TEMPERA 0 0 0 0 2   2 L
```

```
          234-52
VERSN    1Glove10.in    Fans:  Off    Hall Doors:  Open
TIMES    5000   25    25    25    0
TAMB   298.  101300.     0.
EAMB   298.  101300.     0.
HI/F    0.00
WIDTH    23.0
DEPTH    6.58
HEIGH    4.88
HVENT   1  2  1   2.14  2.13   0.00
HVENT   1  2  2   2.14  2.13   0.00
HVENT   1  2  3   1.07  2.13   0.00
HVENT   1  2  4   1.07  2.13   0.00
CEILI GYPSUM
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.    0.   12.0    38400000.  300. 400.   0.
LFBO   1
LFBT   2
FPOS   3.3   3.3  0.0
FTIME   100  200  300. 400. 500.  600.  700.  800. 5000.
FHIGH   0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
FAREA   2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5
FQDOT   0.0  469E3  1876E3 4221E3 7504E3 11725E3 16884E3 22981E3 30000E3
30000E3
CJET OFF
DUMPR glove10a.hi
WINDOW       0     0  -100  1280  1024   1100
GRAPH   1  120.  300.    0.  600.  920.   10. 5 TIME  METERS
GRAPH   2  740.  300.    0.  1220. 920.   10. 5 TIME  CELSIUS
INTER   0 0 0 0 1   1 U
TEMPERA 0 0 0 0 2   1 U
TEMPERA 0 0 0 0 2   1 L
TEMPERA 0 0 0 0 2   2 L
```

234-52

```
VERSN   1 Glove12.in   Fans:  Off   Hall Doors: Closed
TIMES   5000  25   25   25   0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F   0.00
WIDTH   23.0
DEPTH   6.58
HEIGH   4.88
HVENT  1  2  3   1.07  2.13   0.00
HVENT  1  2  4   1.07  2.13   0.00
CEILI GYPSUM
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.   12.0   38400000.  300. 400.   0.
LFBO  1
LFBT  2
FPOS  3.3  3.3  0.0
FTIME  100  200  300. 400. 500.  600.  700.  800. 5000.
FHIGH  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
FAREA  2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5
FQDOT  0.0  469E3  1876E3 4221E3 7504E3 11725E3 16884E3 22981E3 30000E3
30000E3
CJET OFF
DUMPR glove12a.hi
WINDOW      0    0  -100  1280  1024   1100
GRAPH  1  120.  300.    0.  600.  920.   10. 5 TIME  METERS
GRAPH  2  740.  300.    0.  1220. 920.   10. 5 TIME  CELSIUS
INTER  0 0 0 0 1   1 U
TEMPERA 0 0 0 0 2   1 U
TEMPERA 0 0 0 0 2   1 L
TEMPERA 0 0 0 0 2   2 L
```

```
VERSN   2 234-5Z. ROOM 321 FIRE-1
TIMES   600   20   20    0    0
TAMB  298. 101300.    0.
EAMB  298. 101300.    0.
HI/F    0.00
WIDTH   60.00
DEPTH   26.00
HEIGH   4.60
HVENT   1 2 1   1.830  2.000  0.000  0.000
CVENT   1 2 1   1.00   1.00   1.00   1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   42000000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS  13.00  10.00  0.00
FTIME   30.   60.  300.
FMASS  0.0000 0.1548 0.3119 0.3119
FHIGH   0.00  0.00  0.00  0.00
FAREA   0.00  3.55  7.10  7.10
FQDOT  0.00    6.50E+06 1.31E+07 1.31E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR RM321_1.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 234-5Z, ROOM 321 FIRE-2
TIMES   600   20   20    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00
WIDTH  60.00
DEPTH  26.00
HEIGH   4.60
HVENT  1 2 1  1.830  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   42000000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS  13.00  10.00   0.00
FTIME    30.   60.   300.
FMASS  0.0000 0.2762 0.5548 0.5548
FHIGH   0.00   0.00   0.00   0.00
FAREA   0.00   6.30  12.60  12.60
FQDOT  0.00    1.16E+07 2.33E+07 2.33E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR RM321_2.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 234-5Z. ROOM 321 FIRE-3
TIMES   600   20   20    0    0
TAMB  298. 101300.    0.
EAMB  298. 101300.    0.
HI/F    0.00
WIDTH  60.00
DEPTH  26.00
HEIGH   4.60
HVENT  1 2 1  1.830  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   42000000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS  13.00  10.00   0.00
FTIME    30.   60.  300.
FMASS  0.0000 0.4286 0.8643 0.8643
FHIGH   0.00  0.00  0.00  0.00
FAREA   0.00  9.80  19.60  19.60
FQDOT  0.00    1.80E+07 3.63E+07 3.63E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR RM321_3.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 234-5Z, ROOM 321 FIRE-4
TIMES   600   20   20    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00
WIDTH  60.00
DEPTH  26.00
HEIGH   4.60
HVENT  1  2  1  1.830  2.000  0.000  0.000
CVENT  1  2  1  1.00  1.00  1.00  1.00
MVFAN   1  2    0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   42000000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS  13.00  10.00  0.00
FTIME    30.   60.   300.
FMASS  0.0000 0.6239 1.2476 1.2476
FHIGH   0.00  0.00  0.00  0.00
FAREA   0.00  14.10  28.30  28.30
FQDOT  0.00    2.62E+07 5.24E+07 5.24E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR RM321_4.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2. BLDG 242-Z STORAGE ANEX PLASTIC FIRE
TIMES   600   20   15    0    0
TAMB  298.  101300.     0.
EAMB  298.  101300.     0.
HI/F    0.00
WIDTH   6.00
DEPTH  11.00
HEIGH   4.00
HVENT  1  2  1   0.910  2.000  0.000  0.000
CVENT  1  2  1   1.00  1.00  1.00  1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI STEELSHT
WALLS STEELSHT
FLOOR STEELSHT
CHEMI    0.   0.  12.0   10000000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   5.50  3.00  0.00
FTIME   100.  150.  200.  250.  300, ...600.
FMASS  0.0000 0.0470 0.1060 0.1890 0.2940 0.4000 0.4000
FHIGH   0.00  0.00  0.00  0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00  0.00  0.00  0.00  0.00
FQDOT  0.00    4.70E+05 1.06E+06 1.89E+06 2.94E+06 4.00E+06 4.00E+06
CJET OFF
HCR   0.200 0.200 0.200 0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 242-Z.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2. BLDG 236-Z MT Glovebox Fire
TIMES   600   20   15    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F   0.00
WIDTH  12.00
DEPTH   8.00
HEIGH   3.00
HVENT  1  2  1   1.820  2.000  0.000  0.000
CVENT  1  2  1   1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   10000000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   5.50  3.00  0.00
FTIME   100.  146.  600.
FMASS  0.0000 0.0470 0.1000 0.1000
FHIGH   0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00. 0.00
FQDOT  0.00    4.70E+05 1.00E+06 1.00E+06
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 236-Z.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2  PFP, BLDG 291-Z TRANSFORMER ROOM FIRE - RUN #1
TIMES   600   20   15    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00  0.00
WIDTH  10.70  16.90
DEPTH   8.50  8.50
HEIGH   4.40  4.40
HVENT  1  2  1   1.000   4.000   3.700
HVENT  1  3  1   0.910   2.000   0.000   0.000
CVENT  1  2  1   1.00   1.00   1.00   1.00
CVENT  1  3  1   1.00   1.00   1.00   1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE  CONCRETE
WALLS CONCRETE  CONCRETE
FLOOR CONCRETE  CONCRETE
CHEMI    0.   0.  12.0   46400000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25   5.35   0.00
FTIME    50.   62.   600.
FMASS  0.0000 0.0102 0.0155 0.0155
FHIGH   0.00   0.00   0.00   0.00
FAREA   0.00   0.00   0.00   0.00
FQDOT  0.00    4.69E+05 7.20E+05 7.20E+05
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 291_1.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2  PFP. BLDG 291-Z TRANSFORMER ROOM FIRE - RUN #2
TIMES   600   20   15   0   0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00  0.00
WIDTH  10.70  16.90
DEPTH   8.50  8.50
HEIGH   4.40  4.40
HVENT  1  2  1   1.000  4.000  3.700
HVENT  1  3  1   0.910  2.000  0.000  0.000
CVENT  1  2  1   1.00  1.00  1.00  1.00  1.00
CVENT  1  3  1   1.00  1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE  CONCRETE
WALLS CONCRETE  CONCRETE
FLOOR CONCRETE  CONCRETE
CHEMI    0.   0.  12.0   46400000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25  5.35  0.00
FTIME    50.  100.  150.  600.
FMASS  0.0000 0.0102 0.0404 0.0921 0.0921
FHIGH   0.00  0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00  0.00  0.00
FQDOT  0.00    4.69E+05 1.88E+06 4.28E+06 4.28E+06
CJET OFF
HCR   0.200 0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 291_2.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2  PFP, BLDG 291-Z TRANSFORMER ROOM FIRE - RUN #3
TIMES   600   20   15   0   0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00  0.00
WIDTH  10.70  16.90
DEPTH   8.50  8.50
HEIGH   4.40  4.40
HVENT  1  2  1   1.000   4.000   3.700
HVENT  1  3  1   0.910   2.000   0.000   0.000
CVENT  1  2  1   1.00  1.00  1.00  1.00  1.00  1.00  1.00
CVENT  1  3  1   1.00  1.00  1.00  1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE  CONCRETE
WALLS CONCRETE  CONCRETE
FLOOR CONCRETE  CONCRETE
CHEMI    0.   0.  12.0   46400000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25  5.35  0.00
FTIME    50.  100.  150.  200.  244.  600.
FMASS  0.0000 0.0102 0.0404 0.0921 0.1615 0.2411 0.2411
FHIGH   0.00  0.00  0.00  0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00  0.00  0.00  0.00  0.00
FQDOT  0.00    4.69E+05 1.88E+06 4.28E+06 7.50E+06 1.12E+07 1.12E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 291_3.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 PFP, BLDG 291-Z TRANSFORMER ROOM FIRE - RUN #4
TIMES   600   20   15    0    0
TAMB  298. 101300.    0.
EAMB  298. 101300.    0.
HI/F    0.00  0.00
WIDTH   10.70  16.90
DEPTH   8.50   8.50
HEIGH   4.40   4.40
HVENT   1  2  1   1.000   4.000   3.700
HVENT   1  3  1   0.910   2.000   0.000   0.000
CVENT   1  2  1   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00
CVENT   1  3  1   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE  CONCRETE
WALLS CONCRETE  CONCRETE
FLOOR CONCRETE  CONCRETE
CHEMI    0.   0. 12.0   46400000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25   5.35   0.00
FTIME    50.   100.   150.   200.   250.   300.   338.   600.
FMASS  0.0000 0.0102 0.0404 0.0921 0.1615 0.2524 0.3635 0.4607 0.4607
FHIGH   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
FAREA   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
FQDOT  0.00    4.69E+05 1.88E+06 4.28E+06 7.50E+06 1.17E+07 1.69E+07 2.14E+07
2.14E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007 0.007 0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022 0.022 0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 291_4.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 PFP, BLDG 2721 DIESEL OIL SPILL FIRE - RUN #1
TIMES   600   20   15   0   0
TAMB  298.  101300.   0.
EAMB  298.  101300.   0.
HI/F   0.00
WIDTH   8.53
DEPTH   5.18
HEIGH   3.05
HVENT  1 2 1  0.910  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00  1.00
MVFAN   1  2    0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI   0.   0.  12.0   46400000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25  5.35  0.00
FTIME   50.   62.   600.
FMASS  0.0000 0.0102 0.0155 0.0155
FHIGH   0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00  0.00
FQDOT  0.00    4.69E+05 7.20E+05 7.20E+05
CJET OFF
HCR   0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 2721_1.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 PFP. BLDG 2721 DIESEL OIL SPILL FIRE - RUN #2
TIMES   600   20   15    0    0
TAMB  298.  101300.     0.
EAMB  298.  101300.     0.
HI/F    0.00
WIDTH   8.53
DEPTH   5.18
HEIGH   3.05
HVENT  1 2 1  0.910  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   46400000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25  5.35  0.00
FTIME    50..  100.  150.  600.
FMASS  0.0000 0.0102 0.0404 0.0921 0.0921
FHIGH   0.00  0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00  0.00  0.00
FQDOT  0.00    4.69E+05 1.88E+06 4.28E+06 4.28E+06
CJET OFF
HCR  0.200 0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 2721_2.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 PFP. BLDG 2721 DIESEL OIL SPILL FIRE - RUN #3
TIMES   600   20   15   0   0
TAMB  298. 101300.   0.
EAMB  298. 101300.   0.
HI/F   0.00
WIDTH   8.53
DEPTH   5.18
HEIGH   3.05
HVENT  1 2 1  0.910  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00  1.00  1.00  1.00  1.00
MVFAN   1  2    0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI   0.   0. 12.0   46400000. 300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.25  5.35  0.00
FTIME   50.  100.  150.  200.  244.  600.
FMASS 0.0000 0.0102 0.0404 0.0921 0.1615 0.2410 0.2410
FHIGH   0.00  0.00  0.00  0.00  0.00  0.00  0.00
FAREA   0.00  0.00  0.00  0.00  0.00  0.00  0.00
FQDOT 0.00    4.69E+05 1.88E+06 4.28E+06 7.50E+06 1.12E+07 1.12E+07
CJET OFF
HCR   0.200 0.200 0.200 0.200 0.200 0.200 0.200
CO    0.007 0.007 0.007 0.007 0.007 0.007 0.007
OD    0.022 0.022 0.022 0.022 0.022 0.022 0.022
STPMAX  5.00
DUMPR 2721_3.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 232-Z, TRASH BAG FIRE-1
TIMES   600   20   20    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00
WIDTH  13.40
DEPTH   7.60
HEIGH   4.60
HVENT  1 2 1  1.830  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0    12500000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   3.80  6.70  0.00
FTIME    60.  600.
FMASS  0.0000 0.0240 0.0240
FHIGH   0.00  0.00  0.00
FAREA   0.00  0.00  0.00
FQDOT  0.00    3.00E+05 3.00E+05
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 232_1.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 232-Z, TRASH BAG FIRE-2
TIMES   600   20   20    0    0
TAMB   298. 101300.    0.
EAMB   298. 101300.    0.
HI/F    0.00
WIDTH   13.40
DEPTH    7.60
HEIGH    4.60
HVENT   1  2  1   1.830   2.000   0.000   0.000
CVENT   1  2  1   1.00   1.00   1.00
MVFAN    1   2      0.00 140000.00  0.800E+00
INELV    1   3.50   2   3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.    0.  12.0    12500000.  300. 400. 0.000
LFBO   1
LFBT   2
FPOS    3.80   6.70   0.00
FTIME     60.   600.
FMASS  0.0000 0.0480 0.0480
FHIGH    0.00   0.00   0.00
FAREA    0.00   0.00   0.00
FQDOT  0.00     6.00E+05 6.00E+05
CJET OFF
HCR    0.200 0.200 0.200
CO     0.007 0.007 0.007
OD     0.022 0.022 0.022
STPMAX  5.00
DUMPR 232_2.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0    0.    0. 1279. 1023. 4095.
```

```
VERSN   2 232-Z, TRASH BAG FIRE-3
TIMES   600   20   20   0   0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F   0.00
WIDTH  13.40
DEPTH   7.60
HEIGH   4.60
HVENT  1 2 1  1.830  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   12500000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   3.80  6.70  0.00
FTIME    60.  600.
FMASS  0.0000 0.0720 0.0720
FHIGH   0.00  0.00  0.00
FAREA   0.00  0.00  0.00
FQDOT  0.00    9.00E+05 9.00E+05
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 232_3.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 232-Z, TRASH BAG FIRE-4
TIMES   600   20   20    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00
WIDTH  13.40
DEPTH   7.60
HEIGH   4.60
HVENT  1  2  1   1.830  2.000  0.000  0.000
CVENT  1  2  1   1.00  1.00  1.00
MVFAN   1  2    0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   12500000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   3.80  6.70  0.00
FTIME    60.  600.
FMASS  0.0000 0.0960 0.0960
FHIGH   0.00  0.00  0.00
FAREA   0.00  0.00  0.00
FQDOT  0.00    1.20E+06 1.20E+06
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 232_4.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 243-Z. TRASH BAG FIRE-1
TIMES   600   20   20    0    0
TAMB  298.  101300.     0.
EAMB  298.  101300.     0.
HI/F    0.00
WIDTH   14.30
DEPTH   9.14
HEIGH   4.00
HVENT  1 2 1  0.910  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0    12500000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.57  7.15  0.00
FTIME    60.  600.
FMASS  0.0000 0.0240 0.0240
FHIGH   0.00  0.00  0.00
FAREA   0.00  0.00  0.00
FQDOT  0.00    3.00E+05 3.00E+05
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 243_1.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0   0.   0. 1279. 1023. 4095.
```

```
VERSN   2 243-Z, TRASH BAG FIRE-2
TIMES   600   20   20    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00
WIDTH   14.30
DEPTH   9.14
HEIGH   4.00
HVENT   1  2  1   0.910   2.000   0.000   0.000
CVENT   1  2  1   1.00   1.00   1.00
MVFAN   1   2     0.00 140000.00  0.800E+00
INELV   1   3.50   2   3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0    12500000.  300. 400. 0.000
LFBO   1
LFBT   2
FPOS    4.57   7.15   0.00
FTIME    60.   600.
FMASS  0.0000 0.0480 0.0480
FHIGH    0.00   0.00   0.00
FAREA    0.00   0.00   0.00
FQDOT  0.00     6.00E+05 6.00E+05
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 243_2.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0    0.    0. 1279. 1023. 4095.
```

```
VERSN   2 243-Z, TRASH BAG FIRE-3
TIMES   600   20   20    0    0
TAMB  298.  101300.    0.
EAMB  298.  101300.    0.
HI/F    0.00
WIDTH   14.30
DEPTH   9.14
HEIGH   4.00
HVENT   1  2  1   0.910   2.000   0.000   0.000
CVENT   1  2  1   1.00   1.00   1.00
MVFAN   1   2     0.00 140000.00  0.800E+00
INELV   1   3.50   2   3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0    12500000.  300. 400. 0.000
LFBO   1
LFBT   2
FPOS   4.57   7.15   0.00
FTIME    60.   600.
FMASS  0.0000 0.1200 0.1200
FHIGH   0.00   0.00   0.00
FAREA   0.00   0.00   0.00
FQDOT  0.00    1.50E+06 1.50E+06
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 243_3.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW  0    0.    0. 1279. 1023. 4095.
```

```
VERSN   2 243-Z, TRASH BAG FIRE-4
TIMES   600   20   20    0    0
TAMB  298. 101300.    0.
EAMB  298. 101300.    0.
HI/F    0.00
WIDTH  14.30
DEPTH   9.14
HEIGH   4.00
HVENT  1 2 1  0.910  2.000  0.000  0.000
CVENT  1 2 1  1.00  1.00  1.00
MVFAN   1  2     0.00 140000.00  0.800E+00
INELV   1  3.50  2  3.50
CEILI CONCRETE
WALLS CONCRETE
FLOOR CONCRETE
CHEMI    0.   0.  12.0   12500000.  300. 400. 0.000
LFBO  1
LFBT  2
FPOS   4.57  7.15  0.00
FTIME    60.  600.
FMASS  0.0000 0.2400 0.2400
FHIGH   0.00  0.00  0.00
FAREA   0.00  0.00  0.00
FQDOT  0.00    3.00E+06 3.00E+06
CJET OFF
HCR   0.200 0.200 0.200
CO    0.007 0.007 0.007
OD    0.022 0.022 0.022
STPMAX  5.00
DUMPR 243_4.HI
THRMF THERMAL2.DF
DEVICE 1
WINDOW 0   0.   0. 1279. 1023. 4095.
```

APPENDIX D

Compliance of Existing Gloveboxes with the DGFPS

D1.0 GENERAL

Table D-1 provides a summary of the requirements stipulated by the DGFPS and, for comparison purposes, the existing conditions of the 94-1 Thermal Stabilization Process gloveboxes. Since only new gloveboxes are required to comply with the DGFPS, the DGFPS requirements are not applicable to the existing 94-1 gloveboxes. However, this section identifies the existing level of protection compared to that required for new gloveboxes. Each of the requirements summarized in Table A-1 are discussed in the following sections.

Other gloveboxes in the PFP facility have similar physical and operational characteristics to those used in the 94-1 process. In general, the existing PFP gloveboxes are not in compliance with the DGFPS. Features such as acrylic plastic window panels and incomplete automatic suppression systems are deficiencies relating to fire hazard.

In this section, the active and passive fire protection features required to comply with the DGFPS are compared with the 94-1 Stabilization Process Line. In Section 5.0, alternative fire protection features are presented for all active and inactive PFP gloveboxes in lieu of application of all DGFPS requirements to existing gloveboxes.

D1.1 Construction

The DGFPS requires that gloveboxes be constructed of noncombustible materials. The purpose of this appears to be to minimize the potential fuel load and resulting fire spread within the glovebox. Noncombustible windows may also help delay breaching the glovebox enclosure. Once containment of the glovebox is violated, airborne materials and combustion products can escape to the room resulting in both a life safety hazard and contamination of the room and associated equipment. In addition, breaching the glovebox enclosure may allow a fire to spread to additional combustibles within the room.

The frames and walls of the 94-1 gloveboxes are constructed of stainless steel. This is in compliance with DGFPS criteria. However, some window panels are constructed of acrylic plastic (i.e., polymethylmethacrylate or PMMA). This material ignites when exposed to small fires (see Section 7.3.2) and results in a rapid rate of heat release and fire spread. In order to comply with the DGFPS, all of the acrylic plastic windows must be replaced with wire glass, fire rated glass, or laminated safety glass.

In the past, as glovebox window panels have been replaced, polycarbonate (i.e., Lexan) panels have been used. The fire performance of polycarbonate is markedly better than that of PMMA (i.e., harder to ignite and lower rate of heat release). However, polycarbonate windows still represent a significant combustible fuel load in the glovebox. As such, the DGFPS only permits the use of fire retardant polycarbonate where the glovebox atmosphere or operations do not allow glass. In this case, the polycarbonate is required to be "sandwiched" with noncombustible material (such as glass) whenever possible. Unless it can be demonstrated that

Table D-1. 94-1 Thermal Stabilization Process Gloveboxes

Glovebox Component	Required for New Gloveboxes	Existing 94-1 Gloveboxes	Compliance
Construction			
Frame	Noncombustible materials	Stainless steel (noncombustible)	Yes
Window Material	Wire glass, fire rated glass, or laminated safety glass (where glovebox atmosphere or operations do not allow glass, fire retardant polycarbonate may be used)	Gloveboxes have acrylic (PMMA), polycarbonate and glass windows	No
Gloves	Hypalon [du Pont de Nemours & Company] or neoprene	Hypalon	Yes
Containment	Separation/isolation dampers or doors activated by fusible link, fire detection/suppression system, and manual operation	Several existing airlocks can be used to separate sections of the process line, however, they are not in compliance with the DGFPS	No
Heating Devices	All heating devices shall be equipped with automatic high-temperature shutoff switches	All furnaces are equipped with automatic high-temperature and temperature deviation shutoff controls	Yes
Automatic Fire Suppression/Inerting Systems			
Gloveboxes containing combustible or pyrophoric metals	Inert gas purging system (commonly argon or nitrogen)	According to facility staff, there are no gloveboxes which may potentially contain pyrophoric metals	Not Applicable
Gloveboxes containing flammable/combustible liquids, oxidizers, or where waste characterization operations are involved	Automatic sprinkler or dry chemical suppression system (except where an inerting system is provided)	Incomplete protection - several gloveboxes along the inactive RMC line are equipped with a Halon system; other gloveboxes used for furnace operations are equipped or will be equipped with dry chemical systems; LWBS are also used	No
Gloveboxes containing multiple hazards (such as pyrophoric metals and flammable liquids)	FHA determines best protection system (i.e., inerting or suppression system)	According to facility staff, there are no gloveboxes which may potentially contain pyrophoric metals; therefore there are no multiple hazard gloveboxes	Not Applicable
Manual Fire Suppression	All gloveboxes must include provisions for manual fire fighting	Fire extinguishers are located throughout the rooms serving the 94-1 gloveboxes	Yes

Table D-1 94-1 Thermal Stabilization Process Gloveboxes (continued)

Glovebox Component	Required for New Gloveboxes	Existing 94-1 Gloveboxes	Compliance
Extinguishing Agent	Based on the most likely fire hazards	Dry chemical extinguishers and Magnesium Oxide sand	Yes
Portable Fire Extinguishers	Quick-disconnect couplings shall be provided (if not feasible, fire extinguishers with bayonet-type connectors shall be used)	Some gloveboxes are equipped with quick-disconnect couplings; bayonet-type fire extinguishers provided in other areas	Yes
Fire Detection Systems	All gloveboxes shall be provided with an automatic fire detection system (a separate detection system is not required if the glovebox is equipped with an automatic suppression or inerting system)	Most, but not all gloveboxes are equipped with heat detectors	No
Ventilation			
Supply/Exhaust Openings	Ventilation should incorporate a downdraft design (i.e., supply opening near the top of the box and the exhaust opening near the bottom)	Ventilation does not incorporate a downdraft design	No
Exhaust Filters and Screens	Prefilters and fire screens required on primary exhaust openings	Prefilters and fire screens are provided on most, but not all primary exhaust openings	No
Flowrate	Gloveboxes using flammable liquids or gases shall have sufficient ventilation flowrates to prevent the atmosphere from reaching 25% of the lower flammable limit (unless inert atmosphere is provided)	Gloveboxes where flammable liquids and gasses are generated are provided with purging systems to prevent the buildup of flammable gas mixtures	Yes
Overpressure Protection	Required where failure of the primary exhaust system or internal pressurization may result in glovebox over-pressurization	Emergency exhaust is provided in the event of glovebox overpressure	Yes
Multi-Unit Exhaust Manifolds	Every glovebox shall have its own exhaust port; single exhaust manifolds connecting an entire glovebox line shall not be used	Most gloveboxes have their own exhaust port; a limited number of gloveboxes exhaust through other gloveboxes	No
Construction	Noncombustible materials for ducts (rigid and flexible) and insulation	Ducts are constructed of noncombustible materials	Yes

Table D-1 94-1 Thermal Stabilization Process Gloveboxes (continued)

Glovebox Component	Required for New Gloveboxes	Existing 94-1 Gloveboxes	Compliance
Operating Safeguards	Operated to minimize fire potential - limit combustible materials and flammable liquids/gases to the amount required for daily operations; daily housekeeping to ensure equipment and operations are orderly; operating procedures to reflect the fire protection measures required for safe operations associated with the glovebox	Combustible materials remain in several inactive gloveboxes; housekeeping appears to be adequately maintained	No

the use of glass windows is not feasible, all acrylic and polycarbonate window panels must be replaced with wire glass, fire rated glass, or laminated safety glass in order to comply with the DGFPS.

Glovebox gloves are required to be Hypalon (trademark of E.I. du Pont de Nemours & Company) or neoprene. All gloves used in the 94-1 gloveboxes are Hypalon. This meets the requirements of the DGFPS.

During the site visit, many of the gloves were left inside the gloveboxes while they were not being used. The DGFPS requires that "when the gloves are not in use, they shall be extracted from the box and secured on the outside using an elastic cord or by tieing the gloves together (provided the potential for an exposure fire from outside the box does not exist)." Although there is always a potential for an exposure fire from outside the box, the direct exposure fuel load is typically greater inside the gloveboxes than outside for active process lines. As such, gloves should be extracted from the glovebox when not in use.

The DGFPS requires separation/isolation dampers or doors to minimize fire propagation in glovebox process lines. The dampers or doors must close upon activation of a fusible device. They also must close when the fire suppression/detection system is activated, and be able to be opened and shut manually. Currently, there are several airlocks which can be used to separate sections of the inactive and active process lines. The locations of the existing airlocks in the 94-1 Process Line are as follows:

1. In glovebox HC-2, between HC-21A and HC-4. The airlock separates the gloveboxes in Rooms 228A, B, C and Rooms 230A, B, which are equipped with a Halon fire suppression system, from the remainder of the process line.

2. Between gloveboxes HC-5 and HC-2, separating the RMC Line from the inactive RMA Line.

3. In glovebox HC-4, separating the RMC Line from the gloveboxes in Rooms 235B and C.

4. In glovebox HA-19, separating the glovebox from the HA-28 conveyor.

The location and number of separation/isolation dampers is required to be determined from a fire protection engineering analysis. The analysis depends on the suppression/detection systems utilized, the status of the gloveboxes (i.e., active or removed from service), and the combustible fuel load within the gloveboxes. Recommendations regarding glovebox separations are presented in Section 7.5. To comply with the DGFPS criteria closure of the airlocks must be provided by fusible link, activation of the detection/suppression system (on either side of the damper), and manual operation.

In accordance with the DGFPS, all heating devices must be equipped with automatic high-temperature shutoff switches. All furnaces used in the 94-1 Stabilization Process are equipped

or will be equipped with automatic high temperature and temperature deviation shutoff controls. This shutoff is provided in three independent ways [PFD-Z-190-00004, Rev B]. First, if the temperature in the furnace exceeds the high temperature set point of 1050°C (maximum temperature of the furnace is 1093°C), a relay removes power to the furnace. Second, if the measured furnace temperature deviates ±20°C from the programmed set point, power is removed from the furnace. Third, the temperature in the furnace gloveboxes is measured by three thermocouples. If the temperature of any of the thermocouples exceeds the alarm set point of 70°C, power is removed from all furnaces in the glovebox. The alarm set point is lower than the activation temperature of the Halon or dry chemical systems (i.e., 93°C). Furnace temperature controls are in compliance with the DGFPS.

In accordance with the DGFPS, all electrical components in the glovebox are required to comply with the applicable sections of the *National Electric Code*, NFPA 70. Also, utilities (e.g., water, air, gas, etc.) serving gloveboxes must be provided with remote shut off or isolation valves.

D1.2 Automatic Fire Suppression/Inerting Systems

The DGFPS requires an automatic sprinkler or dry chemical fire suppression in any glovebox containing flammable/combustible liquids, oxidizers, or where waste characterization operations are involved. If combustible or pyrophoric metals are involved, an argon or nitrogen inerting system may be required in lieu of the suppression system. If the fuel load and operations in the glovebox are not indicative of those described above, an automatic suppression system is not explicitly required by the DGFPS in existing gloveboxes.

For the 94-1 Stabilization Process Line, based on the materials used and stored in the gloveboxes, fire suppression is required by the DGFPS in all gloveboxes. The gloveboxes in this process line may be used for waste characterization operations and/or contain oxidizers or flammable/combustible liquids. In addition, the future use of the gloveboxes is uncertain and continuously changing. More importantly, since none of the existing gloveboxes meet the construction criteria of the DGFPS, fire suppression is required to address potential hazards associated with the fuel loads present in the active process. These requirements also apply to gloveboxes connected to the 94-1 Process Line which have been removed from service.

Currently, some of the 94-1 gloveboxes are provided with automatic fire suppression systems. The gloveboxes in Rooms 228A, B, C and Rooms 230A and B are protected by a total flooding Halon system. DOE has mandated the phase out of "non-essential" Halon systems [DOE, 1993]. Currently, there is no plan to remove the existing Halon system. Additionally, gloveboxes HC-227S and HC-60 are each equipped with a Limited Water Bottle Station (LWBS) and gloveboxes HA-20MB and HA-21I will each have a dry chemical system. However, other gloveboxes are unprotected including gloveboxes HA-23S, 235-B-5, HA-28, HC-4, HC-3, and HC-4 and HC-6 in Room 166.

In order to comply with the requirements of the DGFPS, all of the 94-1 gloveboxes must be equipped with automatic fire suppression. Therefore, if the existing Halon system is

deactivated, a replacement fire suppression system is required. Likewise, the gloveboxes currently without a fire suppression system must be provided with either an automatic sprinkler or dry chemical system. In addition, if in the future any of the gloveboxes in the 94-1 Stabilization Process will contain pyrophoric or combustible metals, a local inerting system is required for those gloveboxes.

D1.3 Manual Fire Suppression

The DGFPS requires provisions for manual fire fighting for all gloveboxes. The agent used for fire suppression must be based on the most likely fire hazards. Where the potential for metal fires is present, magnesium oxide sand, copper metal powder (30-60 mesh), carbon microspheres, or an equivalent extinguishing agent shall be provided. Where the fire potential is from other (non-metal) combustibles, dry chemical extinguishers are recommended. Where portable fire extinguishers are used, quick-disconnect couplings must be provided. If it is not feasible to install quick-disconnect couplings, fire extinguishers with bayonet-type connectors may be used. However, the designer should document the basis for not installing quick-disconnect couplings in the design report.

Currently, dry chemical fire extinguishers are provided throughout the rooms containing gloveboxes. In some areas where there is the potential for combustible metal fires, Magnesium Oxide sand is also provided. Quick-disconnect couplings are used on some of the gloveboxes; however, in many cases bayonet-type connectors are used instead. The specific gloveboxes equipped with quick-disconnect couplings has not been documented nor has the basis for not providing all of the gloveboxes with them. Even so, the current manual fire suppression conditions generally meet the requirements of the DGFPS.

D1.4 Fire Detection

The DGFPS requires all gloveboxes to be provided with an automatic fire detection system. An exception to this requirement is if the glovebox is equipped with an automatic fire suppression or gas inerting system. Since all of the gloveboxes on the 94-1 Stabilization Process Line are required to have an automatic suppression system, a separate fire detection system is not required.

Nearly all of the gloveboxes on the 94-1 Process Line are equipped with heat detectors. Gloveboxes HC-227S and HC-7 are the only gloveboxes without heat detectors (or future planned heat detectors). However, glovebox HC-227S is equipped with a limited water bottle station so it does not requires a separate detection system. No additional fire detection devices in any of the 94-1 gloveboxes are required to comply with the DGFPS criteria.

D1.5 Ventilation

The DGFPS requires glovebox ventilation systems to be protected against fire. It is recommended (i.e., "should" is used as specifier in DGFPS requirement) that the ventilation system incorporates a downdraft design. This configuration has the ventilation inlet opening

located near the top of the box and the exhaust opening near the bottom. By doing so, the heavy combustion products, typically located higher in the box, will cause less damage to the exhaust filters. In addition, all primary exhaust openings are required to be provided with prefilters and fire screens to reduce vapor mist and fire propagation to HEPA filters. The intent of the DGFPS criteria appears to be to prevent damage to the HEPA filters and minimize the spread of fire and/or contamination beyond the confines of the glovebox.

The E-4 Exhaust Ventilation Drawings (Drawing No. H-2-23400) do not provide details with respect to the height of the supply and exhaust inlet openings for the 94-1 gloveboxes. However, based on the information gathered during the site survey, the ventilation system does not appear to incorporate a downdraft design. Based on the drawings, all of the primary exhaust openings are provided with fire screens and, with few exceptions, are also provided with prefilters. Since a downdraft design is only recommended, modifying the existing design is not required to comply with the DGFPS. However, prefilters are required on all primary exhaust openings. As such, any primary exhaust opening not currently provided with a prefilter must be provided with a prefilter. These include gloveboxes HC-227S, HC-7, HC-15A, B, C, HC-60, and gloveboxes HC-4 and HC-6 in Room 166.

If flammable liquids or gases are used in a glovebox, ventilation flowrates are required to be sufficient to prevent the atmosphere from reaching 25% of the lower flammable limit unless an inert atmosphere is provided. Flammable liquids or gases are not anticipated to be used in the 94-1 Stabilization Process gloveboxes. However, feed items that originated in the Plutonium Reclamation Facility (PRF) potentially contain tributyl phosphate (TBP) which upon thermal decomposition produces butene. Only the furnaces in HC-21C will thermally treat PRF material. To prevent a flammable gas buildup, air is continuously circulated through the furnaces at a rate of 2-3 cfm. In addition, a cover gas of CO_2 is introduced into the furnace in the temperature regime where flammable gases may be generated. The CO_2 is fed into the furnace at a flow rate of 30-35 cfh, which will maintain the amount of butene below the flammable concentrations [PFD-Z-190-00004, Rev B]. The ventilation and CO_2 cover gas systems are in compliance with the DGFPS with respect to flowrate considerations.

The DGFPS requires the designer to evaluate whether "dump valves" are required to prevent glovebox over-pressurization if the primary exhaust system fails, or if there is a breach in the glovebox, or internal pressurization. Currently, the 94-1 Process Line is equipped with emergency exhaust manifolds which open when the glovebox pressure exceeds -0.5" WG. Emergency exhaust is provided within each of the glovebox sections potentially isolated by airlocks.

The DGFPS does not permit multi-unit exhaust manifolds. Each glovebox is required to have its own exhaust port in order to minimize fire exposure to adjacent boxes. Single exhaust manifolds that connect an entire glovebox line are not permitted. Most of the existing 94-1 gloveboxes are provided with their own exhaust ports. However, a limited number of gloveboxes, such as those used by the conveyor systems, exhaust through other gloveboxes.

Noncombustible materials are required for glovebox ventilation ducts (both rigid and flexible) and insulation. The existing ventilation ducts are constructed of noncombustible materials in compliance with the DGFPS.

D1.6 Operating Safeguards

The DGFPS requires that gloveboxes be operated to minimize the potential for a fire. This involves limiting the quantity of combustible materials and flammable liquids/gases to the amount required for daily operations. In addition, daily housekeeping inspections are required to ensure equipment and operations are orderly, and that there are no unnecessary flammable/combustible liquids or other combustibles in or near the gloveboxes. Glovebox operating procedures must reflect the fire protection measures required for safe operations associated with a glovebox. If glovebox fire protection systems are impaired, compensatory measures must be implemented to mitigate the potential risk until the system is fully restored to service.

Currently, there are combustible materials and hydraulic oil filled systems remaining in several inactive gloveboxes. Removal of unnecessary combustibles is required to comply with the DGFPS. Housekeeping efforts appeared to be maintained during the site visit. Proper housekeeping efforts must be continued.

APPENDIX E

Detailed Cost Breakdowns

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
232Z		WB29465	ALARM	W15000	10/83	9,981	12,915

1 ITEMS FOR ROOM =

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z		FA10183	GLOVEBOX	W87000	03/82	64,149	88,609
2345Z		FA20022	AGITATOR	W15000	05/87	8,660	10,473
2345Z		FA20305	CONTROLLER	W15000		566	
2345Z		FA20826	PUMP	W15000	07/91	10,215	11,456
2345Z		FA20830	TURBINE	W15000	05/91	22,153	24,845
2345Z		FA21403	MONITOR	W15000	04/84	141,361	182,780
2345Z		FA23683	TRANSFORMER	W54000	08/49	18,004	93,831
2345Z		FA23684	TRANSFORMER	W54000	08/49	18,004	93,831
2345Z		FA23685	TRANSFORMER	W54000	08/49	18,005	93,837
2345Z		FA24024	MOTOR	W15000		5,584	
2345Z		FA25520	MOTOR	W15000	08/93	14,988	15,556
2345Z		FA25654	GLOVEBOX	W15000	07/84	167,048	215,993
2345Z		F026622	PUMP	W15000	01/63	6,176	32,187
2345Z		F039104	ROAD	W15000	07/49	38,660	201,484
2345Z		F136390	DUCT	W15000	06/50	773,010	4,028,696
2345Z		F165665	SITE WK /GRADING	W15000	06/50	453,212	2,362,005
2345Z		F174335	POWER WIRING	W15000	06/50	938,353	4,890,414
2345Z		F174340	GENERAL SYSTEM EQUIPMENT	W15000	09/60	13,462	70,160
2345Z		F174690	BUILDING INDUSTRIAL	W15000	06/50	14,878,314	77,541,309
2345Z		F174866	GENERAL SYSTEM EQUIPMENT	W15000	06/50	2,758,697	14,377,501
2345Z		F175129	GENERAL SYSTEM EQUIPMENT	W15000	09/59	25,459	132,685
2345Z		F175343	GENERAL SYSTEM EQUIPMENT	W15000	09/60	223,072	1,162,584
2345Z		F176517	FENCE	W15000	08/49	76,564	399,029
2345Z		F176727	GENERAL STATION EQUIP	W54000	08/49	9,951	51,862
2345Z		F176832	LIGHT FIXTURE	W54000	06/49	6,992	36,440
2345Z		F221334	PUBLIC ADDRESS UNIT	W15000	03/65	14,662	72,416
2345Z		F221673	POWER WIRING	W15000	10/63	41,403	215,780
2345Z		F223620	GENERAL SYSTEM EQUIPMENT	W15000	11/91	188,031	210,877
2345Z		F226222	INSTRUMENTATION	W15000	06/50	43,322	225,781
2345Z		F226223	INSTRUMENTATION	W15000	04/92	908,239	991,706
2345Z		F226224	INTERCOMMUNICATION EQUIP	W15000	12/52	19,514	101,701
2345Z		F226225	INSTRUMENTATION	W15000	01/66	65,542	313,677
2345Z		F226229	INSTRUMENTATION	W15000	02/86	85,010	106,118
2345Z		F226483	INSTRUMENTATION	W15000	09/65	5,710	28,202
2345Z		F227418	PIPING	W15000	06/50	1,755,108	9,147,096
2345Z		F257893	PIPING	W15000	05/95	860,012	860,012
2345Z		F257894	POWER WIRING	W15000	11/73	16,434	44,461
2345Z		F257895	INSTRUMENTATION	W15000	11/73	43,523	117,747
2345Z		F258335	FIRE ALARM EQUIPMENT	W15000	11/73	2,009,734	5,437,134
2345Z		F261760	PAVED AREA	W15000	01/79	50,625	83,506
2345Z		F262090	MONITORING SYSTEM	W15000	03/79	989,919	1,632,871
2345Z		F262530	FILTER BOX	W15000	12/80	22,502	34,946
2345Z		F262536	PIPING	W15000	12/80	740,408	1,149,854
2345Z		F262544	FIBER OPTICS	W8P000	09/80	62,746	97,445
2345Z		F262551	RETENTION WALL	W15000	12/79	506,640	835,703
2345Z		F262615	ALARM SOURCE HOLDERS	W15000	09/81	282,843	405,880
2345Z		F263531	TANK	W15000	09/86	6,905	8,620
2345Z		F263598	VALVE	W15000	03/87	55,705	67,364
2345Z		F263652	FURNACE	W15000	03/87	19,030	23,013
2345Z		F263762	HEATER	W15000	03/87	8,074	9,764

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z		F264619	MONITORING SYSTEM	W15000	07/84	107,970	139,605
2345Z		F264725	AGITATOR	W15000	10/84	21,631	27,969
2345Z		F265089	TURNOUT	W52000		0	
2345Z		F265090	TURNOUT	W52000		0	
2345Z		F265141	BARRIER	W15000	05/85	139,617	179,157
2345Z		F265253	DISSOLVER	W15000	01/86	534,221	666,868*
2345Z		F265558	GENERAL SYSTEM EQUIPMENT	W15000	08/87	417,896	505,362*
2345Z		F265602	RAMP	W15000	12/87	14,323	17,321
2345Z		F269333	INTRUSION DETECTION SYS	W15000	09/93	263,370	273,352
2345Z		HS00043	STORAGE FACILITY	W15000	05/94	81,908	82,490
2345Z		HS00045	STORAGE FACILITY	W15000	05/94	57,277	57,684
2345Z		HS00046	STORAGE FACILITY	W15000	05/94	57,278	57,685
2345Z		HS00047	STORAGE FACILITY	W15000	05/94	57,278	57,685
2345Z		WB26728	CHROMATOGRAPH	W15000	08/83	33,279	43,063
2345Z		WB55167	COMPUTER	W15000		1,000	
2345Z		WC25331	COMPUTER	W15000		3,120	
2345Z		WC57049	COMPUTER	W15000		3,146	
2345Z		1E00120	SCOOTER	W15000	08/88	5,398	6,459
2345Z		1E00131	SCOOTER	W15000	02/94	8,058	8,115
2345Z		1E00685	SCOOTER	W15000	06/93	7,465	7,748
2345Z		1E00686	SCOOTER	W15000	09/93	7,466	7,749
2345Z		7503936	FORKLIFT	W15000	12/93	24,639	25,573
2345Z		7503938	FORKLIFT	W15000		7,559	
2345Z		7503939	FORKLIFT	W15000		7,559	
2345Z		7504114	FORKLIFT	W15000	11/82	33,215	45,880
2345Z		7806020	LAWN MOWER	W15000	12/92	9,287	10,140
	*					31,396,260	130,559,146
	76 ITEMS FOR ROOM =						
2345Z	A LINE	F136025	HOOD	W15000	07/62	5,578	29,071
2345Z	A LINE	F221678	SHIELDING	W15000	10/63	19,136	99,731
	*					24,714	128,802
	2 ITEMS FOR ROOM = A LINE						
2345Z	A LINE MEZ	FA25720	MOTOR CONTROL CENTER	W15000	08/63	6,685	34,840
2345Z	A LINE MEZ	F221640	MOTOR CONTROL CENTER	W15000	08/63	6,685	34,840
	*					13,370	69,680
	2 ITEMS FOR ROOM = A LINE MEZ						
2345Z	C LINE	F175147	BALANCE	W15000	08/51	17,954	93,571
2345Z	C LINE	F175161	PUMP	W15000	09/59	7,803	40,667
2345Z	C LINE	F221424	POWER WIRING	W15000	02/63	14,020	73,068
2345Z	C LINE	F257051	SHIELDING	W15000	02/74	20,796	52,500

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					60,573	259,806
	4 ITEMS FOR ROOM = C LINE						
2345Z	C*LINE	F265327	FIRE SUPPRESSION SYSTEM	W15000	03/86	553,332	690,724
	1 ITEMS FOR ROOM = C*LINE						
2345Z	CANYON	3403961	MANLIFT-SCISSORS	W15000	05/87	10,763	13,016
	1 ITEMS FOR ROOM = CANYON						
2345Z	CENTRAL*CONTROL	F175250	BALANCE	W15000	09/60	23,091	120,343
2345Z	CENTRAL*CONTROL	F175340	HEATER	W15000	09/60	7,766	40,474
	*					30,857	160,817
	2 ITEMS FOR ROOM = CENTRAL*CONTROL						
2345Z	CHANGEROOM	WC26364	MONITOR	W8P000	06/92	68,034	74,286
	1 ITEMS FOR ROOM = CHANGEROOM						
2345Z	COORDW76460N39800	F175882	TANK	W15000	06/50	50,252	261,898
	1 ITEMS FOR ROOM = COORDW76460N39800						
2345Z	COORDW76580N41120	F175881	TANK	W15000	12/44	15,002	78,186
	1 ITEMS FOR ROOM = COORDW76580N41120						
2345Z	CORR*1	FA25633	PANEL	W15000	01/81	56,366	80,885
2345Z	CORR*1	FA25741	POWER SUPPLY	W15000	10/92	9,500	10,373
2345Z	CORR*1	FA25742	POWER SUPPLY	W15000		0	
	*					65,866	91,258
	3 ITEMS FOR ROOM = CORR*1						
2345Z	CORR*3	FA25628	PANEL	W15000	01/81	56,366	80,885
2345Z	CORR*3	FA25635	PANEL	W15000	01/81	56,366	80,885
	*					112,732	161,770
	2 ITEMS FOR ROOM = CORR*3						
2345Z	CORR*7	FA25730	MONITOR	W15000	01/79	16,290	26,870

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	1 ITEMS FOR ROOM = CORR*7						
2345Z	DOCK5	WB34413	ANALYZER	W15000	06/87	56,302	68,086
2345Z	DOCK5	WB39572	CHROMATOGRAPH	W15000	12/84	6,340	8,198
2345Z	DOCK5	WC53016	PRINTER	W15000	06/87	7,996	9,670
	*					70,638	85,954
	3 ITEMS FOR ROOM = DOCK5						
2345Z	DOOR*124	F261726	MONITOR	W15000	01/79	16,290	26,870
	1 ITEMS FOR ROOM = DOOR*124						
2345Z	DOOR*125	FA25705	MONITOR	W15000	01/86	64,782	80,867
	1 ITEMS FOR ROOM = DOOR*125						
2345Z	DUCT LEVEL	FA25301	FILTER BOX	W15000	02/86	7,167	8,947
2345Z	DUCT LEVEL	F265209	FILTER BOX	W15000	02/86	7,167	8,947
	*					14,334	17,894
	2 ITEMS FOR ROOM = DUCT LEVEL						
2345Z	DUCT*LEVEL*150	FA25610	AIR CONDITIONER	W15000	05/88	59,684	71,412
	1 ITEMS FOR ROOM = DUCT*LEVEL*150						
2345Z	DUCTLEVEL	WB34305	AIR CONDITIONER	W15000	06/63	5,698	29,696
2345Z	DUCTLEVEL	WB34306	AIR CONDITIONER	W15000	10/84	113,768	147,102
	*					119,466	176,798
	2 ITEMS FOR ROOM = DUCTLEVEL						
2345Z	D136	WC49986	PIPE LATHE	W15000		8,775	
2345Z	D136	WC49987	PIPE LATHE	W15000		8,775	
	*					17,550	
	2 ITEMS FOR ROOM = D136						
2345Z	EFIELD	FA25795	TRANSFORMER	W15000	08/87	83,820	101,364
	1 ITEMS FOR ROOM = EFIELD						
2345Z	F3E4*FILER*SYS	F261027	GENERAL SYSTEM EQUIPMENT	W15000	04/76	193,044	408,964

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	1 ITEMS FOR ROOM = F3E4*FILER*SYS						
2345Z	HA19-B1 A	F136851	FURNACE	W15000	12/63	48,670	253,653
	1 ITEMS FOR ROOM = HA19-B1 A						
2345Z	MAIN*ENTRANCE	FA25695	MONITOR	W15000	01/79	16,290	26,870
	1 ITEMS FOR ROOM = MAIN*ENTRANCE						
2345Z	NORTH*SIDE	F257757	ENCLOSURE	W15000	12/73	11,164	30,203
2345Z	NORTH*SIDE	F258707	GLOVEBOX	W15000	04/77	25,245	49,243
	*					36,409	79,446
	2 ITEMS FOR ROOM = NORTH*SIDE						
2345Z	OFFSITE	WC17776	COMPUTER	W15000		2,457	
2345Z	OFFSITE	WC30976	COMPUTER	W15000		2,792	
	*					5,249	
	2 ITEMS FOR ROOM = OFFSITE						
2345Z	OUTSIDE	7305255	WELDER	W15000	06/80	5,990	9,302
	1 ITEMS FOR ROOM = OUTSIDE						
2345Z	PARKING	1E00982	SCOOTER	W15000	08/85	6,980	8,957
	1 ITEMS FOR ROOM = PARKING						
2345Z	PERIMETER	F039087	FENCE	W15000	12/44	28,144	146,678
2345Z	PERIMETER	F264299	FENCE	W15000	09/82	115,131	159,030
2345Z	PERIMETER	F264300	LIGHT FIXTURE	W15000	09/82	98,075	135,471
	*					241,350	441,179
	3 ITEMS FOR ROOM = PERIMETER						
2345Z	PERIMETER*FENCE	F264301	DETECTION SYSTEM	W15000	09/82	977,226	1,349,842
2345Z	PERIMETER*FENCE	F264302	DETECTION SYSTEM	W15000	09/82	796,059	1,099,596
2345Z	PERIMETER*FENCE	F264303	DETECTION SYSTEM	W15000	09/82	207,394	286,473
	*					1,980,679	2,735,911
	3 ITEMS FOR ROOM = PERIMETER*FENCE						
2345Z	RMC LINE	F263587	FURNACE	W15000	03/86	6,647	8,297

DETAIL COST BREAKDOWN BY ROOM FOR LEA MCKINNIS

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
1 ITEMS FOR ROOM = RMC LINE							
2345Z	ROOM 228	F174011	FEEDER	W15000	09/58	7,696	40,109
2345Z	ROOM 228	F174021	HOOD	W15000	09/58	36,805	191,817
2345Z	ROOM 228	F174028	HOOD	W15000	03/55	5,878	30,634
	*					50,379	262,560
3 ITEMS FOR ROOM = ROOM 228							
2345Z	SOUTH	FA25430	AIR CONDITIONER	W15000	12/80	10,855	16,858
1 ITEMS FOR ROOM = SOUTH							
2345Z	SOUTH*SIDE	F257756	ENCLOSURE	W15000	12/73	11,165	30,206
1 ITEMS FOR ROOM = SOUTH*SIDE							
2345Z	STR19	WB33714	COMPUTER	W15000	11/87	3,520	4,257
2345Z	STR19	WB84282	COMPUTER	W15000		3,318	
2345Z	STR19	WB86608	COMPUTER	W15000		1,646	
2345Z	STR19	WC04437	COMPUTER	W15000		1,510	
2345Z	STR19	WC10455	COMPUTER	W15000		3,699	
2345Z	STR19	WC10456	COMPUTER	W15000		3,699	
2345Z	STR19	WC22084	COMPUTER	W15000		3,268	
2345Z	STR19	WC25399	COMPUTER	W15000		3,349	
2345Z	STR19	WC26120	COMPUTER	W15000		3,268	
2345Z	STR19	WC26121	COMPUTER	W15000		3,268	
2345Z	STR19	WC31191	COMPUTER	W15000		3,956	
	*					34,501	4,257
11 ITEMS FOR ROOM = STR19							
2345Z	TASK*III*RMA	F175143	BALANCE	W15000	03/55	24,684	128,646
1 ITEMS FOR ROOM = TASK*III*RMA							
2345Z	TC	WB29659	OSCILLOSCOPE	W15000	06/82	6,672	9,216
2345Z	TC	WB29684	OSCILLOSCOPE	W15000	04/84	16,153	20,886
2345Z	TC	WB54478	ANALYZER	W15000	12/89	17,295	20,251
	*					40,120	50,353
3 ITEMS FOR ROOM = TC							
2345Z	TOOLC	WB97260	OSCILLOSCOPE	W15000	06/90	8,065	9,290
1 ITEMS FOR ROOM = TOOLC							

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	TOOLCRIB	WB29661	OSCILLOSCOPE	W15000	01/83	12,117	15,679
2345Z	TOOLCRIB	WB97201	MULTIMETER	W15000	07/89	8,723	10,214
2345Z	TOOLCRIB	WC02298	ANALYZER	W15000	04/85	5,986	7,681
2345Z	TOOLCRIB	WC45808	DATA COLLECTOR	W15000		9,400	
	*					36,226	33,574
	4 ITEMS FOR ROOM = TOOLCRIB						
2345Z	TOOLROOM	WB29664	OSCILLOSCOPE	W15000	06/82	5,312	7,337
	1 ITEMS FOR ROOM = TOOLROOM						
2345Z	WEST*ANAL*LAB	F255005	ENCLOSURE	W15000	09/71	6,833	21,619
	1 ITEMS FOR ROOM = WEST*ANAL*LAB						
2345Z	YARD	FA30101	GLOVEBOX	W15000	07/81	67,353	96,652
2345Z	YARD	FA30123	GLOVEBOX	W15000	10/85	202,182	259,440
2345Z	YARD	FA30125	GLOVEBOX	W15000	09/80	28,489	44,243
2345Z	YARD	FA30319	ENCLOSURE	W15000	08/84	20,000	25,860
2345Z	YARD	FA30404	GLOVEBOX	W15000	11/78	83,901	151,483
2345Z	YARD	FA30405	GLOVEBOX	W15000	06/82	78,489	108,417
	*					480,414	686,095
	6 ITEMS FOR ROOM = YARD						
2345Z	Z1*PANEL*CORR1	F262451	GENERAL STATION EQUIP	W15000	01/81	223,482	320,697
	1 ITEMS FOR ROOM = Z1*PANEL*CORR1						
2345Z	1E106	1E00106	SCOOTER	W15000	06/88	6,852	8,198
	1 ITEMS FOR ROOM = 1E106						
2345Z	100	WC34757	COMPUTER	W15000		1,591	
	1 ITEMS FOR ROOM = 100						
2345Z	101	WC26169	COMPUTER	W15000		3,120	
	1 ITEMS FOR ROOM = 101						
2345Z	102	WC30573	COMPUTER	W15000		1,591	
	1 ITEMS FOR ROOM = 102						
2345Z	103	WB23968	COMPUTER	W15000		1,610	
2345Z	103	WC41244	COMPUTER	W15000		2,512	

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					4,122	
	2 ITEMS FOR ROOM = 103						
2345Z	104	WB86280	COMPUTER	W15000		1,646	
2345Z	104	WB95797	COMPUTER	W15000		1,610	
2345Z	104	WC14146	COMPUTER	W15000		2,010	
2345Z	104	WC30971	COMPUTER	W15000		2,792	
2345Z	104	WC40042	CELLULAR PHONE	W15000		429	
2345Z	104	WC42267	COMPUTER	W15000		2,512	
	*					10,999	
	6 ITEMS FOR ROOM = 104						
2345Z	107	WC39326	COMPUTER	W15000		2,222	
2345Z	107	WC41238	COMPUTER	W15000		2,512	
2345Z	107	WC45836	COMPUTER	W15000		2,158	
	*					6,892	
	3 ITEMS FOR ROOM = 107						
2345Z	108	WC36214	COMPUTER	W15000		3,200	
	1 ITEMS FOR ROOM = 108						
2345Z	110	FA25697	PANEL	W15000	01/81	56,366	80,885
	1 ITEMS FOR ROOM = 110						
2345Z	112	WC41380	COMPUTER	W15000		2,512	
	1 ITEMS FOR ROOM = 112						
2345Z	117	WB86302	COMPUTER	W15000		1,646	
	1 ITEMS FOR ROOM = 117						
2345Z	118	WC45326	COMPUTER	W15000		2,158	
2345Z	118	WC47278	FACSIMILE	W15000		2,601	
	*					4,759	
	2 ITEMS FOR ROOM = 118						
2345Z	119	WC39039	RECORDER	W15000		629	
2345Z	119	WC40519	COMPUTER	W15000		3,438	

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					4,067	
2 ITEMS FOR ROOM = 119							
2345Z	131	FA25663	HOOD	W15000	06/74	38,734	97,784
2345Z	131	FA25668	HOOD	W15000	06/74	38,736	97,789
	*					77,470	195,573
2 ITEMS FOR ROOM = 131							
2345Z	132	FA25622	PUMP	W15000	09/76	7,483	15,853
2345Z	132	WB10695	VACUUM SYSTEM	W15000	04/84	9,590	12,400
2345Z	132	WB10697	MASS SPECTROMETER	W15000	04/84	524,088	677,646*
2345Z	132	WB10699	MASS SPECTROMETER	W15000	12/84	439,638	568,452*
2345Z	132	WB26736	COMPUTER	W15000	12/84	3,320	4,293
	*					984,119	1,278,644
5 ITEMS FOR ROOM = 132							
2345Z	132MS	WB26737	MASS SPECTROMETER	W15000	06/63	44,194	230,326
2345Z	132MS	WB34307	MASS SPECTROMETER	W15000	06/63	69,599	362,729
	*					113,793	593,055
2 ITEMS FOR ROOM = 132MS							
2345Z	134	FA25616	HOOD	W15000	01/44	6,372	33,209
2345Z	134	FA25621	HOOD	W15000	03/87	59,062	71,424
2345Z	134	FA25626	HOOD	W15000	03/87	59,063	71,425
	*					124,497	176,058
3 ITEMS FOR ROOM = 134							
2345Z	134INBOX	WC02481	PUMP	W15000	12/84	10,369	13,407
1 ITEMS FOR ROOM = 134INBOX							
2345Z	135	FA25606	HOOD	W15000	01/44	6,372	33,209
2345Z	135	FA25611	HOOD	W15000	01/44	6,372	33,209
	*					12,744	66,418
2 ITEMS FOR ROOM = 135							
2345Z	136	FA25640	HOOD	W15000	03/61	19,414	101,180
2345Z	136	WB10683	SOURCE	W15000	02/69	15,482	60,607

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	136	WB10684	CONSOLE	W15000	01/84	96,257	124,460
2345Z	136	WB34308	QUANTOMETER	W15000	02/69	46,197	180,847
	*					177,350	467,094
	4 ITEMS FOR ROOM = 136						
2345Z	137	FA25601	HOOD	W15000	03/61	19,414	101,180
2345Z	137	WB26740	CAMERA	W15000	10/81	15,117	21,693
	*					34,531	122,873
	2 ITEMS FOR ROOM = 137						
2345Z	139	FA25669	HOOD	W15000	01/53	6,372	33,209
2345Z	139	FA25674	HOOD	W15000	01/66	18,340	87,773
2345Z	139	FA25679	HOOD	W15000	01/53	6,372	33,209
2345Z	139	FA25684	HOOD	W15000	03/71	14,706	46,528
2345Z	139	WC47005	HYGROMETER	W15000	09/91	17,104	19,182
	*					62,894	219,901
	5 ITEMS FOR ROOM = 139						
2345Z	140	WC10996	COMPUTER	W15000		3,247	
2345Z	140	WC36645	COMPUTER	W15000		1,591	
	*					4,838	
	2 ITEMS FOR ROOM = 140						
2345Z	140A	WB28116	COMPUTER	W15000		800	
2345Z	140A	WB92817	COMPUTER	W15000		1,610	
	*					2,410	
	2 ITEMS FOR ROOM = 140A						
2345Z	140B	WB49475	DETECTOR	W15000	10/90	9,337	10,755
	1 ITEMS FOR ROOM = 140B						
2345Z	141	FA25659	HOOD	W15000	09/73	6,360	17,206
	1 ITEMS FOR ROOM = 141						
2345Z	143	FA25602	HOOD	W15000	06/74	11,102	28,027
2345Z	143	FA25607	HOOD	W15000	06/74	11,103	28,030
	*					22,205	56,057

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2 ITEMS FOR ROOM = 143							
2345Z	144	FA25612	HOOD	W15000	06/75	6,655	15,384
2345Z	144	FA25617	HOOD	W15000	11/70	11,141	40,274
2345Z	144	FA25627	HOOD	W15000	01/53	6,372	33,209
2345Z	144	FA25631	HOOD	W15000	06/75	6,655	15,384
2345Z	144	FA25632	HOOD	W15000	01/53	6,878	35,846
2345Z	144	FA25637	HOOD	W15000	01/53	6,372	33,209
2345Z	144	WB34401	ANALYZER	W15000	05/87	35,066	42,405
2345Z	144	WB92124	COMPUTER	W15000	11/90	11,809	13,603
2345Z	144	WC11477	METER	W15000	10/91	12,383	13,888
2345Z	144	WC28184	ANALYZER	W15000	10/90	36,228	41,731
	*					139,559	284,933
10 ITEMS FOR ROOM = 144							
2345Z	145	FA25664	HOOD	W15000	06/65	34,862	172,183
2345Z	145	WB10680	PRESS	W15000	10/70	37,489	135,519
2345Z	145	WB26615	DETECTOR	W15000	06/87	38,739	46,847
2345Z	145	WB34304	COUNTER	W15000	11/86	47,426	59,202
2345Z	145	WB34310	DETECTOR	W15000	09/86	17,456	21,790
2345Z	145	WB34438	DETECTOR	W15000	08/87	11,029	13,337
2345Z	145	WC04776	DETECTOR	W15000	09/84	6,927	8,957
2345Z	145	WC21572	COMPUTER	W15000		1,591	
2345Z	145	WC22385	COMPUTER	W15000		1,591	
2345Z	145	WC38163	DETECTOR	W15000	09/92	10,689	11,671
	*					207,799	469,506
10 ITEMS FOR ROOM = 145							
2345Z	146	FA25653	HOOD	W15000	05/73	39,834	107,767
2345Z	146	FA25658	HOOD	W15000	01/45	11,037	57,522
	*					50,871	165,289
2 ITEMS FOR ROOM = 146							
2345Z	147	WC36915	COMPUTER	W15000		1,591	
2345Z	147	WC42230	COMPUTER	W15000		3,385	
	*					4,976	
2 ITEMS FOR ROOM = 147							
2345Z	148	FA25685	HOOD	W15000	01/44	6,372	33,209
1 ITEMS FOR ROOM = 148							

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	149	FA25690	GLOVEBOX	W15000	07/85	205,094	263,177
2345Z	149	WB10663	SPECTROPHOTOMETER	W15000	10/81	25,090	36,004
2345Z	149	WB10691	CHROMATOGRAPH	W15000	04/85	9,996	12,827
2345Z	149	WB10693	ANALYZER	W15000	07/84	27,398	35,426
	*					267,578	347,434
	4 ITEMS FOR ROOM = 149						
2345Z	150	WB10694	SHIELD	W15000	09/84	7,675	9,924
2345Z	150	WB26616	DETECTOR	W15000	04/87	15,752	19,040
2345Z	150	WB36450	DETECTOR	W15000	08/87	16,117	19,45[illegible]
2345Z	150	WB71463	CONVERTER	W15000	09/87	12,303	14,878
2345Z	150	WC21580	COMPUTER	W15000		1,591	
2345Z	150	WC26687	COMPUTER	W15000		3,120	
2345Z	150	WC26688	COMPUTER	W15000		3,120	
2345Z	150	WC26745	COMPUTER	W15000		3,131	
2345Z	150	WC38542	DETECTOR	W15000	10/85	14,680	18,837
2345Z	150	WC39050	SPECTROMETER	W15000	12/92	9,959	10,874
	*					87,448	93,052
	10 ITEMS FOR ROOM = 150						
2345Z	151	WB26823	DETECTOR	W15000	10/85	18,249	23,417
	1 ITEMS FOR ROOM = 151						
2345Z	152	FA15730	GLOVEBOX	W15000	10/86	102,827	128,359
2345Z	152	FA25680	HOOD	W15000	04/72	16,590	47,856
	*					119,417	176,215
	2 ITEMS FOR ROOM = 152						
2345Z	153	FA25665	HOOD	W15000	01/44	6,372	33,209
2345Z	153	FA25670	HOOD	W15000	01/44	6,372	33,209
2345Z	153	FA25675	HOOD	W15000	06/71	5,329	16,860
2345Z	153	WB10692	ANALYZER	W15000	12/80	5,766	8,955
2345Z	153	WB97232	ANALYZER	W15000	12/89	23,810	27,879
	*					47,649	120,112
	5 ITEMS FOR ROOM = 153						
2345Z	154	FA25645	GLOVEBOX	W15000	02/85	183,861	235,930
2345Z	154	FA25655	FURNACE	W15000	06/78	7,210	13,018
2345Z	154	FA25660	DETERMINATOR	W15000	05/78	32,075	57,911
2345Z	154	WB26748	CARBON DETERMINATOR	W15000	05/82	13,685	18,903
2345Z	154	WB34302	SULFUR DETERMINATOR	W15000	06/77	11,888	23,189

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*						
	5 ITEMS FOR ROOM = 154					248,719	348,951
2345Z	155	FA25646	HOOD	W15000	01/44	6,372	33,209
2345Z	155	FA25650	HOOD	W15000	01/44	6,372	33,209
2345Z	155	WB34418	SPECTROPHOTOMETER	W15000	07/87	56,147	67,899
	*						
	3 ITEMS FOR ROOM = 155					68,891	134,317
2345Z	156	FA25642	GLOVEBOX	W15000	07/84	167,047	215,992
2345Z	156	FA25647	HOOD	W15000	01/44	6,372	33,209
2345Z	156	WC54549	TITRATOR	W15000		9,131	
	*						
	3 ITEMS FOR ROOM = 156					182,550	249,201
2345Z	157	FA25636	GLOVEBOX	W15000	07/84	167,048	215,993
2345Z	157	FA25641	GLOVEBOX	W15000	07/84	167,048	215,993
2345Z	157	WB26752	METER	W15000	04/85	6,724	8,628
2345Z	157	WB28103	SPECTROPHOTOMETER	W15000	11/86	11,065	13,812
	*						
	4 ITEMS FOR ROOM = 157					351,885	454,426
2345Z	159	WB29462	ALARM	W15000	10/83	9,980	12,914
2345Z	159	WB29464	ALARM	W15000	10/83	9,980	12,914
2345Z	159	WB29466	ALARM	W15000	10/83	9,979	12,913
2345Z	159	WB29650	ALARM	W15000	10/83	9,980	12,914
2345Z	159	WB29660	ALARM	W15000	10/83	9,980	12,914
2345Z	159	WB29672	ALARM	W15000	10/83	9,981	12,915
2345Z	159	WB29677	ALARM	W15000	10/83	9,980	12,914
	*						
	7 ITEMS FOR ROOM = 159					69,860	90,398
2345Z	161	WC23446	COMPUTER	W15000		1,027	
	1 ITEMS FOR ROOM = 161						
2345Z	162	WB36463	COMPUTER	W15000		1,560	
	1 ITEMS FOR ROOM = 162						

$6,024,152
+ 2,118,511
$8,142,663

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	180	WC35031	COMPUTER	W15000		0	
2345Z	180	WC42546	CENTRIFUGE	W15000	07/93	10,366	10,759
	*					383,329	450,241
10 ITEMS FOR ROOM = 180							
2345Z	182	WB42179	MICROSCOPE	W15000	03/81	133,641	191,775
2345Z	182	WB71589	DETECTOR	W15000	11/90	6,000	6,911
	*					139,641	198,686
2 ITEMS FOR ROOM = 182							
2345Z	183	FA30491	GLOVEBOX	W15000	07/63	12,762	66,512
2345Z	183	WB31124	COMPUTER	W15000	06/87	8,273	10,005
2345Z	183	WB34436	ANALYZER	W15000	06/87	50,963	61,630
2345Z	183	WB39291	ANALYZER	W15000	01/89	23,556	27,582
2345Z	183	WB49457	COMPUTER	W15000	05/81	16,171	23,205
2345Z	183	WB49458	COUNTER/ANALYZER	W15000	05/81	13,699	19,658
2345Z	183	WC48948	LASER	W15000	11/92	142,481	155,575
2345Z	183	WC56467	WEIGHING STATION	W15000		26,447	
	*					294,352	364,167
8 ITEMS FOR ROOM = 183							
2345Z	185	WB53111	COUNTER	W15000	02/78	22,745	41,066
2345Z	185	WB89225	ANALYZER	W15000	11/88	28,251	33,802
2345Z	185	WC37053	COMPUTER	W15000		1,591	
2345Z	185	WC37535	SPECTROMETER	W15000	07/92	15,181	16,576
2345Z	185	WC46585	COMPUTER	W15000		2,158	
	*					69,926	91,444
5 ITEMS FOR ROOM = 185							
2345Z	187	FA30492	HOOD	W15000	12/78	30,920	55,826
2345Z	187	FA30493	HOOD	W15000	12/78	30,921	55,828
2345Z	187	FA30494	HOOD	W15000	12/78	30,919	55,824
2345Z	187	FA30495	HOOD	W15000	01/44	15,942	83,085
	*					108,702	250,563
4 ITEMS FOR ROOM = 187							
2345Z	188	FA30481	GLOVEBOX	W15000	01/69	14,574	57,053
2345Z	188	FA30496	GENERATOR	W15000	09/78	34,522	62,329
2345Z	188	WB34411	GENREATOR	W15000	07/87	8,210	9,928

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					57,306	129,310
	3 ITEMS FOR ROOM = 188						
2345Z	189	WC50682	COMPUTER	W15000		2,071	
2345Z	189	WC53158	AUTOSAMPLER	W15000	01/95	17,180	17,180
2345Z	189	WC57046	CHROMATOGRAPH	W15000	07/94	61,178	61,612
	*					80,429	78,792
	3 ITEMS FOR ROOM = 189						
2345Z	192	FA31030	COUNTER	W15000	06/95	390,946	390,946
2345Z	192	WB30988	BOX COUNTER	W15000	11/88	158,724	189,913
2345Z	192	WB36804	COMPUTER	W15000		1,560	
2345Z	192	WB72388	COUNTER	W15000	01/90	0	0
2345Z	192	WB72389	COUNTER	W15000	04/90	158,313	182,361
2345Z	192	WB97228	DETECTOR	W15000	04/91	17,579	19,715
2345Z	192	WC10422	COMPUTER	W15000		3,247	
	*					730,369	782,935
	7 ITEMS FOR ROOM = 192						
2345Z	192A	FA25793	CRANE	W15000	08/91	18,883	21,177
2345Z	192A	WB85060	CONTAINER	W15000	02/78	11,989	21,646
2345Z	192A	WB85061	CONTAINER	W15000	09/75	5,895	13,627
2345Z	192A	WB85062	CONTAINER	W15000	09/75	5,896	13,629
2345Z	192A	WB85063	CONTAINER	W15000	09/75	5,896	13,629
2345Z	192A	WB85064	CONTAINER	W15000	09/75	5,895	13,627
2345Z	192A	WB85065	CONTAINER	W15000	09/75	5,896	13,629
	*					60,350	110,964
	7 ITEMS FOR ROOM = 192A						
2345Z	194	FA08341	GLOVEBOX	W15000	06/78	11,990	21,648
2345Z	194	FA10156	AIR CONDITIONER	W15000	02/83	51,668	66,858
2345Z	194	F264596	GLOVEBOX	W15000	04/84	16,604	21,469
2345Z	194	WB23892	OSCILLOSCOPE	W15000	07/89	15,212	17,812
2345Z	194	WB72397	ULTRAPROBE	W15000	06/90	9,872	11,372
2345Z	194	WB93242	ANALYZER/BALANCER	W15000	08/89	18,330	21,463
2345Z	194	WB94720	COMPUTER	W15000		1,610	
2345Z	194	WC14091	COMPUTER	W15000		2,010	
2345Z	194	WC37516	HYGROMETER	W15000	09/91	15,280	17,137
2345Z	194	WC41267	COMPUTER	W15000		2,512	
2345Z	194	WC49994	FACSIMILE	W15000		500	
2345Z	194	WC50654	COMPUTER	W15000		2,071	

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					147,659	177,759
	12 ITEMS FOR ROOM = 194						
2345Z	194D	WC40710	COMPUTER	W15000		2,516	
	1 ITEMS FOR ROOM = 194D						
2345Z	198	WB29429	BANDSAW	W15000	02/83	24,686	31,944
2345Z	198	WC32513	TELEVISION	W15000		653	
2345Z	198	WC34592	RECORDER	W15000		384	
	*					25,723	31,944
	3 ITEMS FOR ROOM = 198						
2345Z	200	WC30879	COMPUTER	W15000		3,956	
	1 ITEMS FOR ROOM = 200						
2345Z	200A	WC09405	COMPUTER	W15000		1,610	
2345Z	200A	WC41858	ENGRAVING SYSTEM	W15000		12,495	
	*					14,105	
	2 ITEMS FOR ROOM = 200A						
2345Z	201	WC02223	CAMERA	W15000	09/80	330	512
2345Z	201	WC02225	CAMERA	W15000	04/85	1,280	1,642
2345Z	201	WC12976	FIBERSCOPE	W15000	08/81	5,681	8,152
2345Z	201	WC12985	CAMCORDER	W15000	01/87	1,200	1,451
	*					8,491	11,757
	4 ITEMS FOR ROOM = 201						
2345Z	202	FA24137	DEMINERALIZER	W15000	05/87	8,200	9,916
2345Z	202	WA82037	BALANCE	W15000		0	
2345Z	202	WA82040	BALANCE	W15000		0	
2345Z	202	WA82043	BALANCE	W15000		0	
2345Z	202	WB49468	BALANCE	W15000	12/82	5,498	7,594
2345Z	202	WC16119	MILL	W15000	04/91	5,287	0
	*					18,985	17,510
	6 ITEMS FOR ROOM = 202						
2345Z	205	WB95056	COMPUTER	W15000		3,318	
2345Z	205	WC32271	COMPUTER	W15000		1,591	

RLPS-MCKINNIS

RL Property System
DETAIL COST BREAKDOWN BY ROOM FOR LEA MCKINNIS

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BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					4,909	
	2 ITEMS FOR ROOM = 205						
2345Z	205CAB	WB32036	RECORDER	W15000		800	
2345Z	205CAB	WC21342	TELEVISION	W15000	02/87	530	641
2345Z	205CAB	WC23843	COMPUTER	W15000		2,620	
2345Z	205CAB	WC36797	COMPUTER	W15000		3,370	
	*					7,320	641
	4 ITEMS FOR ROOM = 205CAB						
2345Z	208	WC31677	COPIER	W15000	06/92	9,398	10,262
	1 ITEMS FOR ROOM = 208						
2345Z	209	WB23502	COMPUTER	W15000		3,408	
2345Z	209	WC19330	COMPUTER	W15000		1,027	
2345Z	209	WC22976	COMPUTER	W15000		3,316	
2345Z	209	WC37534	READER PRINTER	W15000	05/92	27,784	30,337
2345Z	209	WC39690	COMPUTER	W15000		4,415	
2345Z	209	WC40608	COMPUTER	W15000		2,516	
2345Z	209	WC40726	COMPUTER	W15000		2,516	
2345Z	209	WC40867	COMPUTER	W15000		4,415	
2345Z	209	WC52393	COMPUTER	W15000		2,071	
	*					51,468	30,337
	9 ITEMS FOR ROOM = 209						
2345Z	210	WB97712	COMPUTER	W15000		1,610	
	1 ITEMS FOR ROOM = 210						
2345Z	211	WC07433	COMPUTER	W15000	06/90	11,649	13,418
2345Z	211	WC15115	COMPUTER	W15000		2,115	
2345Z	211	WC25633	COMPUTER	W15000		3,120	
	*					16,884	13,418
	3 ITEMS FOR ROOM = 211						
2345Z	212	WC09387	COMPUTER	W15000		1,610	
2345Z	212	WC40866	COMPUTER	W15000		4,415	
	*					6,025	

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	2 ITEMS FOR ROOM = 212						
2345Z	215	WC45218	COMPUTER	W15000		2,158	
	1 ITEMS FOR ROOM = 215						
2345Z	216	WC23185	COMPUTER	W15000		2,996	
	1 ITEMS FOR ROOM = 216						
2345Z	217	WC41310	COMPUTER	W15000		2,512	
	1 ITEMS FOR ROOM = 217						
2345Z	217A	WB82851	COMPUTER	W15000		784	
	1 ITEMS FOR ROOM = 217A						
2345Z	218	WC00836	FACSIMILE	W15000		1,498	
2345Z	218	WC21953	COMPUTER	W15000		3,120	
2345Z	218	WC42618	COMPUTER	W15000		2,649	
2345Z	218	WC47056	COMPUTER	W15000		2,158	
	*					9,425	
	4 ITEMS FOR ROOM = 218						
2345Z	218A	WC32116	COMPUTER	W15000		2,792	
	1 ITEMS FOR ROOM = 218A						
2345Z	218B	WB95784	COMPUTER	W15000		1,610	
	1 ITEMS FOR ROOM = 218B						
2345Z	218E	WB41734	COMPUTER	W15000		1,560	
	1 ITEMS FOR ROOM = 218E						
2345Z	221A	WB39915	COUNTER	W15000	04/90	73,471	84,631
2345Z	221A	WB85992	COMPUTER	W33000		874	
2345Z	221A	WC04262	COMPUTER	W33000		1,510	
2345Z	221A	WC05252	COMPUTER	W33000		3,204	
2345Z	221A	WC36968	COMPUTER	W15000		1,591	
2345Z	221A	WC47394	COMPUTER	W33000		2,158	
2345Z	221A	WC49330	COMPUTER	W33000		2,158	
	*					84,966	84,631

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	7 ITEMS FOR ROOM = 221A						
2345Z	221A*CEILING	FA10143	AIR CONDITIONER	W15000	06/80	33,595	52,173
	1 ITEMS FOR ROOM = 221A*CEILING						
2345Z	221E	WA14236	BALANCE	W15000	09/77	8,265	16,122
2345Z	221E	WB31837	COMPUTER	W75000	01/88	9,948	11,903
	*					18,213	28,025
	2 ITEMS FOR ROOM = 221E						
2345Z	221F	WC01127	COMPUTER	W33000		1,610	
	1 ITEMS FOR ROOM = 221F						
2345Z	227	FA25634	HOOD	W15000	05/66	54,358	260,152
2345Z	227	FA25638	GLOVEBOX	W15000	05/66	75,528	361,469
	*					129,886	621,621
	2 ITEMS FOR ROOM = 227						
2345Z	228	FA25404	HOOD	W15000	09/59	26,704	139,173
2345Z	228	FA25409	HOOD	W15000	09/60	66,975	349,054
2345Z	228	FA25413	HOOD	W15000	09/59	106,085	552,883
2345Z	228	FA25414	HOOD	W15000	09/60	19,794	103,160
2345Z	228	FA25418	HOOD	W15000	09/60	13,463	70,165
2345Z	228	FA25656	HOOD	W15000	09/59	45,594	237,622
2345Z	228	FA25657	HOOD	W15000	09/71	54,732	173,167
2345Z	228	FA25661	HOOD	W15000	09/59	22,133	115,351
2345Z	228	FA25662	HOOD	W15000	09/59	33,925	176,807
2345Z	228	F173968	BELT	W15000	09/59	8,744	45,571
2345Z	228	F173971	FILTER	W15000	09/58	27,655	144,130
2345Z	228	F173972	TANK	W15000	09/58	7,942	41,391
2345Z	228	F173976	CALCINER	W15000	09/58	21,493	112,015
2345Z	228	F174005	TANK	W15000	09/58	5,130	26,736
2345Z	228	F174009	FEEDER	W15000	09/58	7,696	40,109
2345Z	228	F174014	BALANCE	W15000	06/50	24,500	127,687
	*					492,565	2,455,021
	16 ITEMS FOR ROOM = 228						
:2345Z	228A	FA25652	HOOD	W15000	09/60	31,459	163,955
	1 ITEMS FOR ROOM = 228A						
:2345Z	228B	FA25419	HOOD	W15000	09/60	22,607	117,821

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	228B	FA25424	HOOD	W15000	09/60	19,987	104,166
2345Z	228B	FA25428	HOOD	W15000	09/60	18,093	94,295
2345Z	228B	FA25429	HOOD	W15000	09/60	13,805	71,948
2345Z	228B	FA25433	HOOD	W15000	09/60	11,915	62,097
2345Z	228B	FA25434	HOOD	W15000	09/60	17,740	92,456
2345Z	228B	FA25438	HOOD	W15000	09/60	18,044	94,040
2345Z	228B	FA25443	HOOD	W15000	09/60	15,029	78,327
	*					137,220	715,150
	8 ITEMS FOR ROOM = 228B						
2345Z	228C	FA25423	HOOD	W15000	09/60	8,015	41,772
2345Z	228C	FA25439	HOOD	W15000	09/60	19,901	103,718
2345Z	228C	FA25444	HOOD	W15000	09/60	9,753	50,830
2345Z	228C	FA25448	HOOD	W15000	09/60	30,639	159,681
2345Z	228C	WB29423	GENERATOR	W15000	07/87	8,211	9,930
	*					76,519	365,931
	5 ITEMS FOR ROOM = 228C						
2345Z	230A	FA25449	HOOD	W15000	09/59	72,893	379,896
2345Z	230A	FA25453	HOOD	W15000	07/62	14,625	76,221
	*					87,518	456,117
	2 ITEMS FOR ROOM = 230A						
2345Z	230B	FA25454	HOOD	W15000	07/62	17,740	92,456
	1 ITEMS FOR ROOM = 230B						
2345Z	230C	FA25401	HOOD	W15000	09/59	47,578	247,962
2345Z	230C	FA25402	HOOD	W15000	09/70	36,000	130,136
	*					83,578	378,098
	2 ITEMS FOR ROOM = 230C						
2345Z	232	FA25651	HOOD	W15000	11/73	81,233	219,768
2345Z	232	FA25788	OFF GAS SCRUBBER	W15000	04/87	520,224	629,107
2345Z	232	WC05347	COMPUTER	W15000	07/90	14,204	16,362
2345Z	232	WC29821	GENERATOR	W15000	01/92	14,363	15,683
2345Z	232	WC29822	GENERATOR	W15000	01/92	14,363	15,683
	*					644,387	896,603
	5 ITEMS FOR ROOM = 232						

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	233	F174030	HOOD	W15000	03/55	14,636	76,278
2345Z	233	F174037	HOOD	W15000	03/55	5,818	30,322
2345Z	233	F174039	HOOD	W15000	03/55	13,188	68,732
2345Z	233	F174042	HOOD	W15000	03/55	13,188	68,732
2345Z	233	F174044	HOOD	W15000	03/55	13,189	68,737
2345Z	233	F174046	HOOD	W15000	03/55	14,751	76,878
2345Z	233	F174048	HOOD	W15000	03/55	15,375	80,130
2345Z	233	F174063	HOOD	W15000	03/55	14,849	77,389
2345Z	233	F174067	HOOD	W15000	03/55	13,990	72,912
2345Z	233	F174079	HOOD	W15000	03/55	8,163	42,543
2345Z	233	F174086	HOOD	W15000	03/55	8,163	42,543
2345Z	233	F174090	HOOD	W15000	03/55	7,118	37,097
2345Z	233	F174103	HOOD	W15000	03/55	8,719	45,441
2345Z	233	F174106	HOOD	W15000	03/55	8,718	45,436
2345Z	233	F174107	CONVEYOR	W15000	03/55	62,320	324,793
2345Z	233	F174171	PLATFORM	W15000	09/58	44,239	230,560
2345Z	233	F174181	SHIELDING	W15000	09/59	9,455	49,277
2345Z	233	F174182	SHIELDING	W15000	09/59	52,020	271,113
2345Z	233	F174183	SHIELDING	W15000	09/59	51,398	267,871
2345Z	233	F174184	MG SET	W15000	06/50	15,500	80,781
2345Z	233	WB49476	DETECTOR	W15000	10/90	9,337	10,755
2345Z	233	WB53112	ANALYZER	W15000	10/83	8,689	11,244
2345Z	233	WB71418	MONITOR	W15000	08/87	6,689	8,089
2345Z	233	WC02447	ANALYZER	W15000	07/84	11,315	14,630
2345Z	233	WC02486	ANALYZER	W15000	07/84	11,314	14,629
2345Z	233	WC04286	COMPUTER	W15000		1,510	
2345Z	233	WC21982	COMPUTER	W15000		3,671	
2345Z	233	WC38070	ANALYZER	W15000	02/88	8,771	10,495
2345Z	233	WC38071	ANALYZER	W15000	02/88	8,771	10,495
2345Z	233	WC48819	DETECTOR	W15000	07/84	12,413	16,050
2345Z	233	WC50274	ANALYZER	W15000	07/84	6,184	7,996
2345Z	233	WC50277	ANALYZER	W15000	07/84	11,316	14,632
	*					494,777	2,176,580
	32 ITEMS FOR ROOM = 233						
2345Z	234	WB36503	OSCILLOSCOPE	W15000	01/88	9,355	11,193
2345Z	234	WB45604	ANALYZER	W15000	05/88	18,107	21,665
2345Z	234	WB83817	DETECTOR	W15000	02/89	11,159	13,066
2345Z	234	WC02267	COMPACTOR	W15000	01/72	6,200	17,885
2345Z	234	WC32683	COMPUTER	W15000		3,246	
	*					48,067	63,809
	5 ITEMS FOR ROOM = 234						
2345Z	234A	WC13694	TABLE LIFT	W15000	06/84	6,419	8,300
2345Z	234A	WC38068	ANALYZER	W15000	05/88	12,642	15,126

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					19,061	23,426
	2 ITEMS FOR ROOM = 234A						
2345Z	2345ZLEAD	F187436	TRACK	W52000	07/86	410,597	512,548
2345Z	2345ZLEAD	F187437	TURNOUT	W52000	07/86	12,985	16,209
	*					423,582	528,757
	2 ITEMS FOR ROOM = 2345ZLEAD						
2345Z	2345ZPASSING	F187438	TRACK	W52000	07/86	30,935	38,616
	1 ITEMS FOR ROOM = 2345ZPASSING						
2345Z	235	FA25672	HOOD	W15000	12/63	18,509	96,463
2345Z	235	F266509	BLOWER	W15000	11/79	5,089	8,394
	*					23,598	104,857
	2 ITEMS FOR ROOM = 235						
2345Z	235A1	FA25666	HOOD	W15000	03/55	6,667	34,746
2345Z	235A1	FA25667	HOOD	W15000	03/55	6,667	34,746
	*					13,334	69,492
	2 ITEMS FOR ROOM = 235A1						
2345Z	235B	FA25676	HOOD	W15000	08/63	33,089	172,450
2345Z	235B	FA25677	AIRLOCK	W15000	02/64	10,270	52,557
2345Z	235B	FA25681	HOOD	W15000	02/64	32,666	167,168
2345Z	235B	FA25682	HOOD	W15000	07/62	5,578	29,071
2345Z	235B	FA25687	HOOD	W15000	08/63	25,193	131,298
	*					106,796	552,544
	5 ITEMS FOR ROOM = 235B						
2345Z	235C	FA25671	HOOD	W15000	07/62	5,578	29,071
2345Z	235C	FA25686	HOOD	W15000	08/63	5,613	29,253
2345Z	235C	FA25692	HOOD	W15000	07/62	5,578	29,071
2345Z	235C	FA25696	HOOD	W15000	10/63	113,285	590,407
2345Z	235C	FA25725	HOOD	W15000	07/62	5,578	29,071
2345Z	235C	F221530	BALANCE	W15000	08/63	19,002	99,033
	*					154,634	805,906

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	6 ITEMS FOR ROOM = 235C						
2345Z	238D	WC01857	SHREDDER	W15000	12/76	15,688	33,235
	1 ITEMS FOR ROOM = 238D						
2345Z	251A	WC39117	COMPUTER	W15000		2,522	
	1 ITEMS FOR ROOM = 251A						
2345Z	251B	WC47048	COMPUTER	W15000		2,158	
	1 ITEMS FOR ROOM = 251B						
2345Z	252	WC15286	COMPUTER	W15000		2,010	
2345Z	252	WC19347	COMPUTER	W15000		1,027	
	*					3,037	
	2 ITEMS FOR ROOM = 252						
2345Z	261	WC56241	ROUTER	W61000	06/95	26,889	26,889
	1 ITEMS FOR ROOM = 261						
2345Z	262	FA25781	MG SET	W15000	03/55	16,000	83,387
	1 ITEMS FOR ROOM = 262						
2345Z	263	FA25600	AIR CONDITIONER	W15000	11/90	56,230	64,771
2345Z	263	FA25605	AIR CONDITIONER	W15000	11/90	56,230	64,771
2345Z	263	F175229	PUMP	W15000	09/60	7,041	36,696
2345Z	263	F175230	PUMP	W15000	09/60	8,866	46,207
	*					128,367	212,445
	4 ITEMS FOR ROOM = 263						
2345Z	264	FA25755	FILTER BOX	W15000	12/80	22,502	34,946
2345Z	264	FA25770	FILTER BOX	W15000	12/80	22,502	34,946
2345Z	264	F173990	PUMP	W15000	09/58	10,580	55,140
2345Z	264	F173992	PUMP	W15000	09/58	10,580	55,140
2345Z	264	F221513	MG SET	W15000	05/59	22,650	118,045
2345Z	264	F266525	PUMP	W15000	11/91	19,743	22,142
2345Z	264	F266526	PUMP	W15000	11/91	19,744	22,143
	*					128,301	342,502
	7 ITEMS FOR ROOM = 264						

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	265	WB71600	LOAD BANK	W15000	07/90	7,255	8,357
	1 ITEMS FOR ROOM = 265						
2345Z	265A14	FA25468	GENERATOR	W15000	04/55	10,646	55,484
	1 ITEMS FOR ROOM = 265A14						
2345Z	266	FA25459	CONTROLLER	W15000	01/79	16,292	26,874
2345Z	266	FA25463	CONDITIONER	W15000	05/87	11,551	13,969
2345Z	266	FA25691	PUMP	W15000	12/80	52,734	81,896
2345Z	266	F266278	BREAKER	W15000	02/89	32,071	37,552
2345Z	266	F266279	BREAKER	W15000	02/89	32,071	37,552
2345Z	266	WB71461	DAVID MODULE	W8P000	12/87	20,000	0
2345Z	266	WB95813	TESTER	W15000	10/89	15,480	18,126
2345Z	266	WB96288	ANALYZER	W15000	11/89	15,922	18,643
2345Z	266	WC17459	SWITCHER	W8P000	07/90	29,100	33,520
2345Z	266	WC45107	TEST SET	W15000	12/93	43,336	44,978
	*					268,557	313,110
	10 ITEMS FOR ROOM = 266						
2345Z	267	FA25457	CONTROL PANEL	W15000	10/92	45,000	49,135
	1 ITEMS FOR ROOM = 267						
2345Z	270	WB49473	CONTROLLER	W15000	12/82	26,854	37,093
	1 ITEMS FOR ROOM = 270						
2345Z	300	WC58010	ACCUSTRIP SYSTEM	W17000	03/95	22,608	22,608
	1 ITEMS FOR ROOM = 300						
2345Z	301	WB44994	CAMERA	W15000		1,350	
2345Z	301	WB92811	COMPUTER	W15000		3,318	
2345Z	301	WC04389	COMPUTER	W15000		1,510	
2345Z	301	WC25999	COMPUTER	W15000		1,827	
	*					8,005	
	4 ITEMS FOR ROOM = 301						
2345Z	302	WC42426	COMPUTER	W15000		2,649	
	1 ITEMS FOR ROOM = 302						
2345Z	303	WB36597	COMPUTER	W31000		1,560	
2345Z	303	WC32279	COMPUTER	W31000		1,591	

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	303	WC42048	COMPUTER	W31000		2,512	
2345Z	303	WC42496	COMPUTER	W31000		2,649	
2345Z	303	WC42630	COMPUTER	W31000		2,649	
	*					10,961	
	5 ITEMS FOR ROOM = 303						
2345Z	303A	WC47390	COMPUTER	W15000		2,158	
2345Z	303A	WC49329	COMPUTER	W15000		2,158	
	*					4,316	
	2 ITEMS FOR ROOM = 303A						
2345Z	303B	WB83307	COMPUTER	W15000		1,560	
2345Z	303B	WC47386	COMPUTER	W15000		2,158	
2345Z	303B	WC49343	COMPUTER	W15000		2,158	
	*					5,876	
	3 ITEMS FOR ROOM = 303B						
2345Z	303C	WC45297	COMPUTER	W15000		2,158	
	1 ITEMS FOR ROOM = 303C						
2345Z	303D	WC32892	COMPUTER	W15000		3,571	
	1 ITEMS FOR ROOM = 303D						
2345Z	303E	WC30991	COMPUTER	W38000		4,194	
	1 ITEMS FOR ROOM = 303E						
2345Z	303F	WC45216	COMPUTER	W15000		2,158	
	1 ITEMS FOR ROOM = 303F						
2345Z	303G	WC34815	COMPUTER	W33000		1,591	
2345Z	303G	WC37454	COMPUTER	W33000		2,522	
	*					4,113	
	2 ITEMS FOR ROOM = 303G						
2345Z	303H	WC36242	COMPUTER	W15000		3,317	
2345Z	303H	WC37233	MONITOR	W15000	06/92	24,417	26,661
	*					27,734	26,661

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	2 ITEMS FOR ROOM = 303H						
2345Z	303J	WC00571	COMPUTER	W15000		3,247	
2345Z	303J	WC04450	COMPUTER	W15000		1,510	
	*					4,757	
	2 ITEMS FOR ROOM = 303J						
2345Z	303K	WC42152	COMPUTER	W31000		2,512	
2345Z	303K	WC45677	FACSIMILE	W15000		2,581	
	*					5,093	
	2 ITEMS FOR ROOM = 303K						
2345Z	303L	WB97720	COMPUTER	W31000		1,610	
	1 ITEMS FOR ROOM = 303L						
2345Z	303M	WC21825	COMPUTER	W15000		3,120	
	1 ITEMS FOR ROOM = 303M						
2345Z	304	WC29823	GENERATOR	W15000	01/92	14,363	15,683
2345Z	304	WC32691	GENERATOR	W15000	03/92	13,167	14,377
2345Z	304	WC32692	GENERATOR	W15000	03/92	13,167	14,377
2345Z	304	WC37620	TELEVISION	W15000		600	
2345Z	304	WC37673	RECORDER	W15000		356	
2345Z	304	WC42431	COMPUTER	W15000		2,649	
	*					44,302	44,437
	6 ITEMS FOR ROOM = 304						
2345Z	304B	WC23455	COMPUTER	W15000		1,027	
2345Z	304B	WC30326	CAMERA	W15000		430	
2345Z	304B	WC34555	CAMCORDER	W15000		735	
	*					2,192	
	3 ITEMS FOR ROOM = 304B						
2345Z	306	F174272	MOTOR CONTROL CENTER	W15000	06/50	8,700	45,342
	1 ITEMS FOR ROOM = 306						
2345Z	306A	WB31835	COMPUTER	W8P000	05/87	450,501	544,791
2345Z	306A	WB31880	DISK DRIVE	W8P000		25,280	
2345Z	306A	WB40427	COMPUTER	W8P000		2,000	

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	306A	WB44598	DISK DRIVE	W8P000	01/91	53,280	59,754
2345Z	306A	WB90688	PRINTER	W8P000	01/85	7,006	8,990
2345Z	306A	WB92003	COMPUTER	W8P000	12/89	24,225	28,365
2345Z	306A	WB95762	COMPUTER	W62000		1,610	
2345Z	306A	WC26166	COMPUTER	W8P000		3,120	
2345Z	306A	WC44115	COMPUTER	W62000		2,581	
	*					569,613	641,900
	9 ITEMS FOR ROOM = 306A						
2345Z	306B	F262579	AIR CONDITIONER	W8P000	09/80	10,850	16,850
	1 ITEMS FOR ROOM = 306B						
2345Z	308	FA25615	FILTER BOX	W15000	09/81	72,796	104,462
2345Z	308	FA25620	FILTER BOX	W15000	12/80	22,502	34,946
2345Z	308	FA25698	PUMP	W15000	12/80	52,734	81,896
2345Z	308	FA25703	DEMISTER	W15000	08/79	23,335	38,491
2345Z	308	FA25713	DEMISTER	W15000	08/79	23,335	38,491
2345Z	308	FA25787	FILTER BOX	W15000	09/81	60,290	86,516
2345Z	308	FA25792	HEAT EXCHANGER	W15000	12/80	21,257	33,012
2345Z	308	FA25796	HEAT EXCHANGER	W15000	12/80	6,445	10,009
2345Z	308	FA25797	PUMP	W15000		0	
2345Z	308	F262535	MOTOR CONTROL CENTER	W15000	12/80	9,646	14,980
2345Z	308	F269050	HEAT EXCHANGER	W15000	12/93	23,561	24,454
2345Z	308	F269060	POWER WIRING	W15000	12/93	67,297	69,848
2345Z	308	F269063	POWER WIRING	W15000	12/93	198,194	205,706
	*					581,392	742,811
	13 ITEMS FOR ROOM = 308						
2345Z	320	FA25782	FILTER HOUSING	W15000	11/90	226,125	260,473
2345Z	320	FA25791	FILTER HOUSING	W15000	11/90	222,525	256,327
	*					448,650	516,800
	2 ITEMS FOR ROOM = 320						
2345Z	321	FA20825	DRYER SYSTEM	W15000	01/90	361,145	416,003
2345Z	321	FA20882	DRYER SYSTEM	W15000	01/90	361,145	416,003
2345Z	321	FA25461	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25462	TANK	W15000		0	
2345Z	321	FA25464	FAN	W15000	06/50	36,696	191,249
2345Z	321	FA25465	PUMP	W15000	12/80	5,777	8,972
2345Z	321	FA25466	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25467	TANK	W15000		0	
2345Z	321	FA25469	FAN	W15000	06/50	36,698	191,259
2345Z	321	FA25470	BLOWER	W15000	10/92	25,000	27,297

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	321	FA25471	TANK	W15000	06/88	19,817	23,711
2345Z	321	FA25472	CHILLER	W15000	10/92	40,000	43,676
2345Z	321	FA25474	FAN	W15000	06/50	36,698	191,259
2345Z	321	FA25475	BLOWER	W15000	10/92	25,000	27,297
2345Z	321	FA25476	CHILLER	W15000	10/92	40,000	43,676
2345Z	321	FA25478	FAN	W15000	06/50	36,697	191,254
2345Z	321	FA25479	FAN	W15000	06/50	36,698	191,259
2345Z	321	FA25480	PUMP	W15000	12/80	5,777	8,972
2345Z	321	FA25482	STILL	W15000	06/50	6,509	33,923
2345Z	321	FA25483	FAN	W15000	06/50	36,697	191,254
2345Z	321	FA25484	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25485	FAN	W15000	10/92	25,000	27,297
2345Z	321	FA25486	TANK	W15000	04/55	12,651	65,933
2345Z	321	FA25487	DRYER	W15000	10/92	0	0
2345Z	321	FA25488	FAN	W15000	06/50	36,697	191,254
2345Z	321	FA25489	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25490	FAN	W15000	10/92	25,000	27,297
2345Z	321	FA25492	CHILLER	W15000	10/92	32,500	35,487
2345Z	321	FA25493	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25494	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25496	POWER SUPPLY	W15000	03/87	11,946	14,446
2345Z	321	FA25498	WASHER	W15000	06/50	6,086	31,718
2345Z	321	FA25499	WASHER	W15000	06/50	6,086	31,718
2345Z	321	F263258	LINE CONDITIONER	W15000	04/85	9,508	12,201
2345Z	321	WB54418	HOIST	W15000	06/88	5,644	6,753
2345Z	321	WC41764	GANTRY CRANE	W15000	05/93	6,274	6,512
2345Z	321	WC41765	GANTRY CRANE	W15000	05/93	6,274	6,512
2345Z	321	WC46786	COMPUTER	W15000		2,158	
	*					1,332,694	2,844,500
	38 ITEMS FOR ROOM = 321						
2345Z	321*CONTROL	FA25491	MONITOR	W15000	12/80	7,998	12,421
	1 ITEMS FOR ROOM = 321*CONTROL						
2345Z	321*RMA*LINE	FA25477	DRYER	W15000	06/50	18,100	94,332
	1 ITEMS FOR ROOM = 321*RMA*LINE						
2345Z	321*RMC*LINE	FA25481	DRYER	W15000	10/92	32,750	35,760
	1 ITEMS FOR ROOM = 321*RMC*LINE						
2345Z	321B	WC00111	COMPUTER	W15000		1,610	
	1 ITEMS FOR ROOM = 321B						
2345Z	322	WB97292	RECORDER	W15000		400	

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BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345Z	322	WB97293	CONTROLLER	W15000	05/90	35,356	40,727
	*					35,756	40,727
	2 ITEMS FOR ROOM = 322						
2345Z	323	WC05353	COMPUTER	W15000		3,204	
2345Z	323	WC25021	COMPUTER	W15000		1,827	
	*					5,031	
	2 ITEMS FOR ROOM = 323						
2345Z	336	F175067	AGITATOR	W15000	04/55	7,932	41,339
	1 ITEMS FOR ROOM = 336						
2345Z	337	F175070	AGITATOR	W15000	04/55	9,330	48,625
	1 ITEMS FOR ROOM = 337						
2345Z	340	WB91740	COMPUTER	W15000		3,802	
2345Z	340	WC05282	COMPUTER	W15000		870	
2345Z	340	WC14132	COMPUTER	W15000		2,010	
2345Z	340	WC21041	COMPUTER	W15000		1,827	
2345Z	340	WC47051	COMPUTER	W15000		2,158	
	*					10,667	
	5 ITEMS FOR ROOM = 340						
2345Z	4TH*FLOOR	F226230	CHEMICAL PREP EQUIP	W15000	06/50	33,844	176,385
	1 ITEMS FOR ROOM = 4TH*FLOOR						
2345Z	5	WC30589	COMPUTER	W15000		1,591	
	1 ITEMS FOR ROOM = 5						
2345Z	501	FA30777	HYGROMETER	W15000	06/94	5,676	5,716
	1 ITEMS FOR ROOM = 501						
2345Z	718	WC23175	COMPUTER	W33000		3,281	
2345Z	718	WC23930	COMPUTER	W33000		3,281	
2345Z	718	WC56286	VIEWER CHARGER	W33000	07/91	5,939	6,661
	*					12,501	6,661

$5,825,178

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	3 ITEMS FOR ROOM = 718						
2345Z	728	WC26349	MONITOR	W8P000	09/92	73,333	80,072
	1 ITEMS FOR ROOM = 728						
2345Z	81	WC19704	COMPUTER	W15000		1,827	
	1 ITEMS FOR ROOM = 81						
2345Z	82	WB83497	FACSIMILE	W15000		1,664	
	1 ITEMS FOR ROOM = 82						
2345Z	83	WC13308	COMPUTER	W15000		2,583	
	1 ITEMS FOR ROOM = 83						
2345Z	86	WB72678	COMPUTER	W15000		2,645	
	1 ITEMS FOR ROOM = 86						
2345Z	87	WC37449	COMPUTER	W15000		2,522	
	1 ITEMS FOR ROOM = 87						
2345Z	88	WC30607	COMPUTER	W15000		3,966	
2345Z	88	WC45928	COMPUTER	W15000		2,158	
2345Z	88	WC46002	COMPUTER	W15000		5,377	
	*					11,501	
	3 ITEMS FOR ROOM = 88						
2345Z	89	WC45284	COMPUTER	W15000		2,158	
	1 ITEMS FOR ROOM = 89						
2345Z	90	WB23952	COMPUTER	W15000		3,214	
*						50,207,544	167,171,811
	1 ITEMS FOR ROOM = 90						

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2345ZA		F268006	BUILDING	W15000	10/92	587,000	640,945
1 ITEMS FOR ROOM =							
2345ZA	713	WC00490	COMPUTER	W15000		1,610	
*						588,610	640,945
1 ITEMS FOR ROOM = 713							

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
236Z		F136758	HOOD	W15000	10/63	41,503	216,301
236Z		F221884	BUILDING INDUSTRIAL	W15000	06/64	1,936,887	9,912,019 *
236Z		F221891	POWER WIRING	W15000	06/88	311,123	372,259
236Z		F221908	DUCT	W15000	06/64	62,717	320,954
236Z		F221925	PIPING	W15000	06/64	509,065	2,605,140 *
236Z		F222206	GENERAL SYSTEM EQUIPMENT	W15000	02/91	267,162	299,622
236Z		F226233	INSTRUMENTATION	W15000	06/64	276,653	1,415,772 *
236Z		F226235	PROCESS CELL EQUIP	W15000	06/64	304,166	1,556,570 *
236Z		F226471	INSTRUMENTATION	W15000	01/66	10,448	50,003
236Z		F226669	EVAPORATOR	W15000	05/70	10,789	39,001
236Z		F229880	CENTRIFUGE	W15000	09/71	5,669	17,936
236Z		F256070	TANK	W15000	11/71	5,798	18,344
236Z		F256072	TOWER	W15000	11/71	14,911	47,177
236Z		F256073	TOWER	W15000	11/71	14,911	47,177
236Z		F257102	PROCESS CELL EQUIP	W15000	11/70	128,427	464,251
236Z		F257246	COMPACTOR	W15000	06/73	12,149	32,868
236Z		F257311	CUBE RECOVER	W15000	06/73	49,132	132,922
236Z		F258010	HOOD	W15000	11/71	8,382	20,192
236Z		F258336	FIRE ALARM EQUIPMENT	W15000	11/73	225,372	609,721 *
236Z		F262349	CAMERA	W15000	04/84	5,470	7,073
236Z		F262459	GENERAL SYSTEM EQUIPMENT	W15000	01/81	301,362	432,454
236Z		F264775	TANK	W15000	10/85	49,377	63,361
236Z		F264776	TANK	W15000	10/85	62,655	80,399
236Z		F264817	TANK	W15000	04/85	13,843	17,763
236Z		F265205	INTERCOMMUNICATION EQUIP	W15000	02/86	198,198	247,411
236Z		F266508	CENTRIFUGE	W15000	03/85	33,182	42,579
236Z		F266642	BRIDGE	W15000	02/91	53,000	59,439
236Z		F269337	TANK	W15000	03/95	196,408	196,408
	*					5,106,759	19,325,116
	28 ITEMS FOR ROOM =						
236Z	AMU	F266643	TANK	W15000	02/91	15,000	16,822
	1 ITEMS FOR ROOM = AMU						
236Z	BACK*OF*241Z	F256075	TANK	W15000	11/71	6,462	20,445
	1 ITEMS FOR ROOM = BACK*OF*241Z						
236Z	CANYON	FA25510	FILTRATE EVAPORATOR	W15000	08/92	35,536	38,802
236Z	CANYON	F227189	TANK	W15000	09/70	45,000	162,670
	*					80,536	201,472
	2 ITEMS FOR ROOM = CANYON						
236Z	CONTROL	FA25735	PANEL	W15000	01/81	85,645	122,901
236Z	CONTROL	FA25740	PANEL	W15000	01/81	85,645	122,901

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	*					171,290	245,802
	2 ITEMS FOR ROOM = CONTROL						
236Z	CORR*13	FA25460	ALARM	W15000	06/64	5,248	26,857
	1 ITEMS FOR ROOM = CORR*13						
236Z	CORR*31	FA25785	MOTOR CONTROL CENTER	W15000	06/64	8,870	45,392
	1 ITEMS FOR ROOM = CORR*31						
236Z	CORR*47	F221886	ALARM	W15000	06/64	5,248	26,857
	1 ITEMS FOR ROOM = CORR*47						
236Z	CORR47	WC37231	MONITOR	W15000	06/92	24,417	26,661
236Z	CORR47	WC37232	MONITOR	W15000	06/92	24,417	26,661
	*					48,834	53,322
	2 ITEMS FOR ROOM = CORR47						
236Z	EAST*SIDE	FA20898	TANK	W15000	09/90	300,819	346,513
	1 ITEMS FOR ROOM = EAST*SIDE						
236Z	EAST*1ST*FLR	FA25452	HOOD	W15000	06/64	169,421	867,012
	1 ITEMS FOR ROOM = EAST*1ST*FLR						
236Z	PROCESS*CELL	F221935	CRANE	W15000	06/64	45,917	234,980
236Z	PROCESS*CELL	F222011	SHIELDING	W15000	06/64	119,963	613,911
236Z	PROCESS*CELL	F255364	TANK	W15000	08/72	22,614	65,232
236Z	PROCESS*CELL	F255365	TANK	W15000	08/72	22,615	65,235
	*					211,109	979,358
	4 ITEMS FOR ROOM = PROCESS*CELL						
236Z	SECTIONEB	FA20876	PUMP	W15000	07/91	10,215	11,456
	1 ITEMS FOR ROOM = SECTIONEB						
236Z	WA57604	F266510	DRYER	W15000	06/82	5,071	7,005
	1 ITEMS FOR ROOM = WA57604						
236Z	WA76211	F266507	CENTRIFUGE	W15000	03/85	33,182	42,579

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
1 ITEMS FOR ROOM = WA76211							
236Z	WA90683	F266512	CENTRIFUGE	W15000	01/85	38,214	49,036
1 ITEMS FOR ROOM = WA90683							
236Z	WA90684	F266513	CENTRIFUGE	W15000	01/85	39,591	50,803
1 ITEMS FOR ROOM = WA90684							
236Z	WEST*1ST*FLR	FA25446	HOOD	W15000	06/64	168,651	863,071
1 ITEMS FOR ROOM = WEST*1ST*FLR							
236Z	1ST	WB34417	GENERATOR	W15000	07/87	8,210	9,928
236Z	1ST	WB44502	GENERATOR	W15000	01/88	6,620	7,921
236Z	1ST	WB44503	GENERATOR	W15000	01/88	6,621	7,922
	*					21,451	25,771
3 ITEMS FOR ROOM = 1ST							
236Z	10	FA25447	HOOD	W15000	06/64	7,863	40,239
236Z	10	FA25451	HOOD	W15000	06/64	7,557	38,673
	*					15,420	78,912
2 ITEMS FOR ROOM = 10							
236Z	19	F222000	LOADOUT FACILITY	W15000	06/64	24,438	125,061
236Z	19	WC13568	ANALYZER	W15000	07/91	16,508	18,514
236Z	19	WC14870	DETECTOR	W15000	01/91	13,046	14,631
236Z	19	WC29308	COMPUTER	W15000		4,150	
	*					58,142	158,206
4 ITEMS FOR ROOM = 19							
236Z	2ND FLOOR	F223679	MONITOR	W15000	02/67	7,888	35,738
1 ITEMS FOR ROOM = 2ND FLOOR							
236Z	20	FA25437	HOOD	W15000	06/64	7,557	38,673
236Z	20	FA25441	HOOD	W15000	06/64	7,558	38,678
	*					15,115	77,351
2 ITEMS FOR ROOM = 20							
236Z	27	FA25442	HOOD	W15000	06/64	30,948	158,376

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	1 ITEMS FOR ROOM = 27						
236Z	34	FA25436	MOTOR CONTROL CENTER	W15000	06/64	13,402	68,585
236Z	34	F269044	MOTOR CONTROL CENTER	W15000	12/93	49,891	51,782
	*					63,293	120,367
	2 ITEMS FOR ROOM = 34						
236Z	35	FA25432	MOTOR CONTROL CENTER	W15000	06/64	8,870	45,392
236Z	35	F262903	PUMP	W15000	12/83	29,487	38,156
236Z	35	F262904	PUMP	W15000	12/83	29,489	38,159
236Z	35	F263160	AIR SYSTEM	W15000	02/83	198,017	256,234
236Z	35	F269041	PUMP	W15000	12/93	24,781	25,720
236Z	35	F269042	PUMP	W15000	12/93	24,781	25,720
236Z	35	F269047	HEAT EXCHANGER	W15000	12/93	23,561	24,454
236Z	35	F269048	HEAT EXCHANGER	W15000	12/93	23,561	24,454
236Z	35	F269049	HEAT EXCHANGER	W15000	12/93	23,561	24,454
236Z	35	F269057	PIPING	W15000	12/93	1,273,087	1,321,337
236Z	35	F269059	POWER WIRING	W15000	12/93	302,838	314,316
	*					1,962,033	2,138,396
	11 ITEMS FOR ROOM = 35						
236Z	4TH	FA25784	MONITOR	W15000	03/87	28,414	34,361
	1 ITEMS FOR ROOM = 4TH						
236Z	4TH*FLOOR	F226494	CHEMICAL PREP EQUIP	W15000	06/64	111,854	572,413
	1 ITEMS FOR ROOM = 4TH*FLOOR						
236Z	40	F226234	CHEMICAL PREP EQUIP	W15000	06/64	8,766	44,860
	1 ITEMS FOR ROOM = 40						
236Z	41	FA25407	HOOD	W15000	04/65	83,933	414,545
236Z	41	FA25411	HOOD	W15000	06/64	13,946	71,369
236Z	41	FA25412	HOOD	W15000	06/64	15,945	81,599
236Z	41	FA25416	HOOD	W15000	06/64	35,844	183,432
236Z	41	FA25417	HOOD	W15000	10/68	40,845	170,087
236Z	41	FA25421	CENTRIFUGE	W15000	03/85	33,182	42,579
236Z	41	F255535	PUMP	W15000	09/73	43,270	117,063
236Z	41	WB34410	GENERATOR	W15000	07/87	8,211	9,930
	*					275,176	1,090,604
	8 ITEMS FOR ROOM = 41						

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
236Z	42	FA25422	HOOD	W15000	06/64	5,102	26,109
1 ITEMS FOR ROOM = 42							
236Z	44	FA25406	MOTOR CONTROL CENTER	W15000	06/64	7,990	40,889
236Z	44	F269054	CONTROL PANEL	W15000	12/93	110,933	115,137
	*					118,923	156,026
2 ITEMS FOR ROOM = 44							
236Z	44*PANL*A	F221927	ALARM UNIT	W15000	06/64	10,344	52,935
1 ITEMS FOR ROOM = 44*PANL*A							
236Z	45	F225503	ALARM SYSTEM	W15000	06/64	10,386	53,150
1 ITEMS FOR ROOM = 45							
236Z	5TH*FLR	FA25427	HOOD	W15000	06/64	7,558	38,678
1 ITEMS FOR ROOM = 5TH*FLR							
236Z	50	FA25426	HOOD	W15000	06/64	40,326	206,368
1 ITEMS FOR ROOM = 50							
236Z	60	FA25431	HOOD	W15000	06/64	6,978	35,710
236Z	60	WC40016	CAMCORDER	W15000		809	
	*					7,787	35,710
*						9,223,446	28,283,249
2 ITEMS FOR ROOM = 60							

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
241Z		F174396	TANK	W15000	06/50	56,011	291,913
241Z		F174708	PIT	W15000	06/50	83,924	437,387
241Z		F221762	GENERAL SYSTEM EQUIPMENT	W15000	11/90	200,000	230,380
241Z		F221763	DUCT	W15000	06/64	9,174	46,948
241Z		F223163	STATION	W15000	01/65	6,468	31,945
241Z		F257730	DETECTOR ASSEMBLY	W15000	03/75	8,464	19,565
241Z		F257888	PIPING	W15000	11/73	133,918	362,302
241Z		F257889	PUMP	W15000	11/73	25,569	69,174
241Z		F257890	AGITATOR	W15000	11/73	20,726	56,072
241Z		F257891	POWER WIRING	W15000	11/73	72,981	197,443
241Z		F257892	TANK	W15000	11/73	6,434	17,407
241Z		F262666	BUILDING INDUSTRIAL	W15000	02/81	93,522	134,204
241Z		F262670	FILTER HOUSING	W15000	02/81	199,696	286,564
241Z		F262672	HOIST	W15000	02/81	11,295	16,208
241Z		F262673	PIPING	W15000	02/81	256,679	368,334
241Z		F262674	PIPING	W15000	01/91	297,186	333,294
241Z		F263110	ALARM	W15000	12/82	36,048	49,793
241Z		F269100	PIPING	W15000	09/94	6,035,311	6,078,162
	*					7,553,406	9,027,095
	18 ITEMS FOR ROOM =						
241Z	CAUSTIC*STORAGE	F266644	PUMP	W15000	11/90	17,101	19,699
241Z	CAUSTIC*STORAGE	F266645	PUMP	W15000	11/90	11,464	13,205
	*					28,565	32,904
	2 ITEMS FOR ROOM = CAUSTIC*STORAGE						
241Z	UNDERGROUND	F174323	TANK	W15000	03/55	16,181	84,331
241Z	UNDERGROUND	F174381	TANK	W15000	06/50	28,692	149,534
241Z	UNDERGROUND	F174383	TANK	W15000	06/50	28,692	149,534
241Z	UNDERGROUND	F174385	TANK	W15000	06/50	28,691	149,529
241Z	UNDERGROUND	F174387	TANK	W15000	06/50	28,691	149,529
241Z	UNDERGROUND	F174388	TANK	W15000	06/50	29,642	154,485
	*					160,589	836,942
	6 ITEMS FOR ROOM = UNDERGROUND						
241Z	175*236	F262952	AGITATOR	W15000	06/82	15,268	21,090
*						7,757,828	9,918,031
	1 ITEMS FOR ROOM = 175*236						

< $250,000

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
242Z		F221624	BUILDING INDUSTRIAL	W15000	06/64	73,228	374,744
242Z		F226236	GLOVEBOX	W15000	05/65	120,484	595,070*
242Z		F226237	TANK	W15000	06/64	53,298	272,753
242Z		F226488	INSTRUMENTATION	W15000	06/64	51,123	261,622
242Z		F226490	DUCT	W15000	06/64	22,544	115,369
242Z		F226491	PIPING	W15000	06/64	260,284	1,332,003*
242Z		F226492	POWER WIRING	W15000	06/64	60,963	311,978
242Z		F226495	GENERAL SYSTEM EQUIPMENT	W15000	06/64	104,782	536,222*
242Z		F257101	SCALE	W15000	11/70	14,268	51,577
242Z		F257718	TANK	W15000	11/74	37,164	93,821
242Z		F257720	TANK	W15000	03/75	22,330	51,618
242Z		F258769	DETECTION SYSTEM	W15000	07/77	6,039	11,780
	*					826,507	4,008,557
	12 ITEMS FOR ROOM =						
242Z	ANNEX	WC32689	GENERATOR	W15000	03/92	13,167	14,377
242Z	ANNEX	WC32690	GENERATOR	W15000	03/92	13,167	14,377
	*					26,334	28,754
	2 ITEMS FOR ROOM = ANNEX						
242Z	308*SE*WALL	F221605	HOOD	W15000	06/64	9,538	48,811
*						862,379	4,086,122
	1 ITEMS FOR ROOM = 308*SE*WALL						

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
243Z		F269051	BUILDING	W15000	12/93	232,912	241,739
243Z		F269061	PIPING	W15000	12/93	2,024,162	2,100,878
243Z		F269062	POWER WIRING	W15000	12/93	440,227	456,912
	*					2,697,301	2,799,529
*						2,697,301	2,799,529

3 ITEMS FOR ROOM =

~ $500,000

DETAIL COST BREAKDOWN BY ROOM FOR LEA MCKINNIS

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
267Z	NORTH*2345	F266006	BUILDING SERVICE	W15000	06/88	6,240	7,466

1 ITEMS FOR ROOM = NORTH*2345

ILDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
:721Z		FA25405	CONTROL PANEL	W15000	10/83	120,195	155,532 *
:721Z		FA25410	GENERATOR	W15000	10/83	52,550	68,000 *
:721Z		FA25415	GENERATOR	W15000	10/83	52,550	68,000 *
:721Z		FA25420	GENERATOR	W15000	10/83	52,550	68,000 *
:721Z		F264550	BUILDING SERVICE	W15000	10/83	413,828	535,493
	*					691,673	895,025
	5 ITEMS FOR ROOM =						
:721Z	500	FA25789	CIRCUIT BREAKER	W15000	08/87	106,229	~~128,463~~ *
:						797,902	1,023,488
	1 ITEMS FOR ROOM = 500						

~$500,000

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2734Z		F175711	BUILDING STORAGE	W15000	08/49	34,197	178,225

1 ITEMS FOR ROOM =

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2735Z		F175712	STRUCTURE	W15000	04/55	11,740	61,185
2735Z		WA90753	PUMP	W15000	11/85	5,515	7,077
	*					17,255	68,262
	2 ITEMS FOR ROOM =						
2735Z	BEHIND*SLAB	FA22079	CABINET	W15000	12/92	11,446	12,498
*						28,701	80,760

1 ITEMS FOR ROOM = BEHIND*SLAB

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2736Z		F256107	BUILDING STORAGE	W15000	11/71	501,108	1,585,456
2736Z		F256111	INSTRUMENTATION	W15000	11/71	82,463	260,905
2736Z		F256112	ALARM EQUIPMENT	W15000	11/71	160,730	508,534
2736Z		F262621	TELEVISION SYSTEM	W15000	10/81	433,303	621,790
2736Z		F262799	ALARM SYSTEM	W15000	03/82	18,650	25,761
	*					1,196,254	3,002,446
	5 ITEMS FOR ROOM =						
2736Z	CORRIDOR	WB40788	COMPUTER	W8P000		1,860	
2736Z	CORRIDOR	WB57309	PRINTER	W8P000	09/80	6,000	9,318
	*					7,860	9,318
	2 ITEMS FOR ROOM = CORRIDOR						
2736Z	VAULT	F264322	SHELF MONITOR SYS	W8P000	06/81	6,874	9,864
	1 ITEMS FOR ROOM = VAULT						
2736Z	631	WC23177	COMPUTER	W33000		3,281	
*						1,214,269	3,021,628
	1 ITEMS FOR ROOM = 631						

~ $535,000

FRLPS-MCKINNIS

RL Property System
DETAIL COST BREAKDOWN BY ROOM FOR LEA MCKINNIS

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BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2736ZA		FA25435	GENERATOR	W15000	05/78	18,634	33,644
2736ZA		FA25440	FAN	W15000	05/78	6,572	11,866
2736ZA		FA25445	FAN	W15000	05/78	6,572	11,866
2736ZA		FA25450	FILTER HOUSING	W15000	05/78	55,185	99,637
2736ZA		FA25455	FILTER HOUSING	W15000	05/78	55,185	99,637
2736ZA		F262204	STRUCTURE	W15000	05/78	180,479	325,855
2736ZA		F262205	STACK	W15000	05/78	6,573	11,868
2736ZA		F262206	SAMPLER SYSTEM	W15000	05/78	27,865	50,310
2736ZA		F262211	GENERAL SYSTEM EQUIPMENT	W15000	05/78	194,971	352,020
2736ZA		F262213	SEISMIC CONTROL SYS	W15000	05/78	23,280	42,032
	*					575,316	1,038,735
#						575,316	1,038,735

10 ITEMS FOR ROOM =

IBLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
:2736ZB		FA25714	FAN	W15000		12,954	
:2736ZB		F256109	FIRE ALARM EQUIPMENT	W15000	11/71	37,085	117,333
:2736ZB		F263268	PUMP	W15000	12/83	6,121	7,921
:2736ZB		F264613	BUILDING STORAGE	W15000	10/83	4,782,372	6,188,389
:2736ZB		F264617	CLOSED CIRCUIT TV	W15000	10/83	132,114	170,956
:2736ZB		F264620	ALPHA MONITOR SYSTEM	W15000	07/84	47,238	61,079
:2736ZB		WC27937	COMPUTER	W15000		3,748	
:2736ZB		7504128	FORKLIFT	W15000	10/81	19,525	28,018
	*					5,041,157	6,573,696
	8 ITEMS FOR ROOM =						
:2736ZB	DOOR*475	FA25704	MONITOR	W15000	10/83	33,773	43,702
	1 ITEMS FOR ROOM = DOOR*475						
:2736ZB	LUNCHRM	WB29648	TELEVISION	W15000	08/86	950	1,186
:2736ZB	LUNCHRM	WB92672	PLAYER	W15000		480	
	*					1,430	1,186
	2 ITEMS FOR ROOM = LUNCHRM						
:2736ZB	OFFSITE	WC21551	COMPUTER	W15000		2,021	
	1 ITEMS FOR ROOM = OFFSITE						
:2736ZB	SOUTH	FA25425	AIR CONDITIONER	W15000	12/80	10,855	16,858
	1 ITEMS FOR ROOM = SOUTH						
:2736ZB	600	FA25381	FILTER HOUSING	W15000		0	
:2736ZB	600	FA25387	FAN	W15000		0	
:2736ZB	600	FA25388	FILTER HOUSING	W15000		0	
:2736ZB	600	FA25783	FAN	W15000	01/79	12,954	21,368
	*					12,954	21,368
	4 ITEMS FOR ROOM = 600						
:2736ZB	602	FA25377	COMPRESSOR	W15000	10/83	72,479	93,788
:2736ZB	602	FA25378	COMPRESSOR	W15000	10/83	72,479	93,788
:2736ZB	602	FA25382	CONDITIONER	W15000	12/78	6,564	11,851
	*					151,522	199,427
	3 ITEMS FOR ROOM = 602						
:2736ZB	603	WB36466	COMPUTER	W15000		1,560	

ILDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
7736ZB	603	WB53143	CALCULATOR	W15000	01/76	676	1,432
7736ZB	603	WC22072	COMPUTER	W15000		1,591	
	*					3,827	1,432
	3 ITEMS FOR ROOM = 603						
7736ZB	604	WB31836	TAPE DRIVE	W8P000	05/87	52,043	62,936
7736ZB	604	WB31881	DISK DRIVE	W8P000	05/87	56,688	68,553
7736ZB	604	WB40774	COMPUTER	W8P000	01/88	3,545	4,242
	*					112,276	135,731
	3 ITEMS FOR ROOM = 604						
7736ZB	605	WB92143	COMPUTER	W15000		1,610	
	1 ITEMS FOR ROOM = 605						
7736ZB	606	WC32281	COMPUTER	W15000		1,591	
	1 ITEMS FOR ROOM = 606						
7736ZB	607	WB82994	COMPUTER	W15000		1,646	
7736ZB	607	WC28088	FACSIMILE	W15000		1,069	
	*					2,715	
	2 ITEMS FOR ROOM = 607						
7736ZB	610	WC40697	COMPUTER	W15000		2,516	
	1 ITEMS FOR ROOM = 610						
7736ZB	611	WC04388	COMPUTER	W15000		1,510	
7736ZB	611	WC19732	COMPUTER	W15000		1,827	
	*					3,337	
	2 ITEMS FOR ROOM = 611						
7736ZB	629	WB91387	METAL DETECTOR	W8P000	08/89	4,137	0
	1 ITEMS FOR ROOM = 629						
7736ZB	632	WB26681	COUNTER	W15000	12/78	48,582	87,715
7736ZB	632	WB53103	COUNTER	W15000	02/78	5,800	10,472
	*					54,382	98,187

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
	2 ITEMS FOR ROOM = 632						
2736ZB	634	WC23351	COMPUTER	W15000		1,827	
	1 ITEMS FOR ROOM = 634						
2736ZB	635	WC19307	COMPUTER	W15000		1,027	
2736ZB	635	WC22055	COMPUTER	W15000		1,591	
	*					2,618	
	2 ITEMS FOR ROOM = 635						
2736ZB	636	FA25699	GLOVEBOX	W15000	10/83	220,504	285,332
2736ZB	636	WB34404	GENERATOR	W15000	07/87	8,211	9,930
	*					228,715	295,262
	2 ITEMS FOR ROOM = 636						
2736ZB	637	FA25716	CALORIMETER SYSTEM	W15000	06/80	280,001	434,842
2736ZB	637	F266501	CALORIMETER SYSTEM	W15000	09/73	31,439	85,055
2736ZB	637	WB10682	ANALYZER	W15000	09/84	10,038	12,979
2736ZB	637	WB10698	ANALYZER	W15000	09/84	10,038	12,979
2736ZB	637	WB26658	ANALYZER	W15000	09/84	7,054	9,121
2736ZB	637	WB26659	ANALYZER	W15000	09/84	7,054	9,121
2736ZB	637	WB26663	ANALYZER	W15000	09/84	7,054	9,121
2736ZB	637	WB26664	ANALYZER	W15000	09/84	7,053	9,120
2736ZB	637	WB26672	POWER CONDITIONER	W15000	09/87	11,616	14,047
2736ZB	637	WB26716	ANALYZER	W15000	09/86	7,990	9,974
2736ZB	637	WB28078	COMPUTER	W15000	02/87	31,614	38,231
2736ZB	637	WB28079	PRINTER	W15000	02/87	31,613	38,230
2736ZB	637	WB28080	DISK SUBSYSTEM	W15000	09/86	22,239	27,761
2736ZB	637	WB31687	PRINTER	W15000	09/87	15,992	19,339
2736ZB	637	WB34303	SCAN GAMMA RAY ASSAY	W15000	01/77	127,195	248,107
2736ZB	637	WB34432	DETECTOR	W15000	12/87	8,776	10,613
2736ZB	637	WB39285	DETECTOR	W15000	08/86	11,650	14,543
2736ZB	637	WB39287	DETECTOR	W15000	08/86	11,650	14,543
2736ZB	637	WB39288	DETECTOR	W15000	08/86	11,650	14,543
2736ZB	637	WB39289	DETECTOR	W15000	08/86	11,650	14,543
2736ZB	637	WB39290	CALORIMETER	W15000	07/89	199,019	233,031
2736ZB	637	WB53108	CALORIMETER	W15000	11/72	16,293	46,999
2736ZB	637	WB55918	PRINTER	W15000	02/88	8,555	10,236
2736ZB	637	WB71464	DETECTOR	W15000	12/88	10,500	12,563
2736ZB	637	WB72395	CALORIMETER SYSTEM	W15000	07/89	7,000	8,196
2736ZB	637	WB83816	DETECTOR	W15000	02/89	9,938	11,636
2736ZB	637	WC02224	COMPUTER	W15000		2,232	
2736ZB	637	WC02227	COMPUTER	W15000		2,232	
2736ZB	637	WC02473	DETECTOR	W15000	09/84	8,137	10,521
2736ZB	637	WC11499	DETECTOR	W15000	06/91	8,823	9,895

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
2736ZB	637	WC11505	DETECTOR	W15000	09/91	30,684	34,412
2736ZB	637	WC13573	ANALYZER	W15000	02/91	16,509	18,515
2736ZB	637	WC13578	ANALYZER	W15000	02/91	16,509	18,515
2736ZB	637	WC31193	COMPUTER	W15000		3,956	
2736ZB	637	WC31194	COMPUTER	W15000		3,956	
2736ZB	637	WC38650	DETECTOR	W15000	12/90	9,091	10,472
2736ZB	637	WC46552	COMPUTER	W15000		2,158	
	*					1,018,958	1,471,803
37 ITEMS FOR ROOM = 637							
2736ZB	638	FA25709	PANEL	W15000	05/85	59,241	76,018
2736ZB	638	F264915	GENERATOR	W15000	05/85	49,727	63,810
	*					108,968	139,828
2 ITEMS FOR ROOM = 638							
2736ZB	640	WC26382	ANALYZER	W15000	06/91	7,500	0
1 ITEMS FOR ROOM = 640							
2736ZB	641	F264916	GENERATOR	W15000	05/85	49,727	63,810
2736ZB	641	WB57308	COMPUTER	W8P000	05/87	75,556	91,370
2736ZB	641	WB57312	MULTIPLEXER CABINET	W8P000	05/87	21,648	26,179
2736ZB	641	WB57313	MULTIPLEXER CABINET	W8P000	05/87	23,182	28,034
	*					170,113	209,393
4 ITEMS FOR ROOM = 641							
2736ZB	642	F264917	GENERATOR	W15000	05/85	49,727	63,810
						7,028,539	9,271,683
1 ITEMS FOR ROOM = 642							

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST
291Z		FA22055	FAN	W15000	10/90	13,781	15,874
291Z		FA25495	FAN	W15000	06/50	5,504	28,685
291Z		FA25603	FAN	W15000	06/50	7,527	39,228
291Z		FA25604	FAN	W15000	06/50	6,024	31,395
291Z		FA25608	FAN	W15000	06/50	7,526	39,223
291Z		FA25609	FAN	W15000	06/50	6,023	31,390
291Z		FA25613	FAN	W15000	06/50	13,291	69,269
291Z		FA25614	FAN	W15000	06/50	6,023	31,390
291Z		FA25618	DRYER	W15000	04/84	8,598	11,117
291Z		FA25623	TRANSFORMER	W54000	08/49	18,723	97,579 *
291Z		FA25624	TRANSFORMER	W54000	08/49	17,434	90,861 *
291Z		FA25629	FAN	W15000	06/50	5,504	28,685
291Z		FA25673	PUMP	W15000	01/83	55,127	71,334 *
291Z		FA25678	PUMP	W15000	01/83	55,126	71,333 *
291Z		FA25683	COMPRESSOR	W15000	01/63	9,284	48,385 *
291Z		FA25693	MOTOR CONTROL CENTER	W15000	06/50	7,078	36,888
291Z		FA25694	MOTOR CONTROL CENTER	W15000	06/50	8,754	45,623
291Z		F174688	BUILDING INDUSTRIAL	W15000	06/50	174,318	908,493
291Z		F174699	STACK	W15000	06/52	137,733	717,823
291Z		F226468	INSTRUMENTATION	W15000	06/50	7,292	38,004 *
291Z		F262019	PUMP	W15000	03/79	35,093	57,886 *
291Z		F263164	INTERCOMMUNICATION EQUIP	W15000	03/83	50,424	65,249
291Z		F264421	POWER WIRING	W15000	10/83	809,351	1,047,300
291Z		F266010	PUMP	W15000	09/87	13,202	15,965 *
291Z		F268561	PIPING	W15000	09/93	981,197	1,018,384
291Z		I304459	COMPRESSOR	W15000	05/84	29,400	38,014 ▲
	*					2,489,337	4,695,377
	26 ITEMS FOR ROOM =						
291Z	INSTSHP	WC38648	POWER CONTROL UNIT	W15000	05/91	11,242	12,608
	1 ITEMS FOR ROOM = INSTSHP						
291Z	STACK	F171247	BUILDING INDUSTRIAL	W15000	01/57	16,409	85,519
	1 ITEMS FOR ROOM = STACK						
291Z	500	FA25790	SWITCHGEAR	W15000	08/87	251,879	304,597
291Z	500	WB29411	TEST SET	W15000	06/75	13,305	30,756
	*					265,184	335,353
*						2,782,172	5,128,857
	2 ITEMS FOR ROOM = 500						
						83,814,425	232,663,444

~$530,000

BLDG	ROOM	PROPERTY NUMBER	PRNAME	CUST ORG CODE	IN SERV DATE	PM TOTMEM COST	REPLACE COST

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APPENDIX F

Plutonium Finishing Plant 94-1 Glovebox Cost/Risk Analysis

Revision 1

Prepared for

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P.O. Box 1200
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July 22, 1996
Revised February 5, 1997

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FIGURES

TABLES

Plutonium Finishing Plant 94-1 Glovebox Cost/Risk Analysis

F1.0 INTRODUCTION

F1.1 Background

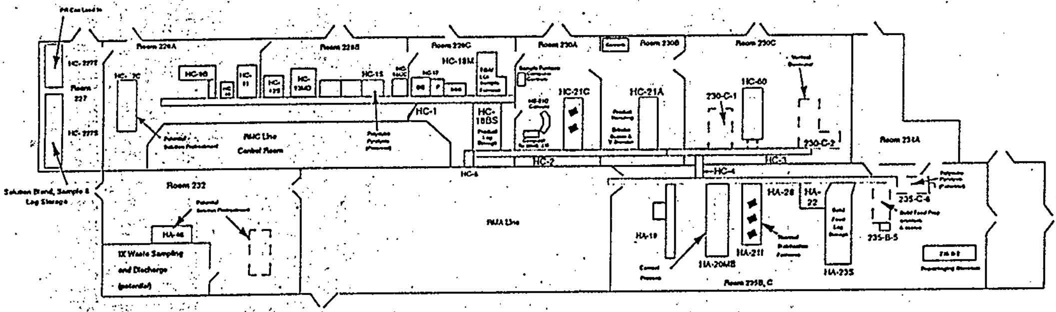
As part of the Fire Hazard Analysis (FHA), an analysis was conducted to determine the level of fire protection needed to limit a glovebox fire to within the glovebox of fire origin. This objective was developed in accordance with the perceived intent of the Department of Energy (DOE) Draft Glovebox Standard [WHC, 1993], which is mandated by DOE RLID 5480.7, Fire Protection, and based on Westinghouse Hanford Company (WHC) fire protection staff input. Developments since the writing of the FHA indicate that the costs associated with providing the recommended level of fire protection in the FHA may not be justified based on the established life of the facility and acceptable loss limitations for specific glovebox operations. As a result, alternative protection options have been investigated with the goal of providing a more cost effective solution while maintaining an acceptable level of risk and safety.

This analysis was developed under contract with WHC and has been accepted by B&W Hanford Company (BWHC). Reference to WHC personnel is found throughout this analysis because interviews were performed while personnel were employed by WHC. Personnel are now employed under the Project Hanford Management Contractor by various contractors throughout the site.

F1.2 Scope and Objectives

A risk analysis was performed for the 94-1 Process Line gloveboxes in the Plutonium Finishing Plant (PFP) Building 234-5Z at the DOE Hanford site. Figure F1 depicts the general layout of the 94-1 glovebox Process area. The objective of this analysis was to identify alternative fire protection options for the individual 94-1 gloveboxes in lieu of those proposed in the FHA. In addition, the fire spread and contamination hazards associated with each protection option are identified. Probability factors are used in order to evaluate the relative risk between the different protection strategies.

For the 94-1 Process line, there are five gloveboxes which do not currently comply with the recommended FHA protection criteria. These gloveboxes include HC-3, HC-4, HA-28, HA-22, and HA-23S. Whereas much of this analysis is focused on these specific gloveboxes, several of the protection strategies developed require modifications to other parts of the process line as well. Likewise, when evaluating the damage potential for the gloveboxes, the entire process line is evaluated based on the existing level of protection and glovebox configurations.



Solids: Thermal Stabilization Processing

Feed introduced into 235-B-5
- through airlock or can sphincter port
- Open cans, weigh, and charge makeup

Lag Storage in HA-23S (feed)
Furnace operations in HC-21C and HA-211
- control consoles in Room 230A

Product Handling in HC-21A
- weigh, sample, sealout, can, move to vaults
- lag storage rack for 8 items

Sample Analysis in Product Lag Storage HC-18M (TGA/LOI)

Liquids: Pretreat (if reqd), Vertical Denitrator Calciner

Feed from PR Cans in HC-227T to HC-227S
Blend, sample store in HC-227S
Transfer good feed directly to vertical denitrator via encased transfer line.
Transfer pretreatment feed to HC-7C for ion exchange (IX) with IX waste transferred to HA-46 (room 232) for sampling and disposal. IX clean product is transferred back to HC-227S for blending and sampling.
Powder from vertical denitrator transferred to 235-B-5, thermally stabilized

Figure F1. Layout of 94-1 Glovebox Process Area

This analysis extends beyond the scope of the FHA in that it considers the existing automatic and manual fire suppression/detection systems, and administrative and operational controls to determine the potential glovebox fire loss. In addition, protection strategies which require BWHC to accept an increased risk beyond that evaluated in the FHA are presented. Based on an acceptable loss limitation and associated level of risk, a feasible and cost effective fire protection strategy can be selected and implemented.

F1.3 Life Safety Considerations

The alternative fire protection strategies developed in this study comply with NFPA 101, *Life Safety Code* [1994 ed.]. The 94-1 Process area is equipped with an automatic sprinkler system and has adequate means of egress for personnel. Because the options identified add protection measures, implementing any of the protection strategies presented in Section 8 will not increase the level of risk or safety to PFP personnel relative to the existing level of protection provided in the 94-1 Process area.

F1.4 Glovebox Fire Protection at Other DOE Sites

The level of protection at other DOE sites varies considerably. There is no one standard which the DOE sites follow regarding glovebox fire protection. The specifics of gloveboxes (e.g., construction, configuration, shielding materials) are different from site to site and often require different levels of protection. The protection provided at other sites does not justify or nullify the level of protection provided at Hanford for the 94-1 gloveboxes. This section is simply intended to identify the different approaches used to protect gloveboxes within the DOE system.

During the investigation of various fire protection options for the 94-1 gloveboxes, other DOE sites were contacted in order to determine the level of protection currently provided in gloveboxes at those sites. The DOE sites contacted include the Rocky Flats Plant, Savannah River, and Lawrence Livermore National Laboratories.

Gloveboxes at the Rocky Flats Plant are required per Rocky Flats policy to have UL approved heat detectors [Campbell, 1996]. Where gloveboxes are connected in process lines, automatic fire dampers are installed within conveyor gloveboxes; however, there are no specific criteria regarding number and location of the dampers. In general, automatic suppression systems are not used in the gloveboxes unless high hazard operations are conducted. With the exception of furnace oxidation processes, gloveboxes containing pyrophoric and/or combustible metals are provided with an inert gas purging system. Rocky Flats fire protection staff indicated that the existing level of glovebox protection has been adequate in the past (since changes made after the 1969 fire) and is not of particular concern.

At the Savannah River site, glovebox fire protection has been primarily handled on a case by case basis. Depending on the use of the particular glovebox, different levels of protection are provided. Glovebox protection features include Halon, automatic suppression (Halon), and automatic heat detectors (no Halon alternative agents are in use) [Wheeler, 1997]. The WSRC

Fire Protection Program manual (2Q) lists the following as mandatory criteria for new or modified glovebox use:

- DOE 6430.1A, *General Design Criteria,*
- NFPA 801, *Facilities Handling Radioactive Materials,*
- NFPA 90A, *Installation of Air Conditioning and Ventilation Systems,* and
- NFPA 91, *Installation of Exhaust Systems for Air Conveying of Materials.*

The same manual lists the following documents as additional criteria:

- DOE *Glovebox Fire Protection Criteria,* DRAFT Rev. 1 (March, 1992),
- DOE-STD-XXXX-95, *Glovebox Fire Protection,*
- FM Loss Prevention Data Sheet 7-61, *Radioactive Materials,*
- WSRC-IM-92-60, *Appendix to WSRC 2Q,* and
- Procedure Manual 2Q, Section 6.0, subsection, "Containment/Confinement of Hazardous Materials."

Manual WSRC-IM-92-60 contains an appendix which provides for the design and operation of gloveboxes. This practice requires compliance with the following:

- WSRC 2Q,
- DOE Fire Protection Resource Manual, *Glovebox Fire Protection Criteria,*
- NFPA 801, *Facilities Handling Radioactive Materials,* and
- NFPA 90A, *Installation of Air Conditioning and Ventilation Systems.*

The appendix to Manual WSRC-IM-92-60 specifies several construction and administrative requirements that management must ensure, such as (1) all gloveboxes and windows are constructed of non-combustible or fire retardant material in accordance with the DOE requirement, and (2) fire detectors are required and must be of the rate compensation type and shall be UL listed/FM approved.

Lawrence Livermore National Laboratories is currently investigating alternative glovebox fire protection strategies [Ray Tell, 1996]. The gloveboxes are currently equipped with heat detectors. The fire protection staff indicated that with the changing mission and use of the gloveboxes, more appropriate protection features are being evaluated.

F2.0 APPROACH

The approach for the development of this study included several tasks. During the development of the FHA [Hughes Associates, Inc., 1996], several site visits were conducted to document the buildings, processes, and fire protection features as well as to obtain general site information. The site visits included a walkdown of the 94-1 Glovebox Process areas, discussions with fire protection and facility personnel, and review of drawings and site plans/documents.

Based on the layout of the existing 94-1 Glovebox Process line, different levels of potential fire loss were developed ranging from loss of a single glovebox to fire spread through the entire process line. Next, a general list of protection options which could potentially reduce the risk of fire spread and damage was developed. Based on input from PFP facility staff, the list of options was refined based on cost, ease of installation, and life expectancy of the process. From the list of feasible protection options, specific fire protection strategies were developed for the 94-1 gloveboxes.

Based on the limited available test data and sound engineering judgement, the relative risk for each of the protection strategies was determined. The relative risk is compared to the level of protection recommended in the FHA for the 94-1 gloveboxes and to the level of protection currently provided. The results of the analysis are presented in a manner such that the potential monetary loss versus the relative probability of achieving such a loss is identified for each of the protection strategies.

F3.0 ASSUMPTIONS AND LIMITATIONS

The results of this study are based on a number of factors. Several site surveys were conducted while developing the Fire Hazard Analysis [Hughes Associates, Inc., 1996] in which information was gathered regarding fuel load, facility operations, suppression/detection systems, and construction features. Additional site drawings, plans, and documents were provided by WHC facility staff and the fire department. It is assumed that the information provided by WHC is accurate. The results presented in this study should not be applied to other "apparently" similar problems without careful review and consideration of the assumptions and procedures documented in this report.

The probabilities presented in this report represent a relative ranking scale among the fire protection strategies discussed. The values are based on the limited available test data and engineering judgement. The probabilities are derived from the analysis presented which reflects the knowledge and experience of Hughes Associates, Inc. The analysis is based in part on the following assumptions:

- The combustible plastic windows in the gloveboxes (i.e., acrylic and/or lexan) provide a means for fire propagation between connected gloveboxes;
- Any fire in a glovebox is assumed to be of sufficient size such that, if left unattended (even if an operator moves materials other than the windows away), the fire will grow to involve the glovebox and subsequently spread to adjacent gloveboxes;
- All gloveboxes, with the exception of HC-3 and HC-4, are equipped with automatic heat detectors [McKinnis, 1996];

- The airlock between gloveboxes HC-2 and HC-3 will be maintained closed in order to maintain the appropriate concentrations for the Halon extinguishing system protecting the eastern portion of the RMC line gloveboxes [McKinnis, 1996];

- Any operational airlocks will prevent fire spread between the gloveboxes;

- Any operational airlocks will prevent airflow between the gloveboxes;

- Automatic sprinkler protection in the gloveboxes is not a feasible option due to criticality concerns [Glover, 1996];

- During operating hours, the process area will be manned by glovebox operators [McKinnis, 1996];

- Glovebox operators will receive hands-on portable fire extinguisher training. They will be educated to recognize the size of the fire capable of being extinguished by a 20 pound ABC dry chemical fire extinguisher. Operators will also be trained in the specific emergency actions to be taken in response to a glovebox fire;

- There are currently no quick-connect couplings installed on any of the 94-1 gloveboxes for fire portable fire extinguishers [McKinnis, 1996];

- The fire department will respond to a fire in the 94-1 Process area within 5-7 minutes following an alarm call [Jordan, 1996];

- The fire department will respond to a fire in the 94-1 Process area using portable type extinguishers. Hose lines will remain outside the building pressure zone unless necessary to contain the fire to the room of origin [Jordan, 1996]. Hose stations are available inside the building for manual fire fighting water; and

- The room automatic suppression system will function as designed (except for the maximum possible fire loss scenario).

F4.0 94-1 GLOVEBOX PROCESS AREA MAXIMUM POSSIBLE FIRE LOSS

The maximum possible fire spread and contamination for a fire in the 94-1 Glovebox Process area was evaluated in the Fire Hazard Analysis (FHA) for PFP [Hughes Associates, Inc., 1996]. Figure F2 shows the maximum area of fire involvement. Contamination for the Maximum Possible Fire Loss (MPFL) scenario was assumed to spread throughout the entire building. The analysis in the FHA assumed failure of the automatic suppression systems in the gloveboxes and building. The MPFL scenario also did not account for manual response by facility staff or the fire department. The purpose of the MPFL scenario was to determine the maximum possible damage resulting from a fire in the 94-1 Process area under worst-case

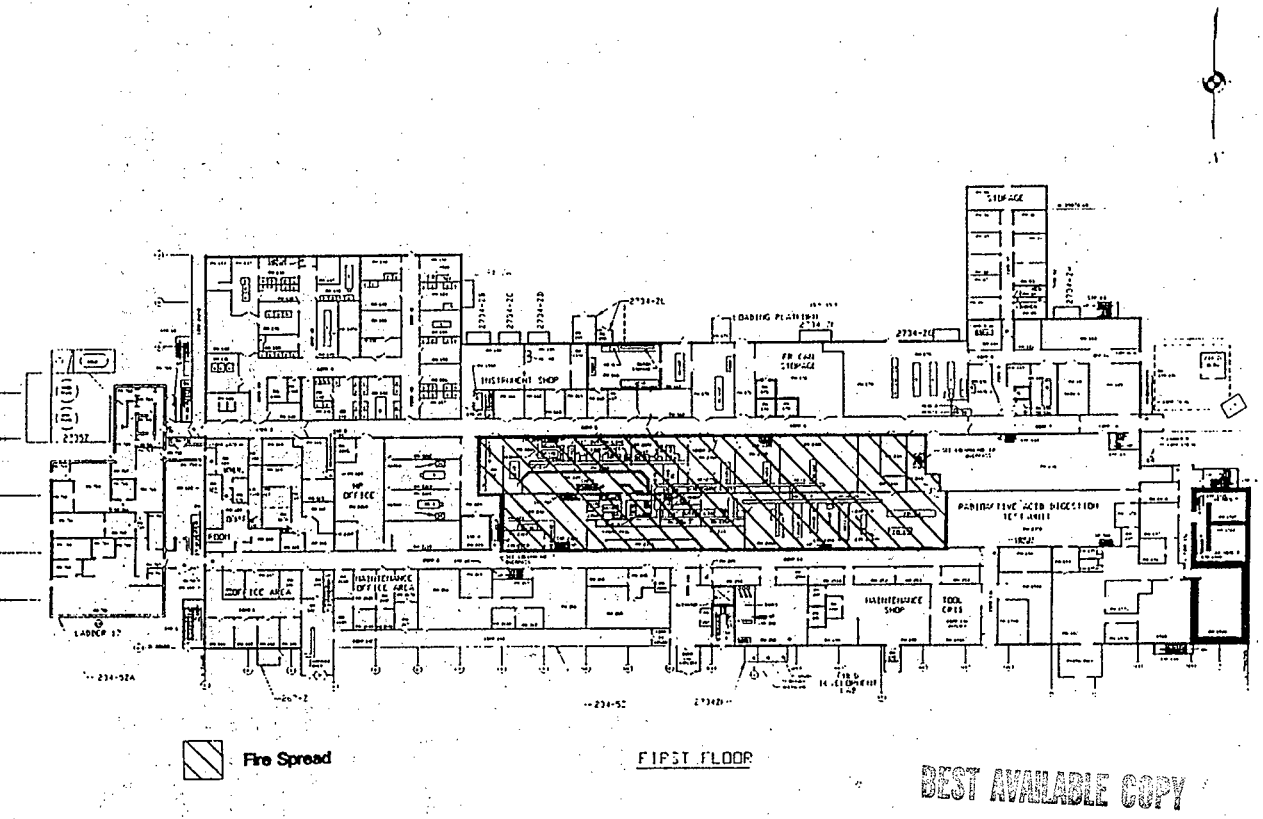


Figure F2. Maximum Fire Spread for 94-1 Process Area Fire Scenario

conditions. Although the present analysis takes credit for automatic and manual fire suppression/detection features, and administrative/operational controls, the MPFL determined in the FHA serves as an upper bound with respect to fire spread and contamination.

Therefore, the MPFL for a fire in the 94-1 Process area is bounded by approximately $14 million [Hughes Associates, Inc., 1996]. This estimate includes loss of contents in the fire area (see Figure F2) and contamination cleanup of the entire building.

F5.0 FIRE AND CONTAMINATION SPREAD

The potential for fire spread and contamination spread has been discussed in the PFP Fire Hazard Analysis [Hughes Associates, Inc., 1996] primarily in terms of worst-case conditions. However, the worst-case analysis does not take credit for many factors that may greatly reduce the probability of fire and contamination spread outside of the glovebox on fire. In order to evaluate alternative fire protection options for the 94-1 gloveboxes, factors, such as automatic and manual fire suppression and detection, must be evaluated. This section discusses the factors that impact fire and contamination spread. Based on these considerations and the physics of the problem, four different levels of fire and contamination spread are identified.

F5.1 Fuel Loading

In general, the combustible fuel load in PFP gloveboxes is low. The acrylic window panels and Hypalon gloves are the primary combustible fuels in the gloveboxes. These items are particularly important because they also provide containment for the gloveboxes. However, neither the plastic windows nor gloves are expected to be the first fuel ignited. Rather, a fire within the glovebox will likely first involve transient combustibles or other fuels associated with the glovebox process. A fire involving these fuels may then ignite the gloves or window panels, resulting in a more serious fire and potential loss of containment.

Of the gloveboxes of interest (i.e., HC-3, HC-4, HA-28, HA-22, and HA-23S), one is inactive (HA-22), three contain conveyors (HC-3, HC-4, and HA-28), and one is used for storage only (HA-23S). Glovebox HA-22 is a small glovebox connected to HA-28. Since it is inactive, HA-22 will not contain combustible materials (other than windows and/or gloves) and will not be used during the 94-1 Process. Therefore, the fire hazard in HA-22 is considered to be low.

Gloveboxes HC-3, HC-4, and HA-28 will be used to transport stainless steel containers (boats) of the pre- and post-processed materials. Additional items that will be transported from time to time will include packages of waste (plastic, rags, paper, or cardboard), tools, equipment, and cans of cement. Criticality Prevention Specifications (CPS-Z-162-80031) limit material to one item at a time being transported in conveyor HC-4 and HA-28. Criticality Prevention Specifications (CPS-Z-162-80170) spacing limitation requires at least six feet between material transported in conveyor HC-3 which allows up to four items to be transported at any one time. Glovebox HA-23S has the highest probability of being the source of a fire because of fuel load and potential ignition sources. This glovebox will store up to 178, one-half liter polyjar

containers filled with lag materials. In addition, HA-23S contains a hydraulic oil filled lift. Although the hydraulic oils used in the PFP gloveboxes are Factory Mutual (FM) approved fire resistant oils (i.e., oils having a high flash point) [TWRS Industrial Safety and Fire Protection, 1995], they still pose an added fuel load. The most likely ignition source of a fire would be a mechanically or electrically overheated component, although pyrophoric materials could also potentially be a source.

F5.2 Window Panel Fire Hazards

Most of the window panels on the gloveboxes are constructed of acrylic plastic (i.e., polymethylmethacrylate or PMMA) and/or polycarbonate. PMMA ignites when exposed to small fires and results in the release of energy and fire spread. The fire performance of polycarbonate is better than that of PMMA (i.e., harder to ignite and lower rate of heat release). However, polycarbonate window panels still represent a fuel load in the gloveboxes.

Many of the PMMA panels extend the length and height of the gloveboxes along several sections. In a vertical configuration, such as the window panels, once the PMMA is ignited, it can sustain and propagate a flame without any external heating. Therefore, if a window panel is ignited, the fire can potentially spread from one glovebox to the next without intervention. In addition, if the PMMA is allowed to burn long enough, the window panel will burn through to the exterior or melt and deform away from the glovebox frame. In either case, the glovebox containment is compromised leading to potential fire spread and contamination of the room.

Because PMMA is inherently a fire hazard, it is necessary to either avoid igniting the PMMA window panels or control the fire before significant damage occurs. Experimental fire test results indicate that PMMA ignites at low incident heat fluxes and burns with a relatively high rate of heat release [Hughes Associates, Inc., 1996]. PMMA will ignite at incident heat fluxes as low as 15 kW/m^2. This flux is produced by small fires impinging upon a PMMA panel. For example, fire tests involving 4 ft by 8 ft sheets of PMMA [Omega Point Laboratories, 1993] mounted in a vertical configuration show that an 18 kW fire can ignite the PMMA sheet in less than two minutes, and once ignited, the PMMA will self propagate the flame. An 18 kW fire is approximately equal to a small pile of burning paper (or several rags) or an 8 in. diameter oil spill fire. Based on this data it can be concluded that a fire involving the typical combustibles found in a glovebox is capable of igniting a PMMA panel. Using polycarbonate would make it more difficult to ignite the window panel but still would not negate the possibility of burn through and loss of containment.

There have been several experimental studies investigating the performance of various glovebox designs under fire conditions [Peatross, 1992; Williams, 1970; Domning, 1970; Domning and Woodward, 1970]. These glovebox fire tests consistently showed that acrylic windows burn through or melt and deform away from the glovebox frame during a fire. Polycarbonate windows tended to melt and deform but did not burn as readily as the PMMA. It was observed in several of the tests that once the glovebox was breached due to burn through or deformation of the window, the intensity of the fire would typically increase due to the additional air supply. Where Pyrex, safety glass, and wired glass were used, the windows

typically cracked but remained in place during the test fires. Only when the glass remained in place was the glovebox integrity maintained.

In general, tests indicate that when noncombustible window panels are used, glovebox fires typically burn themselves out without serious incident. However, where combustible plastic windows are used, containment is almost always lost and the window panels usually contribute to the fuel load resulting in a more serious fire.

The experimental data discussed above demonstrates that PMMA glovebox panels present a fire hazard. It has also been shown that combustibles typically found in gloveboxes are sufficient to ignite acrylic window panels. Polycarbonate windows provide some resistance to ignition and have a lower rate of energy release than PMMA under fire conditions. However, for a glovebox fire, polycarbonate windows can ignite and burn, potentially resulting in loss of containment. Therefore, for the subject process lines which contain plastic windows (primarily believed to be PMMA), a glovebox fire has the potential to propagate throughout the whole line if not suppressed or interrupted by a fire barrier.

F5.3 Automatic Fire Suppression

Controlling a fire before significant damage occurs can be achieved by an automatic fire suppression system. Currently there are three different types of existing automatic fire suppression systems used in PFP gloveboxes:

1. Total flooding Halon systems,
2. Dry chemical systems, and
3. Limited water bottle stations (LWBS).

All of these systems are used in the 94-1 Stabilization process line. The gloveboxes along the HC-1 and HC-2 conveyors are currently protected by a total flooding Halon system. Airlocks and dampers are provided to allow the containment needed to maintain the required Halon concentration in the protected gloveboxes. Due to the Halon system and the physical fire barrier provided by the airlock, the gloveboxes along the HC-1 and HC-2 conveyors are considered fully isolated from the gloveboxes in Room 230C, 235B and 235C. A fire is not expected to propagate between gloveboxes HC-2 and HC-3.

Glovebox HC-60 is the only box to have a LWBS. All other active gloveboxes on the 94-1 process line currently have, or will have, automatic suppression systems installed. It is expected that a glovebox with an automatic suppression system will extinguish a fire and limit the fire spread to within the box. Although the potential may exist for fire spread to other boxes before suppression activation, the impact to this analysis is inconsequential. As a matter of fact, the automatic suppression systems do not ultimately impact the extent of damage in the glovebox line for a fire that starts in an unprotected glovebox. For example, consider a fire that is spreading within HA-28 which is connected to the protected glovebox HA-21I. Since the suppression system in HA-21I (and all other boxes) is a fixed supply system, it will eventually leave the box unprotected as the suppression agent is exhausted. Therefore, no matter when the

system discharges, the fire may potentially be able to spread to HA-21I, despite any partial or temporary extinguishment of the fire. In conclusion, gloveboxes with automatic fire suppression systems are not expected to be the source of multi-glovebox fires, but fire spread to these boxes is possible despite the suppression systems.

F5.4 Fire Detection

Fenwal (trademark of Kidde-Fenwal, Inc) series 17000 thermoswitch temperature controllers are used as fire heat detectors in all gloveboxes except HC-3 and HC-4, which do not have any fire detection. These detectors are wired to control panels located in corridor 14A (outside of pressure Zone 3) and Room 320 located one floor above the process line. Room 320 is manned 24 hours a day. The fire control panel is also monitored by the fire department. The system is configured to initiate a building wide fire alarm when the temperature in a glovebox exceeds a preset threshold limit of 74°C (165°F). The alarm sounded will be a general fire alarm with no distinction of where or what type of fire initiated the alarm. However, personnel are able to determine the location of the fire to within several gloveboxes via the control panels since the panels designate the fire zone(s) in which the heat detectors have alarmed. Although personnel could respond to a fire upon hearing an alarm, the assumed response (which is standard procedure) is that all personnel in the building would evacuate the building.

Besides the time required for personnel to hear the fire alarm and determine which detector(s) have alarmed, there is also some lag time between the temperature in the glovebox and the temperature of the activating detector. Issues such as fire intensity, size of the glovebox, location of the activating device, and ventilation flow rates will all affect the response time of a heat detector with a preset alarm temperature. The response time of the detector is a critical factor in assessing the extent of damage that a fire may cause. For example, an extended delay time can result in a fire that is too large to extinguish with a hand held extinguisher. Consequently, the probability of limiting fire spread to one or two gloveboxes can be greatly increased for gloveboxes with detectors set to lower temperature alarm values. It also follows that fires within gloveboxes with no detectors have a much greater probability of resulting in widespread damage. Based on the likely ignition scenarios, the fire is assumed to start at a fixed location in a glovebox, such as a window.

An analysis using DETACT-QS, as included in FPETOOL [Nelson, 1990], was conducted to estimate the response time of the heat detectors in the gloveboxes and to estimate the potential size of the fire at the time of detection. DETACT solves heat transfer equations between the ceiling jet or plume and the heat sensitive activating device. The input parameters include the height and radial distance of the heat sensitive element above the fire, the actuation temperature and response time index (RTI) of the element, and the heat release rate of the fire.

DETACT-QS assumes that the ceiling is unconfined (i.e., extends infinitely in all directions), which is ideal for large rooms. For smaller compartments, such as a glovebox, this will result in longer than actual predicted actuation times since the heat transfer from the descending hot gas layer is not included. Other factors such as ventilation airflows and heat sinks within the glovebox (e.g., metal structures) can also affect the response time of a detector. The

typical flow rate of air through a 94-1 glovebox is approximately 0.017 m^3/s (35 cfm) [Dick, 1996]. This flow rate is expected to have little affect on the response of the heat detectors. Heat sinks within the glovebox may increase the actual detector response time compared to that predicted by DETACT. Considering these limitations to the model, conservative assumptions are made where appropriate to provide nominal detector response times to glovebox fires.

Table F5.1 shows the DETACT-QS results for a fire in various gloveboxes, assuming different detector actuation temperatures. The heat release rate of the fire is assumed to be a quadratic function of time with a moderate growth rate [NFPA 72, 1996]. The fire size is given as:

$$\dot{Q} = 0.012\, t^2 \quad [kW,s] \tag{F-1}$$

where Q is the heat release rate of the fire (kW), and
t is time (s).

Table F5.1 Detection Time and Fire Size for Various Gloveboxes and Heat Detector Activation Temperatures

Glovebox	Height (from fire to detector)	Detector Activation Temperature					
		74°C (165°F)		57°C (135°F)		38°C (100°F)	
		det. time (s)	fire size (kW)	det. time (s)	fire size (kW)	det. time (s)	fire size (kW)
HA-23S	3.5 m (11.25 ft)	224	590	184	400	128	200
HC-3 HC-4 HA-28	0.6 m (2 ft)	114	150	97	110	71	60

The fire is assumed to be on the lowest level for glovebox HA-23S and on the conveyor for HC-3, HC-4, and HA-28. The fire is also assumed to be at a radial distance of 1.5 m (5 ft) from the detector. This is a worst case assumption for fire location and provides a conservative predicted response time. The RTI for the thermal detectors was not available from the manufacturer since the temperature controllers used are not listed for fire detection. Therefore, a conservative value of 100 $(m/s)^{1/2}$ was used as the RTI in the DETACT model. Again, this provides a conservative estimate for the detector response times.

The DETACT results show that a standard 74°C (165°F) heat detector will respond in 3-4 minutes for a moderate growth rate fire that is 1.5 m (5 ft) away from the detector in HA-23S. At this time, the fire has grown to approximately 590 kW. Lowering the actuation temperature

of the detector to 57°C (135°F) reduces the response time by approximately 15 percent and the fire size at detection by approximately 30 percent. Lowering the actuation temperature further to 38°C (100°F) reduces the response time by over 40 percent and the fire size at detection by almost 65 percent, compared to the existing temperature alarm point. Reducing the activation time and fire size at detection allows more time to respond to the fire and significantly improves the chance of controlling and/or extinguishing a growing fire in a glovebox.

For gloveboxes HC-3, HC-4, and HA-28, the standard 74°C (165°F) heat detectors will respond in approximately 2 minutes for a moderate growth rate fire located 1.5 m (5 ft) from the detector. Lowering the alarm threshold for these detectors will reduce the activation time and fire size similarly to those achieved in HA-23S.

F5.5 Ventilation System

F5.5.1 Glovebox E-4 System

The gloveboxes are maintained at a negative pressure with respect to the rooms via ventilation systems which draw approximately 0.017 m^3/s (35 cfm) through each box. Except for gloveboxes HA-20MB which also has a HEPA filter inlet, all boxes on the HA-28 conveyor line are supplied with dry air from HA-28. Glovebox HA-28 is supplied via a 10 cm (4 in.) duct from the dry air supply system. Glovebox HC-3 has no supply or exhaust ports, but it is connected to HC-60 which is connected to an exhaust system. Supply air to HC-60 is through HEPA filters from the room. Most of the gloveboxes on RMA and RMC conveyor lines are exhausted via 5 or 10 cm ducts through a fire screen, pre-filter, and a HEPA filter.

Overall, the ventilation in the gloveboxes will tend to draw air from the conveyor gloveboxes into the individual process boxes and out through the exhaust ducts. Due to this flow pattern, fires within the conveyor gloveboxes will tend to be drawn into the adjacent boxes contributing to fire spread. However, because of the low volumetric flow rates, the flow pattern is not expected to significantly retard the spread of fire from within an adjacent glovebox to the conveyor glovebox (e.g., HA-23S to HA-28). In typical single opening enclosure fires, a bidirectional flow develops through the opening with air flowing in at the bottom and hot gases and possibly flame coming out the top. The gloveboxes with openings to the conveyor gloveboxes are quite similar to this classic scenario. The small exhaust flow will be insignificant, particularly as the filters become clogged.

Clogging of the filters with soot is expected and can lead to loss of containment [Hughes Associates, Inc., 1996]. However, since all gloveboxes are interconnected through the conveyor box, functional loss of the filters in the box on fire does not necessarily result in immediate loss of containment. The ventilation system is designed to compensate for a rise in pressure by shutting down the supply air and opening up emergency exhaust systems to maintain sufficient negative pressure in the glovebox line. Thus, a partial clogging of some filters can be handled without loss of containment.

It is not possible to accurately predict when loss of containment will occur due to the uncertainties in predicting factors, such as smoke yields, the creation of openings in windows and glove holes, and the extent of clogging of the system filters. Therefore, even though the ventilation system may be able to maintain containment temporarily, it is probable that loss of containment resulting from a glovebox fire will occur unless the fire is extinguished quickly.

F5.5.2 Zone 3, E-3 System

The 94-1 Process area is part of the E-3 ventilation system. The process rooms are in pressure Zone 3, which is maintained at a negative pressure with respect to the remainder of the building. Each of the process rooms has individual supply and exhaust ducts, which help minimize air flow between rooms. The exhaust ducts in each room have a 35 percent efficiency air filter over them to reduce particulate flow to the E-3 system.

For small fires in the process rooms, the individual exhaust ducts are expected to contain smoke spread to a single room. However, for larger fires, such as a fire involving several gloveboxes, smoke generation can start to clog the room exhaust filters. As the filters become clogged, the pressure in the fire room will increase relative to the adjacent spaces. As a result, smoke spread beyond the room of fire origin can occur through existing openings (e.g., doors, wall penetrations, cracks).

The extent of smoke and contamination spread through the process rooms will depend on the fire size, smoke generation, openings between rooms, and extent of filter clogging. Since the E-3 ventilation system will attempt to maintain a uniform pressure throughout Zone 3, smoke spread can potentially extend throughout the entire zone as a result of small pressure differences causing air flows between rooms. However, contamination of the entire zone would require large quantities of smoke and substantial clogging of the exhaust filters. Therefore, this level of contamination is only anticipated for the largest fires (e.g., a fire which spreads throughout all connected gloveboxes).

F5.6 Operator Response

Glovebox operators are trained to respond to fires within the 94-1 process line as long as it does not compromise their safety beyond a level of risk they are willing to accept. For this analysis, it is assumed that the operators will be trained to address a fire in a glovebox. The operator is anticipated to attempt to locate and extinguish a glovebox fire per usual practices [Price, 1996]. If an operator becomes aware of a fire within a glovebox, he/she will first attempt to move all combustibles away from the fire. If the fire can be isolated, it will be allowed to burn out. A second alternative is to smother the fire using sand or a metal cover if available. As a last resort, a bayonet dry chemical extinguisher will be used to penetrate a glove hole and suppress the fire. This last action will result in a breach in the glovebox, and could result in loss of containment depending on other factors, such as the size of the hole and the extent to which the exhaust HEPA filters are clogged.

F5.7 Fire Department

All fire alarms from the glovebox heat detectors are annunciated to the Hanford Fire Department. Upon receiving an alarm, the expected response time of firefighters to the 94-1 Process area will be within 5 to 7 minutes [Jordan, 1996]. The standard doctrine is for the fire department to enter the Process area with portable extinguishers. Hose lines will remain outside the building pressure zone unless necessary to contain the fire to the room of fire origin. This later tactic prevents doors from being opened which can compromise building containment and potentially further the extent of contamination.

In general, the fire department will respond in the same way as the glovebox operators in extinguishing a glovebox fire (primarily using portable extinguishers). Firefighters will tend to be better equipped than the operators (i.e., on mask and able to hook up to manual hose stations inside the building) when they arrive on scene. However, due to the minimum 5 minute response time, the fire department only provides a marginal increase in the level of protection in terms of fire spread through the gloveboxes and contamination compared to the response of the glovebox operators.

The fire department does provide a second level of protection (sprinklers being the first) in maintaining a fire to the room(s) of fire origin.

F5.8 Potential Fire Spread and Contamination

Fire propagation through a glovebox process line is a possibility. This was demonstrated by the unprotected facility, Rocky Flats glovebox fire [Patterson, 1970]. The fire at Rocky Flats originated in a glovebox having plastic window panels. Once the windows ignited, the fire quickly spread to the connected conveyor box. Since the conveyor was also lined with plastic windows, the fire was able to rapidly spread throughout the process line to other gloveboxes. With no fire suppression or fire separations, a fire in one of the 94-1 gloveboxes could potentially spread throughout the process line, similarly to the Rocky Flats fire.

A small fire in one of the 94-1 gloveboxes requires only minutes to ignite the acrylic window panels. During this time, smoke and combustion products will begin to clog the HEPA filters in the exhaust system [Alvares et al., 1980]. Once the window panels ignite, assuming there is no suppression system in the glovebox, the fire will grow in size producing smoke. As the HEPA filters clog, the negative pressure in the glovebox will decrease and a net positive pressure will be created by the hot fire gases. In turn, contaminated smoke can begin to leak to the room since the room is at a lower pressure. As the fire grows in size, the window panels, combustible gloves, and HEPA filters between the glovebox and the room will begin to burn through. This will allow additional air into the glovebox and will provide an additional means for contamination to spread to the room. Since there are currently no fire stops or dampers in the HC-3, HC-4 and HA-28 glovebox conveyors to contain a fire, a fire can potentially spread throughout all of the conveyor lines and connected gloveboxes (including those with automatic suppression systems).

Such a fire would result in significant damage to the gloveboxes and would require contamination cleanup of the rooms containing the process line as a minimum. As discussed in Section 5.5.2, clogging of the room exhaust filters may cause contamination to spread to other rooms and potentially throughout all of Zone 3. Since the building is protected throughout by an automatic sprinkler system, significant thermal damage or fire spread to other rooms is not expected. Even if the sprinkler system failed, the fire department could provide protection and could control the fire to the room of origin.

The extent of fire damage and contamination spread discussed above is anticipated for the current level of fire protection in the gloveboxes. The maximum possible fire loss, assuming no manual intervention (e.g., fire department) or activation of automatic suppression systems, is identified in Section 4. The maximum possible loss is greater than the expected loss for the current level of protection and is presented as an upper bound for fire and contamination spread.

In evaluating alternative fire protection strategies for the 94-1 gloveboxes, four levels of potential fire spread and contamination spread were identified. The potential levels of fire and contamination spread are as follows:

<u>Fire Spread</u>

- All connected gloveboxes
- Single glovebox conveyor line
- Glovebox of fire origin and adjacent glovebox
- Single glovebox

<u>Contamination</u>

- All of Zone 3
- One side of the 94-1 Process Area
- Room of fire origin
- Within the glovebox process line

Both lists represent increasing levels of fire protection with the first bullet in each list representing the extent of fire spread and contamination expected with the current level of fire protection. As will be discussed in Section 8.0, for a particular protection strategy, the corresponding levels of fire spread and contamination will generally coincide; however, the probabilities will not necessarily be the same. The levels of fire spread in gloveboxes reflect the use of both passive and active fire safety measures. Although contamination spread is heavily dependant upon the extent of fire spread, features such as glass windows and glove port covers help maintain containment without significantly reducing fire spread. For these cases, the level of contamination may not coincide with the same level of fire spread.

The extent of fire spread is dependant upon the fuel loading in the gloveboxes, the configuration of the gloveboxes, the ventilation air supply, automatic suppression systems, passive fire barriers, the transport of burning objects on the conveyors, and the response time of operators

and/or the fire department to provide manual suppression. If left uninterrupted, a fire can continue to spread through all connected gloveboxes as discussed above. Providing automatic suppression or passive fire barriers prevents fire spread through the gloveboxes. Both means of protection are reliable and are expected to minimize fire spread to the extent that they are installed.

Where manual suppression is relied upon to limit fire spread, response time is important in determining how far a fire will spread. As discussed in Section 5.4, the growth rate of a glovebox fire is anticipated to be moderate (see Equation 1). At this growth rate, a fire can reach a size of 1,000 kW within 5 minutes. A fire of this size is unlikely to be contained to a single glovebox. Additionally, the fire department will not be able to respond to a fire within this time. Therefore, it is necessary that facility personnel respond to a fire in less than 5 minutes in order to prevent spread into adjacent gloveboxes.

If the fire is controlled within the glovebox of origin, depending upon the peak size and duration of the fire, some damage may occur to connected gloveboxes due to heat and combustion products. If the fire is not controlled in the initial glovebox and is allowed to spread to the conveyor, it is unlikely that the fire will be controlled short of installed fire barriers or automatic suppression in all gloveboxes.

The amount of contamination (smoke spread) throughout the building will be dependant in part on the fire size, the materials involved in the fire, and the number of windows and glove holes breached by the fire. The level of contamination will be greatest near the source of the fire and will decrease in adjacent rooms and as one moves further away from the fire. As discussed earlier, if a fire were to spread throughout all of the gloveboxes, which is anticipated for the current level of protection, smoke can potentially spread throughout all of Zone 3.

Containing a fire to a single glovebox process line (i.e., a single room) greatly reduces the chance of smoke spreading throughout the entire Zone. In this case, the fire size is roughly half the size relative to fire spreading throughout all the gloveboxes. This will reduce the quantity of smoke generated into the room. Since the RMA and RMC sides of the process line are separated by a solid wall and the doors connecting the two sides are self-closing, smoke spread is expected to be limited to a single side of the process area. If the fire becomes very large on a single side of the process line and a large number of window panels and/or glove ports are breached, it is possible that smoke will spread to other areas within the zone.

As the extent of fire spread is further reduced to one or two gloveboxes, this further limits the spread of contamination. Fires involving one or two gloveboxes may not produce sufficient smoke to clog the room exhaust filters and induce buoyancy driven flows into adjacent spaces. Therefore, the spread of contamination is expected to be limited to the room of fire origin.

In order for contamination spread to be limited to the glovebox process line, the gloveboxes must not be breached by the fire. This includes glove ports, window panels, and external HEPA filters. For small fires which are controlled rapidly, it is likely that contamination will be limited to the glovebox process line.

F6.0 DAMAGE POTENTIAL

The criteria used to determine the different levels of fire and contamination spread are presented in Section 5. In this section, the monetary damage resulting from the different levels of fire and contamination spread are determined. The damage potential and cost estimates associated with a fire in the 94-1 glovebox process line include both thermal damage to gloveboxes and equipment due to fire spread and contamination of the facility resulting from loss of glovebox containment. Based on PFP facility direction, loss of production or program continuity is not a monetary concern in this analysis because operations can be relocated. Replacement costs of building contents are based on RL Property Systems cost breakdown as provided by WHC. A copy of the cost breakdown by room for the areas considered in this analysis is included in Appendix A. Cost of contamination cleanup is based on the recent cleanup efforts in Building 232-Z. A fixed rate of $4.00 per square foot of surface area is used as a cleanup cost [McKinnis, 1996].

F6.1 Fire Spread Damage Potential

The monetary damage potential due to fire spread was determined for the four levels of potential fire spread presented in Section 5. The potential levels of fire spread are as follows:

- All connected gloveboxes
- Single glovebox conveyor line
- Glovebox of fire origin and adjacent glovebox
- Single glovebox

In order to estimate the cost due to fire spread, it is assumed that any fire spread to a glovebox results in complete loss of the glovebox and its contents. Also, whereas the different gloveboxes in the 94-1 process have varying replacement costs, the most expensive cost estimates are used in this analysis. This provides a bounding cost estimate for each of the potential loss limitations. Table F6.1 provides a summary of the fire spread damage cost estimates for each level of damage potential.

Table F6.1 Summary of Fire Spread Damage Cost Estimates

	All connected gloveboxes	Single glovebox conveyor line	Glovebox of fire origin and adjacent glovebox	Single glovebox
Cost	$1,740,000	$1,360,000	$620,000	$590,000

For the first level of damage (i.e., all connected gloveboxes), it is assumed that HC-3, HC-4, HC-28, and all gloveboxes connected to these conveyors are lost due to fire. In addition, any equipment within the affected gloveboxes will be damaged and is included in the cost estimates.

Since the airlock separating HC-2 and HC-3 will be maintained closed and the gloveboxes along HC-2 are protected by an automatic Halon system, no fire damage is expected to occur to gloveboxes beyond the airlock.

For the second level of damage (i.e., single glovebox conveyor line), the fire is contained to either HC-3 and gloveboxes connected to HC-3 or to HC-28 and gloveboxes connected to HC-28. In either case, glovebox HC-4, which separates the two conveyor lines, is also assumed to be damaged. Based on the cost breakdown included in Appendix A, the replacement cost of the HC-3 conveyor and connected gloveboxes is approximately $380,000. The replacement cost of the HC-28 conveyor and connected gloveboxes is approximately $1,360,000. As noted earlier, worst case replacement costs are used in this analysis to provide a bounding loss potential. Therefore, the monetary loss potential for a fire which spreads through a single glovebox conveyor line is taken to be $1,360,000.

For the third level of damage, the fire is contained to the glovebox of fire origin and the adjacent glovebox. This level of damage is primarily applicable to a fire in one of the gloveboxes attached to a conveyor in which the glovebox and part of the conveyor becomes involved in the fire. The only gloveboxes without suppression which are attached to the conveyor and included within the scope of this study are HA-22 and HA-23S. Since HA-22 is inactive and has little monetary value, it is assumed that a fire in this scenario involves HA-23S and the adjacent conveyor, HA-28. The replacement cost for HA-23S and the adjacent conveyor is approximately $620,000.

For the fourth level of damage, the fire is contained to a single glovebox. For the 94-1 gloveboxes, HA-23S has the highest replacement cost and will have the greatest combustible fuel loading since it will be used for lag storage. Therefore, the relative risk and loss potential is greater for HA-23S than for other gloveboxes. For this level of damage potential, HA-23S is assumed to be the glovebox involved in the fire. The replacement cost for HA-23S is approximately $590,000.

It should be noted that a fire may occur in one of the other 94-1 gloveboxes (including gloveboxes which have automatic suppression systems). The replacement cost for a single glovebox ranges from $30,000 to $590,000 as seen in the RL Property Systems cost breakdown in Appendix A. However, as noted earlier, worst case replacement costs are used in order to provide a bounding analysis.

F6.2 Contamination Spread Cleanup Costs

The contamination cleanup costs due to smoke spread was determined for the four levels of potential contamination presented in Section 5. The potential levels of contamination are as follows:

- All of Zone 3,
- One side of the 94-1 Process Area,
- Room of fire origin, and

- Within the glovebox process line.

For a given fire, the extent of contamination will depend on the level of smoke spread throughout the room, process area, and pressure zone. The highest level of contamination will be closest to the fire. As smoke spreads to adjacent rooms and other areas within the pressure zone, the level of contamination will decrease significantly. However, there are no reliable methods of determining the level of contamination due to smoke spread for glovebox fires. In addition, cleanup cost estimates are not available for varying degrees of contamination. Therefore, it is assumed that contamination within the spaces affected by smoke spread is uniform, and a single value is used to estimate the cleanup costs. This provides a bounding cost estimate for each of the potential contamination levels. Table F6.2 provides a summary of the cleanup cost estimates for each level of contamination potential.

Table F6.2 Summary of Contamination Cleanup Cost Estimates

	All of Zone 3	One side of process area	Room of fire origin	Within the glovebox process line
Cost	$400,000	$100,000	$40,000	NA

NA - there are no cleanup costs for contamination within gloveboxes

The cleanup cost estimates are based on $4.00 per square foot of surface area in the areas which are contaminated [McKinnis, 1996]. The surface area includes floor, ceiling, and walls for each of the rooms. The cost estimate includes cleanup of equipment within the rooms. Table F6.3 estimates the surface area requiring cleanup for each of the potential contamination levels.

Table F6.3 Summary of Contaminated Surface Areas

	All of Zone 3	One side of process area	Room of fire origin	Within the glovebox process line
Area	100,000 ft^2	25,000 ft^2	10,000 ft^2	NA

NA - there are no cleanup costs for contamination within gloveboxes

The areas included within the Zone 3 ventilation pressure zone are the 94-1 Process area; rooms 221; 224; 225 235D,E; and 236. The RMA side is used for the contaminated area of one side of the 94-1 Process since it provides a greater bounding surface area than the RMC side. The RMA side includes rooms 235A,B,C; 233; and 232. For contamination of the room of fire origin, room 235B,C is used since it is the largest room within the 94-1 Process area. Again, the cleanup costs determined in this analysis are intended to provide an estimate for a glovebox fire.

F7.0 PROTECTION OPTIONS

In this analysis, several different protection options were considered for the 94-1 gloveboxes. Prior to evaluating specific protection strategies, a comprehensive list of fire protection features which would potentially reduce the risk of fire in gloveboxes was developed. The overall goal of the different protection options was to reduce the risk of fire. In order to achieve this goal, several different approaches were considered. The approaches used in limiting the risk of fire included the following:

7.1 Minimize the fuel source beyond the initial fire. This includes transient and fixed combustible materials, plastic window panels, gloves, and combustible materials in the room;

7.2 Provide suppression in the gloveboxes. This includes manual suppression and partial automatic coverage in key areas in order to minimize fire spread;

7.3 Isolate gloveboxes or sections of the connected gloveboxes. This includes permanent separations and separations which are provided manually and/or automatically;

7.4 Isolate or protect gloveboxes externally to prevent fire and contamination spread to the room;

7.5 Decrease the time to fire detection. This includes adding more detectors, modifying the placement of detectors, and/or lowering the alarm limits of the detectors; and

7.6 Improve operational procedures. This includes improving normal operations in order to minimize the chance of a fire and improving response procedures to control or extinguish a fire once detected.

Specific protection options were developed in accordance with the various approaches identified above. The alternate protection methods provided various levels of safety and risk. In some cases, a combination of different features were evaluated to achieve the desired level of protection. Specific fire protection features which were initially considered in this analysis include the following (number refers to the approaches identified earlier in this section):

- Provide an automatic fire damper or repair the existing airlock in glovebox HC-4. This damper will separate the process line and help limit fire spread to more than one glovebox line (No. 7.3);

- Replace the existing acrylic and lexan window panels with glass. This would significantly reduce the available fuel supply and limit fire spread in the gloveboxes (No. 7.1);

- Cover existing acrylic and lexan window panels with wired glass. Covering the windows will help control a fire by limiting the available air supply once the plastic windows start to melt and fall away. In addition, since the windows will be maintained in the opening, the wired glass cover will help maintain negative pressure in the glovebox with respect to the room, thereby reducing the amount of contamination outside of the glovebox (No. 7.4);

- Cover glove ports with noncombustible plugs or covers while the ports are not in use. Covering the ports will help control a fire by limiting the available air supply once the combustible gloves start to burn and develop holes. In addition, because the cover will be maintained, it will help maintain negative pressure in the glovebox with respect to the room, thereby reducing the amount of contamination outside of the glovebox (No. 7.4);

- Shut down the supply air to the gloveboxes upon fire detection. This includes shutting off any automatic air supply as well as providing dampers on the supply HEPA filters serving some gloveboxes. Shutting down supply air will help control a fire by limiting the available air (No. 7.3);

- Provide automatic sprinkler protection in the conveyor glovebox. This will prevent fire spread from one glovebox to another via the conveyor (No. 7.2);

- Extend the existing Halon system to protect the HC-3 conveyor and connected gloveboxes (No. 7.2);

- Install quick-connect couplings for portable fire extinguishers on each glovebox such that a fire in any part of the glovebox can be reached by the suppression agent (No. 7.2);

- Shut off power to the gloveboxes while the area is unoccupied. This will minimize ignition sources during unmanned hours (No. 7.6);

- Evaluate and provide recommendations to improve facility staff and fire department response procedures to glovebox fires (No. 7.6);

- Limit the quantity of combustible materials allowed to be stored in the gloveboxes during manned and unmanned hours (No. 7.1);

- Provide heat detectors in glovebox HC-3 and HC-4. It is assumed that all detectors will be listed or approved as defined by NFPA 72 [1996] (No. 7.5);

- Lower the alarm set point for the glovebox heat detectors (No. 7.5);

- Install an indicating light on each glovebox such that it identifies the location of an activated heat detector (No. 7.6);

- Install smoke detectors in specific gloveboxes where heat detectors may not rapidly detect an incipient fire (No. 7.5);

- Establish a roving fire watch in the glovebox process area. This would increase the chance of identifying potential fire hazards during unmanned hours (No. 7.6); and

- Limit the quantity and location of stored materials outside the gloveboxes. This will reduce the exposure hazard to the gloveboxes and also help prevent fire spread from a glovebox to the room (No. 7.4).

It is important to note that the initial list of options developed above considered most possible solutions with little regard for cost and PFP operational logistics. Once a comprehensive list was developed, the feasibility of each option was evaluated based on WHC input. In Section 8, specific protection strategies are presented which utilize only the most feasible protection options from the list above based on staff input.

F8.0 SELECTED PROTECTION STRATEGIES

From the list of potential protection options, several fire protection strategies were developed to provide various levels of fire loss and contamination cleanup costs as defined in Sections 5 and 6. The specific strategies were developed to optimize fire protection while considering cost, ease of installation and the life expectancy of the project. Tables F8.1 and F8.2 list the seven protection strategies evaluated along with the expected probabilities of obtaining fire spread and contamination in the different levels defined in Sections 5 and 6. Both Tables F8.1 and F8.2 include two tables each (designated a and b) that correspond to analyses for manned and unmanned hours of operation, respectively. Option 1, *Do Nothing* and Option 7, *FHA Criteria*, represent the bounding levels of protection against which the other strategies are evaluated. The potential monetary loss is presented along with each level of fire spread and contamination. This section discusses the selected protection strategies in detail and provides rationale for the relative probabilities for the various protection options.

The probabilities presented in this report represent a relative ranking scale between the fire protection strategies discussed. For example, for each protection option, one of the four designated levels of fire spread will occur. Therefore, the probabilities assigned to each level represents a relative ranking between these four possible outcomes. Consequently, the probabilities sum to 100 percent for each protection option. The values are based on the limited available test data and engineering judgement.

Protection Option 1

Option 1 consists of using the currently existing gloveboxes with no additional hardware or procedural changes. As a result, the extent of fire propagation and potential contamination

Table F8.1a Relative Probability of Fire Spread for Various Protection Strategies During Manned Hours

Protection Option	Protection Strategy	Probability of Fire Spread to Designated Level (percent)			
		All connected gloveboxes ($1,740,000)	Single glovebox conveyor line ($1,360,000)	Single glovebox with damage to adjacent glovebox ($620,000)	Single glovebox ($590,000)
PO 1	- Do nothing	75	20	0	5
PO 2	- HC-4 airlock	5	90	0	5
PO 3	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings	5	20	40	35
PO 4	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Shut down air supply	5	15	45	35
PO 5	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves	5	10	50	35
PO 6	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves - Shut down air supply	0	10	20	70
PO 7	- Automatic suppression in all gloveboxes (FHA criteria)	0	0	5	95
PO 8	- HC-3 & HC-4 detectors/lights - Electrical disconnect - New bayonet design/training - Fire watch	20	5	35	40

Table F8.1b Relative Probability of Fire Spread for Various Protection Strategies During Unmanned Hours

Protection Option	Protection Strategy	Probability of Fire Spread to Designated Level (percent)			
		All connected gloveboxes ($1,740,000)	Single glovebox conveyor line ($1,360,000)	Single glovebox with damage to adjacent glovebox ($620,000)	Single glovebox ($590,000)
PO 1	- Do nothing	75	25	0	0
PO 2	- HC-4 airlock	5	95	0	0
PO 3	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings	5	95	0	0
PO 4	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Shut down air supply	5	90	5	0
PO 5	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves	5	75	20	0
PO 6	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves - Shut down air supply	0	10	80	10
PO 7	- Automatic suppression in all gloveboxes (FHA criteria)	0	0	5	95
PO 8	- HC-3 & HC-4 detectors/lights - Electrical disconnect - New bayonet design/training - Fire watch	75	25	0	0

Table F8.2a Relative Probability of Contamination for Various Protection Strategies During Manned Hours

Protection Option	Protection Strategy	Probability of Contamination to Designated Level (percent)			
		All of Zone 3 ($400,000)	One side of process area ($100,000)	Room of fire origin ($40,000)	Gloveboxes (NA)
PO 1	- Do nothing	65	30	5	0
PO 2	- HC-4 airlock	20	70	10	0
PO 3	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings	5	30	45	20
PO 4	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Shut down air supply	5	30	45	20
PO 5	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves	5	10	40	45
PO 6	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves - Shut down air supply	5	5	15	75
PO 7	- Automatic suppression in all gloveboxes (FHA criteria)	0	0	30	70
PO 8	- HC-3 & HC-4 detectors/lights - Electrical disconnect - New bayonet design/training - Fire watch	30	5	40	25

NA - There is no monetary loss for contamination within the gloveboxes.

Table F8.2b Relative Probability of Contamination for Various Protection Strategies During Unmanned Hours

Protection Option	Protection Strategy	Probability of Contamination to Designated Level (percent)			
		All of Zone 3 ($400,000)	One side of process area ($100,000)	Room of fire origin ($40,000)	Gloveboxes (NA)
PO 1	- Do nothing	65	35	0	0
PO 2	- HC-4 airlock	20	80	0	0
PO 3	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings	20	80	0	0
PO 4	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Shut down air supply	20	75	5	0
PO 5	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves	5	15	80	0
PO 6	- HC-4 airlock - HC-3 & HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves - Shut down air supply	5	5	80	10
PO 7	- Automatic suppression in all gloveboxes (FHA criteria)	0	0	30	70
PO 8	- HC-3 & HC-4 detectors/lights - Electrical disconnect - New bayonet design/training - Fire watch	65	35	0	0

NA - There is no monetary loss for contamination within the gloveboxes.

will be dependant on the available safety features as discussed in Section 5. In summary, the existing system includes the following safety features:

- Heat detectors in all gloveboxes, except for HC-3 and HC-4, which are connected to a central control panel;
- The detectors sound a general, building wide fire alarm when the temperature in a glovebox reaches 74°C (165°F);
- The alarm will automatically notify the fire department which will respond to the process area within 5 to 7 minutes; and
- Glovebox operators are trained to respond to a glovebox fire and will use a bayonet dry chemical extinguisher as a last resort to suppress the fire.

As discussed in Section 5, there are no automatic suppression systems or fire barriers within the subject gloveboxes (i.e., HC-3, HC-4, HA-28, HA-22, and HA-23S). Consequently, fire extinguishment and limitation of damage relies solely on manual intervention which is primarily dependant on the ability, desire, and time for personnel to respond to the fire. If a fire were to develop in a glovebox with a detector (i.e., HC-4, HA-28, or HA-23S) all personnel would evacuate the building unless they happen to notice the fire before leaving. With the current detection and alarm system, it is highly improbable that an operator would hear the alarm, evacuate the space, obtain the zone of fire origin from the control panel, return to the process area, and extinguish the fire before it breached a compartment or spread to an adjacent glovebox. If the operator did perform all the previous tasks (i.e., leave space, examine control panel, and return), the fire would most likely be too large to be extinguished by a portable extinguisher operated by an unprotected person (i.e., no mask or fire gear). Of the five subject gloveboxes, this scenario is particularly credible for glovebox HA-23S which has the highest probability of having a fire due to the large fuel load and hydraulic lift. This 3.5 m (11.5 ft) high glovebox has steel water walls surrounding its perimeter. The glovebox size and multiple levels and the water walls present significant barriers to quickly locating and accessing the seat of the fire within the glovebox.

A fire in glovebox HC-3, which has no detectors, is even more likely to go undetected until it spreads to HC-4 and HA-28 or HC-60, which are equipped with heat detectors. Again, the fire would be expected to be too large for manual suppression to be effective. In conclusion, since there are no fire barriers and extinguishment is highly unlikely, there is a 75% chance that the fire will spread to all of the connected gloveboxes.

There is a small probability (5 percent) that personnel in the process area may notice a glovebox fire early enough to be able to extinguish it and limit fire spread to a single glovebox. However, once the fire grows to a point that it spreads to an adjacent glovebox, it will be too large to manually extinguish. Thus, there is a zero probability of limiting spread to just two boxes. The arrival of the fire department on site with multiple extinguishers and water lines (if necessary) provides a reasonable probability of containing the fire to a single glovebox line by

creating an agent fire barrier at glovebox HC-4. Because of the 5-7 minute response time, credit cannot be taken for firefighters arriving in time to limit the fire to only two gloveboxes.

As discussed in Section 5.5.2, a fire that spreads to all connected gloveboxes is expected to produce smoke that can lead to substantial clogging of the exhaust filters in the Zone 3 rooms. As a result, it is expected that there will be a 65 percent probability that all of Zone 3 will be contaminated. Since there is an expectation that the fire department could be on site in time to contain the fire to a single glovebox line, there is a 30 percent probability that contamination will occur to only one side of the process area and a 10 percent probability that it can be limited to the room of fire origin.

During unmanned hours, protection features that depend on operator response provide no additional safety over the "Do nothing" option (PO 1). Therefore, as will be noted throughout the analyses for the different protection options during unmanned hours, there will generally be a decrease in the probability that a fire will be limited to only one or two gloveboxes and an increase in the probability that a fire will spread to a single glovebox line or to all connected gloveboxes. Limiting fire spread to a single glovebox or a single glovebox with damage to an adjacent box is achieved for the different options because of safety features that allow personnel to respond faster and more effectively to a fire. Obviously, during unmanned hours, credit cannot be given to these safety features.

In the case of Option 1, there is a small change in probability of fire spread during unmanned hours compared to the values presented for manned hours in Table F8.1a. As can be seen by comparing Table F8.1b (unmanned hours) to Table F8.1a, the probability of fire spreading to all connected gloveboxes remains the same. However, the probability that a fire will spread to a single glovebox line increases from 20 percent to 25 percent. During manned hours there is a 5 percent chance that an operator will become quickly aware of a fire and be able to extinguish it so that fire spread is limited to a single glovebox. During unmanned hours, the fire will spread until the fire department can respond (i.e., a 0 percent probability of containing the fire to a single box). Consistent with the analysis during manned hours, the fire department response is credited with limiting fire spread to a single glovebox conveyor line. Therefore, the 5 percent probability of limiting a fire to a single glovebox during manned hours translates into a 5 percent increase in the probability that a fire will spread to a single glovebox line during unmanned hours. This shift in the 5 percent relative probability of containing a fire to a single box is also reflected in a 5 to 0 percent reduction in containing the contamination to the room of fire origin and a 5 percent increase (30 to 35%) in limiting contamination to one side of the process area (Tables F8.2a and F8.2b).

Protection Option 2

Protection Option 2 consists of repairing the stainless steel airlock in glovebox HC-4 to serve as a fire barrier. The double door airlock works in a manner that one door will always be closed so that air (or fire gases) will not pass from HA-28 to HC-3. Typically though, both doors will be closed unless material is being passed through. This provides a barrier to fire spread.

The spread of fire will be equivalent to that with Protection Option 1 except that it will be limited to a single glovebox conveyor line. As a result, the only change in the fire spread probability analysis is a 15 times reduction in the chance of fire spreading to all gloveboxes. If a fire starts in HA-23S or HA-28, there is a 90 percent probability that it will only damage HA-28 and all connecting gloveboxes. Similarly, the HC-4 airlock will limit a fire in the HC-3 conveyor to this glovebox and any connected gloveboxes. This passive protection measure has the advantage of assuring a significant level of containment for fires in the HC-3 glovebox which does not have fire detectors. As discussed for Option 1, there is a small (5 percent) chance that the fire will be discovered early and extinguished so that it will be limited to a single glovebox.

As discussed in Section 5.5.2, containing the fire to one side of the process area decreases the chance of contamination spreading to all of zone 3. This is shown in Table F8.2a, by the 20 percent probability of this level of contamination occurring compared to the 65 percent probability for Option 1. Installing the HC-4 airlock is expected to more than double the probability (from 30% for Option 1 to 70% for this option) that contamination will be limited to one side of the process area.

For the same reasons given for Option 1, evaluating Option 2 for unmanned hours results in a 5 to 0 percent reduction in limiting fire spread to a single glovebox and a 5 percent increase (90 to 95%) in limiting the fire to a single glovebox conveyor line (Tables F8.1a and F8.1b). Similarly, there is a 10 to 0 percent reduction in limiting the contamination to the room of fire origin and a 10 percent increase (70 to 80%) in limiting contamination to one side of the process area (Tables F8.2a and F8.2b). As can be noted in Table F8.1b for unmanned hours, the inclusion of the HC-4 airlock provides additional protection compared to Option 1 that will limit fire spread to a single glovebox line. The effect of this protection feature is reflected in the reduction from a 75 to 5 percent probability that a fire will spread to all connected gloveboxes. Since this feature does not depend on personnel, the probability for fire spreading to all connected gloveboxes is the same during manned and unmanned hours for Option 2.

Protection Option 3

Protection Option 3 builds off of Option 2 with the addition of the following safety features:

- Listed or approved automatic fire detectors shall be installed in glovebox HC-3 and HC-4 in accordance with NFPA 801 and NFPA 72;
- Provide indicating lights on each glovebox to identify heat detector actuation;
- Set the alarm temperature level to 57°C or lower for the heat detectors in glovebox HC-3, HC-4, HA-28, or HA-23S; and
- Provide quick connect ports in glove boxes for portable fire extinguishers.

The main purpose of these safety features is to provide quick notification and location of the fire, and the means to manually extinguish the fire. Installation of heat detectors in glovebox HC-3 and HC-4 will increase the chance of detecting and successfully controlling a fire in this box. Of greater impact is the installation of indicating lights on each glovebox to identify which heat detector has reached an alarm value. Each detector (typically spaced 1.8 m apart) will be wired to a light that is stationed to clearly indicate the location of the detector. Unless obstructions prevent good visibility, it may be possible to use one indicating light for two adjacent detectors. In this case, the light would be centrally located between detectors. Upon detecting an alarm level temperature in a glovebox, the general fire alarm will sound and the indicating light will turn on. The light should be of a suitable brightness, color, and/or pattern (e.g., strobe) so that personnel can locate it from across the room. With this system it is expected that personnel in the process area will be able to respond to a glovebox fire within seconds of the alarm (no more than 1 minute). Even during unmanned hours, the specific identification of actuated heat detectors will improve firefighter response and effectiveness once inside the process area.

Early detection is a key factor in limiting fire damage and contamination. As discussed in Section 5.4, decreasing the alarm temperature level of the heat detectors allows the fire to be detected more quickly which allows personnel to respond sooner to a much smaller and more easily extinguished fire. Therefore, it is advantageous to lower the detection alarm limit to the lowest feasible temperature which does not present a risk of false alarms. An alarm temperature as low as 38°C (100°F) may be feasible considering that there are no heat generating processes in the gloveboxes being analyzed and that the process area is a temperature controlled space. Since the ventilation is set to draw from the conveyor gloveboxes to the attached gloveboxes, the heat generated from gloveboxes with ovens is not expected to affect heat detectors in other gloveboxes.

The alarm temperature limit can be adjusted for the currently installed heat detectors, however, this adjustment has to be done at the factory to assure proper calibration. As a minimum, the heat detectors in gloveboxes HC-3, HC-4, HA-28, and HA-23S should be set to alarm at 57°C. Particularly for glovebox HA-23S, this lower alarm limit will decrease the time to alarm by one-half minute, allowing personnel to respond to an approximately 400 kW fire rather than a 590 kW fire (Section 5.4). This additional time will increase the chance of limiting fire damage to the box of fire origin. With the above modifications, the anticipated time for alarm will be 184 seconds or less based on the modeling discussed in Section 5.4.

Besides this improvement in detection it is also advisable to provide a means to extinguish a glovebox fire without risking loss of containment. The use of a bayonet extinguisher to puncture a glove poses the risk of losing containment and contaminating the room. For this reason, this firefighting tactic is used as a last resort. It is believed that personnel would be more likely to use an extinguisher earlier in a fire event if there was a means to directly inject the agent into the glovebox without breaching the glove port. Earlier extinguishment reduces the risk of a fire growing out of control and causing further contamination and fire spread.

The use of a quick connector mounted in the side of a glovebox can provide an easy means to inject a dry chemical extinguishing agent while maintaining glovebox integrity. This

method is currently a required practice in the "DOE Draft Glovebox Standard" [WHC, 1993]. Factory Mutual has performed the only known set of tests to evaluate this method of injecting dry chemical into a glovebox [King, 1960]. In these tests, the female half of a quick-connector was mounted on a coupling welded to the glovebox wall. This half of the connector has a spring loaded seal that maintains a contamination barrier. A 1 cm tube with a flattened fan shaped tip was connected to the coupling on the inside of the box. The fan shaped nozzle was directed up at a 45 degree angle toward the center of the ceiling. This setup resulted in the agent being diffused at the ceiling and falling like rain. The male half of the connector was installed on a dry chemical extinguisher.

Tests demonstrated that effective agent coverage (greater than 0.65 g/cm^2) could be achieved for various nozzle locations (e.g., side or end of box). Based on these tests, this suppression system is expected to cover 1.7 m^2 (18 ft^2) of glove box floor. It should be noted that these agent application densities are based on the suppression of alcohol pool fires. No tests with burning plastic windows or gloves were performed. As a result, there is no available data to validate the effectiveness of this type of dry chemical system to extinguish the primary fire hazard considered in this analysis. There may be a problem of obtaining sufficient agent coverage on the vertical surfaces of the plastic windows and walls to assure fire suppression.

With the above considerations, it is recommended that a quick connector spacing of 0.9 m be used to conservatively allow for sufficient overlap in agent application in the glovebox. This assumes a 1.2 m deep glovebox. Orientation and design specifications for proper nozzle discharge should be in accordance with the applicable standards [WHC, 1993 and NFPA 17]. At least two 10 lb dry chemical extinguishers should be directly at hand for operators to respond to any glovebox fire. Operators should not have to walk around a glovebox in order to obtain extinguishers.

Although the quick connects offer a safer, easier method to introduce agent into a glovebox, there is one advantage to using a bayonet extinguisher. Penetrating a glove with a bayonet extinguisher allows the person to accurately direct agent to the seat of the fire. Additionally, the person can use a sweeping motion to apply agent across the surfaces on fire. This is a very effective firefighting technique that cannot be done with the fixed quick connect setup. Since there is some uncertainty about the total effectiveness of the quick connect system, bayonet extinguishers should also be staged nearby as currently provided. The ultimate impact of penetrating a glove port with a bayonet is insignificant to the final analysis of this report. It is assumed that by the time a fire is manually extinguished, the fire is large enough to potentially breach the glovebox. Therefore, penetrating a glove poses little additional risk of contaminating the room of fire origin.

Compared to Option 2, the primary advantage of Option 3 is the instant notification to personnel of the fire location via the indicating lights. This fire protection strategy allows glovebox operators to respond immediately to the source of the fire. It is anticipated that the operators could respond in less than 1 minute after the alarm. With a maximum alarm time of 184 seconds, personnel should be able to respond to the fire within 244 seconds. At this time

the fire would be expected to be no larger than 700 kW. This size fire is approximately 80 percent of the maximum fire size that can be suppressed with the dry chemical extinguishers.

As a result of this relatively fast response, there is a 75 percent probability that the fire will be limited to either a single glovebox (35%) or a single glovebox and the adjacent box (40%). Each scenario is approximately equally as likely to occur; the outcome being primarily dependant on the location of the initial fire. For example, if the fire starts near the connection of two gloveboxes, it is likely to spread to portions of both. However, it is reasonable to expect that a 430 kW fire could be contained within one glovebox.

Since glovebox HA-23S is the most likely source of a fire, the particular aspects of this glove box factor significantly in developing the probability estimates. The water walls that surround glovebox HA-23S present a notable impediment to personnel trying to respond to the fire, particularly if more than one wall needs to be moved to adequately fight the fire. Consequently, there is an expected 20 percent probability that the fire may grow to a size that is not extinguishable and, therefore, could spread through the whole conveyor line until reaching the HC-4 airlock. Similar to Options 1 and 2 there is a remote chance (5%) that the fire could spread to all connected gloveboxes via a failure of the HC-4 airlock.

The protection strategies of this option reduce the probability of wide spread contamination as expected with Options 1 and 2. As can be seen in Table F8.2a in comparison to Option 2, there is more than a factor of 2 reduction of the probability that contamination will occur through out one side of the process area. This reduction is primarily attributed to the 75 percent expectation that the fire will be limited to just one or two gloveboxes. As a result, the loss of containment and smoke production are expected to be significantly decreased compared to the outcome of Options 1 and 2 in which the fire has a high probability of spreading through multiple gloveboxes. The most probable outcome (at 45%) will be that only the room will be contaminated. Since there is reasonable expectation that personnel may be able to contain the fire before it breaches a compartment there is a 20 percent probability that containment will be maintained.

In the case of Option 3, there is a substantial change in the relative probabilities of fire spread during unmanned hours compared to the values presented for manned hours in Table F8.1a. As can be seen by comparing Table F8.1b (unmanned hours) to Table F8.1a, the probability of fire spreading to all connected gloveboxes remains the same. This is true because the inclusion of the HC-4 airlock provides the same passive protection during unmanned and manned hours; thus, this feature limits fire spread to a single glovebox conveyor line. However, the probability that a fire will spread to a single glovebox line during unmanned hours increases from 20 percent to 95 percent because during unmanned hours personnel are not present to limit fire spread. The addition of heat detectors, indicating lights, and quick-connect couplings provide no additional fire protection against fire spread when personnel are absent from the space. Therefore, the relative probabilities of limiting fire spread to a single glovebox or a single glovebox with damage to an adjacent glovebox are both decreased to 0 during unmanned hours (Table F8.2b). This decrease is offset by an increase from 20 to 95 percent in the relative

probability that fire will spread to a single glovebox conveyor line during unmanned hours (Table F8.1a and F8.1b, respectively).

During unmanned hours, Option 3 provides the same level of protection against fire spread and contamination as does Option 2. Therefore, the probability of contaminating one side of the process area is 80 percent, and the probability of contaminating all of Zone 3 is 20 percent.

Protection Option 4

Protection Option 4 is the same as Option 3 with the additional modification of automatically shutting down all supply air to the glovebox line upon a fire alarm. This would include shutting down the forced ventilation supply air to the gloveboxes (i.e., HA-20MB and HA-28) and providing external dampers on supply HEPA filters (i.e., HA-20MB and HC-60) which will automatically close upon heat detector actuation). The forced ventilation supply ducts already have automatic cutoff valves that close when the internal glovebox pressure increases above -0.5 in. w.g. Therefore, connecting these valves to the alarm control panel is expected to be a low-cost modification.

The objective of this option is to both slow the growth rate and, ultimately, to extinguish the fire by limiting oxygen. In the initial stages of a fire, there are two sources of air to the fire: the air that is currently within the glovebox line and the additional supply air from the ventilation system. The amount of air that is within the glovebox line could potentially support a fire for 260 s (about 4.5 minutes) at which time it would be a 824 kW fire (assuming a moderate t^2 growth rate). This estimate is expected to be conservatively high. For example, the model assumes the fire burns vigorously for the entire time then suddenly suffocates itself at 4.5 minutes. It is more realistic to expect that the fire would burn at a lower heat release rate for a longer time. Alternately, the fire may even enter an intermittent mode where it temporarily dies down than flares up due to fluctuations in the smoke layer depth and flow of air in the glovebox line. Whatever the case, it is expected that a portable dry chemical extinguisher will be able to extinguish the fire.

The ventilation system can only support a modest size fire, however, there is no time limit due to air supply. The fire could propagate through out the entire glovebox line. Although the nominal amount of supply air to each glovebox is 0.017 m^3/s (35 cfm) the fire could potentially draw four times that flow rate if air was drawn from all connected boxes (i.e., 4 gloveboxes x 0.017 m^3/s = 0.068 m^3/s). This flow rate of air could potentially support a 240 kW fire.

As discussed above, terminating air flow to the glovebox lines would limit the fire to consuming only the air that is within the gloveboxes. Under these conditions, a conservative estimate would predict that the fire would only have enough air to burn for about 4.5 minutes reaching a heat release rate of 824 kW, or it could burn for a longer period of time but at a lower heat release rate.

The degree to which this option is effective depends on the extent that windows and/or glove ports are breached by the fire. Even if all supply air is off, breached windows and glove

ports could potentially provide enough air to sustain a growing fire. On the other hand, shutting down the supply air may reduce the external supply of air to the fire by as much as 100 percent depending on the open area of breached windows. Due to the uncertainty of predicting these events, the increased probability of limiting the fire spread compared to Option 3 is marginal. As shown in Table F8.1a, the probability of limiting fire spread to two gloveboxes increases to 45 percent with a corresponding decrease in the chance that the fire would spread to the whole conveyor line.

Shutting down the supply air will assist the ventilation system in maintaining negative pressure and, thus, limiting contamination. However with the existing system, the supply air would eventually be shut off automatically when decreasing negative pressure indicates a potential loss of containment. In this case, closing dampers on the supply HEPA filters adds an extra level of protection to help maintain negative pressure. It is unclear to what extent these factors will outweigh one another, particularly with respect to the timing of flame spread events. For this reason, this option is not assumed to significantly affect the probability estimates of contamination compared to those of Option 3.

During unmanned hours, the features and analysis of Option 4 are quite similar to those of Option 3. The primary difference is that for Option 4, the automatic shut down of the air supply provides a marginal increase in fire protection by retarding the spread of fire. This increase in protection is reflected in a 5 percent probability that the fire department may respond in time to limit fire spread to a single glovebox with damage to an adjacent glovebox. The difference between manned and unmanned hours for Option 4 is substantial. During unmanned hours, there is only a 5 percent probability of limiting a fire to a single glovebox or a single box with damage to an adjacent compared to an 80 percent probability during manned hours when personnel can respond to the fire.

Compared to Options 2 and 3, the probabilities for limiting contamination are approximately the same for Option 4 during unmanned hours. The probability of contaminating all of Zone 3 is 20 percent, the probability of contaminating only one side of the process area is 75 percent, and the probability of limiting contamination to the room of fire origin is 5 percent. Because of the absence of personnel in the process area during unmanned hours, there is no expectation that the fire or contamination will be limited to a single glovebox. The fire will grow to a size that is expected to breach windows and glove ports. The marginal probability of limiting a fire to a single glovebox and an adjacent box is reflected in a 5 percent probability that contamination will be limited to the room of fire origin.

Protection Option 5

Protection Option 5 is the same as Option 3 with the additional modification of covering all windows and glove ports. The main reason for loss of containment is the failure of plastic windows and gloves which burn out during the fire. One option is to replace these components with noncombustible materials. However, this is not a feasible option due to the costs and the difficulty of maintaining containment during the replacement process. An alternate strategy is to cover the existing acrylic and Lexan windows with wired glass and to double seal the glove

ports with either noncombustible covers or plugs while gloves are not being used. Sealing and protecting glove ports from fire is a recognized practice in the "DOE Draft Glovebox Standard" [WHC, 1993].

This option will result in an increase in the probability of both limiting fire spread and containment. As discussed in Option 4, preventing additional air from entering breached windows and glove ports will not necessarily limit fire spread to the glovebox of fire origin. This is because the ventilation system will continue to supply air to the gloveboxes until the automatic cutoff valve is actuated because of a rise in the internal pressure of the gloveboxes. It is possible that there will be enough air to allow the fire to spread to an adjacent glovebox. Once the forced supply air is shut off, the only source of air will be from one or two supply HEPA filters, depending on which process line is on fire. Without breached windows and glove ports, the fire will have a very limited supply of air. Additionally, without these open ports, there will be no means to exhaust the fire gases from the glovebox. This is advantageous in that the fire will not be expected to grow substantially in an increasingly vitiated environment. The fire will decrease in intensity as the combustion products fill the fire space.

Overall, considering the limited air supply, the probability that the fire could spread throughout the whole conveyor line is quite low. As can be seen in Table F8.1a, there is a 2 fold reduction (20 to 10%) in the probability that the fire will spread to the whole conveyor line when compared to Option 3. As a result of covering windows and glove ports, the growth of the fire should be decreased so that there will be a slightly greater probability of limiting fire spread to just two gloveboxes. Table F8.1a reflects this increase, showing a 50 percent probability of limiting fire spread to a single glovebox and the adjacent glovebox compared to a 40 percent probability for Option 3.

The primary advantage of covering the windows and glove ports is to improve containment. If a fire results in the burn out of a plastic window, the wired glass will serve as a second boundary to maintain containment. Even if the window cracks due to high thermal stresses from the fire, the wire will hold the glass in place, thus, preventing any substantial size cracks or gaps from forming. Similarly, the noncombustible glove port covers/plugs are containment boundaries which limit the consequences of gloves burning in the fire. Because of the expected decrease in fire spread and the potential to maintain containment, there is a 45 percent probability that contamination will be limited to within the glovebox of fire origin. This protection option is therefore about twice as effective as Option 3.

Although large gaps are not expected, hairline cracks may develop in the wired glass, leading to some smoke leakage. For this reason, the probability of contaminating the room of fire origin is still significant (40%). However, due to the unlikely case of developing a significant buoyant smoke plume, there is only a 10 percent probability of contaminating one whole side of the process line. This represents a factor of 3 reduction compared to Option 3.

During unmanned hours, there are several passive fire protection features of Option 5 that will limit fire spread and contamination: the HC-4 airlock and the covers on the windows and gloves. Limiting fire spread to a single glovebox depends primarily on a timely response from

an operator in the process area. Therefore, during unmanned hours, there is a 0 percent probability that the fire will be limited to a single glovebox. However, the fire protection features for this option will retard and/or limit the fire spread by preventing additional air flow through breached windows and glove ports. As a result, there is a 20 percent probability that the fire will be limited to a single glovebox with damage to an adjacent glovebox. By retarding the spread of fire via these passive features, fire fighters are able to respond to smaller fires and limit damage. However, as seen by comparing Table F8.1b to Table F8.1a, the probability of limiting a fire to a single glovebox with damage to an adjacent glovebox during unmanned hours (20%) is less than half of that during manned hours (50%). Correspondingly, there is an increase in the probability of limiting fire spread to a single glovebox conveyor line from 10 percent during manned hours to 75 percent during unmanned hours. Although the window and glove port covers retard fire growth, the fire may continue to spread with air from the supply system. However, both the HC-4 airlock and the fire department will limit the fire from spreading to all connected gloveboxes; therefore, the probability for this extent of spread is the same for manned and unmanned hours (5%).

Installing covers on the windows and glove ports provides increased protection to limit contamination outside a glovebox. During unmanned hours when a fire is expected to spread beyond a single glovebox, there is 0 percent probability that contamination will be limited to the glovebox. Due to small crack leakage, the room of fire origin will be contaminated. However, because of the physical barriers provided by this option, leakage should be limited, and there will be no substantial fire plume outside of the gloveboxes to convectively transport contamination beyond the room. Therefore, there is a large probability of 80 percent that contamination will be limited to the room of origin. Since the fire is expected to spread further during unmanned hours, there is a marginal increase from 10 to 15 percent in the probability of limiting contamination to one side of the process area.

<u>Protection Option 6</u>

Protection Option 6 is the same as Option 3 with the additional modification of covering all windows and glove ports and also automatically shutting down all supply air to the glovebox line upon a fire alarm (i.e., the combination of Options 4 and 5). Tables F8.1 and F8.2 show that individually Options 4 and 5 offer only marginal advantages to the fire protection strategy of Option 3. As a combined strategy, though, Options 4 an 5 have a synergistic effect that is expected to result in a significant reduction in both limiting flame spread and contamination.

As was previously discussed, by limiting the air supply to the glovebox line and preventing windows and glove ports from breaching, fire spread can be dramatically slowed down. Even without manual intervention, fire spread will probably be limited to one to two gloveboxes because of the finite air supply to the fire. The fire size is expected to never exceed 800 kW. In the likely case that glovebox operators are alerted to the fire via the indicating light and audible alarm, there is a high probability (70%) that the fire can be extinguished through a quick connect port with damage limited to the glovebox on fire. As a result of the limited fire growth and the added containment protection of the window and glove port covers, the probability of limiting contamination to within the glovebox line increases to 75 percent. This

is greater than a threefold increase in protection for maintaining containment compared to Option 3.

Even if personnel response is slow or does not occur, maintaining containment is l probable, such that contamination to the room is 3 times as likely to occur compare o contaminating one whole side of the process area. This is reflected in Table F8.2a which shows a 15 percent probability for contaminating the room of fire origin and a 5 percent probability of contaminating one side of the process area. These numbers reflect the fact that even if the fire is not extinguished but allowed to burn out due to lack of oxygen, the window and glove port covers are expected to maintain containment. This is true whether the fire spreads to multiple gloveboxes or remains within the glovebox of fire origin.

During unmanned hours, there are several passive fire protection features of Option 6 that will limit fire spread and contamination: the HC-4 airlock and the covers on the windows and gloves. The automatic shut down of the supply air at detection of a fire will also provide additional protection without the need for personnel intervention. As noted above for manned hours, the combination of these features significantly changes the probability of limiting fire spread and contamination to a glovebox. These features are expected to provide nearly equivalent protection during unmanned hours. The primary difference is that personnel will not be able to limit the fire spread to a single glovebox. This effect is seen in Tables F8.1a and F8.1b as a reduction in probability from 70 to 10 percent for manned to unmanned hours, respectively. However, with the combined limitations on air flow into the gloveboxes, the probability of limiting fire spread to a single glovebox with damage to an adjacent box is 80 percent.

There are similar changes in the probabilities for contamination spread between manned and unmanned hours. There is a reduction from 75 to 10 percent probability that contamination will be limited to a glovebox, and there is a corresponding increase from 15 to 80 percent probability that contamination will be limited to the room of fire origin.

Protection Option 7

Protection Option 7 consists of incorporating the FHA recommendations for glovebox fire protection [Hughes Associates, Inc., 1996]. The principal recommendation is the use of automatic fire suppression systems in all gloveboxes. These systems should extinguish a fire within a minute after detector actuation. Therefore, there is a 95 percent probability that the fire will be contained to a single glovebox. Depending on the location of the fire, there is a small chance that the fire will damage two gloveboxes. Due to the fast extinguishment of the fire, there is a 70 percent chance that contamination will be limited to within the glovebox of fire origin. However, since the fire may be 100 to 200 kW at the time of detector actuation, it is possible that a glove or window may be partially burned through or breached due to cracking or warping. Consequently, there is a 30 percent probability that the room of fire origin may be contaminated.

Automatic suppression systems provide the same level of protection during manned and unmanned hours of operation. Therefore, between manned and unmanned hours, there is no change in the probabilities for the extent of fire spread and contamination.

Protection Option 8

Option 8 consists of the following features:

- Listed or approved automatic fire detectors shall be installed in glovebox HC-3 and HC-4 in accordance with NFPA 801 and NFPA 72;
- Install heat detector indicating lights at gloveboxes and/or install heat detector annunciation panel in process area;
- Set the alarm temperature level to 57°C or lower for the heat detectors in HC-3, HC-4, HA-28, and HA-23S;
- Install electrical disconnect switches to de-energize the power to the interior of the gloveboxes during non-operating hours;
- Implement new bayonet design as specified by PFP (with quick disconnect that is disengaged and left in place after discharging);
- Train personnel for bayonet usage with quick disconnects;
- Implement continuous fire watch during conveyor (HC-3, HC-4, and HA-28) operations or when transporting materials to or from glovebox HA-23S; and
- Modify Response to Glovebox Fire Procedure as required.

The goal of these safety features is to provide quick notification and location of the fire, and the means to manually extinguish the fire. Installation of listed/approved fire detectors in glovebox HC-3 and HC-4 will increase the chance of detecting and successfully controlling a fire in these boxes. Of additional impact is the installation of indicating lights on each glovebox and/or a local annunciation panel to identify which heat detector has reached an alarm value. Each detector (typically spaced 1.8 m apart) will be wired to a light that is stationed to clearly indicate the location of the detector. Unless obstructions prevent good visibility, it may be possible to use one indicating light for two adjacent detectors. In this case, the light would be centrally located between detectors. Upon detecting an alarm level temperature in a glovebox, the general fire alarm will sound and the indicating light will turn on. The light should be of a suitable brightness, color, and/or pattern (e.g., strobe) so that personnel can locate it from across the room. With this system, it is expected that personnel in the process area will be able to respond to a glovebox fire within seconds of the alarm (no more than 1 minute). Even during unmanned hours, the specific identification of actuated heat detectors will improve fire fighter response and effectiveness once inside the process area.

The alternate design to adding indicating lights consists of installing fire alarm annunciation panels in Rooms 230C and 235 B, C. These panels would show a layout of all gloveboxes and associated heat detectors (i.e., each panel would show the layout for both rooms).

Upon a heat detector indicating an alarm temperature condition, a light on the panel would indicate which detector(s) were in alarm. Consequently, personnel in either room would know the exact location of the glovebox which has the alarm. This safety feature requires that personnel in the rooms will check the annunciation panel upon hearing the alarm. It is expected that personnel in the process area will be able to respond to the fire within a minute of hearing the alarm. Compared to the indicating lights, this safety feature is expected to result in slightly longer response times since it may require a person to travel further distances and requires correct interpretation of the annunciation panel. If the person misreads the panel, the response time may be even longer. One advantage of the annunciation panel is the ability of personnel to identify a fire in both rooms even if one is not manned.

The probability for igniting a fire is lowered when a glovebox is inactive. Therefore, there are obvious advantages to de-energizing the power to the interior of a glovebox when not in use. The installation of electrical disconnect switches will serve to reduce potential ignition sources by eliminating all electrical power within the gloveboxes. Therefore, the use of electrical disconnect switches decreases the chances of having a fire inside a glovebox and increases the level of fire protection. However, the potential for a fire to occur as a function of operational (manned or unmanned) conditions is included in Section 9.0. Since the analysis assumes a fire occurs, the use of electrical disconnect switches does not directly impact the relative probability of fire spread and contamination presented in Tables F8.1 and F8.2.

Power to the electrical equipment outside the glovebox is not addressed by this study. A fire starting outside a glovebox will violate the enclosure integrity prior to activation of an interior system. Since the enclosure is breached and the fire is external, suppression relies upon the rooms protection systems.

The addition of detectors and an alarm indicating system will improve the response to a fire. These safety measures must also be combined with an effective means of extinguishing a glovebox fire without risking loss of containment. As mentioned for Option 3, the use of a bayonet extinguisher to puncture a glove poses the risk of losing containment and contaminating the room. This concern arises from the possibility of improper use of the bayonet or from the withdrawal of the bayonet. For these reasons, this fire fighting tactic is typically considered a last resort. In order to make this fire fighting tactic more effective and less risky, a new bayonet design and training program will be instituted as part of this option.

The new bayonet design will follow that developed at Argonne National Laboratories [McKinnis, Dec. 1996]. The bayonet tip will be designed to allow for more efficient penetration and a wider/fuller spray pattern than the current bayonet in use at Hanford. The new design will also include a quick disconnect which allows the bayonet to be disengaged from the extinguisher after discharging. This design, along with appropriate procedural changes, will reduce the risk of breaching the glove itself by avoiding the removal of the bayonet. In addition to the design changes, personnel who will be working in the operational area will be trained to properly use the bayonet extinguisher. This training will include hands-on fire extinguishing training exercises in mockup gloveboxes. Through this training program, personnel are expected to be more prepared to effectively extinguish a glovebox fire with little risk of breaching containment.

Compared to Option 3, the changes in the bayonet design along with the training program is expected to provide enhanced protection over the use of quick connect couplings. The use of a bayonet allows more direct application of agent to the source of the fire than can be obtained with the quick connect coupling design. Though there is a greater probability of potentially breaching containment with a bayonet compared to the quick connect coupling, proper use of the bayonet coupled with early detection should limit the extent of fire spread and contamination.

Providing fire watches during the active use of the gloveboxes is an additional feature of this option which will provide a factor of safety to glovebox operations. Fire watches will consist of glovebox operators who will be directly viewing operations (i.e., transporting materials via conveyors in HC-3, HC-4, and HA-28, or moving materials within HA-23S) in the gloveboxes when they are active. The fire watch will be responsible for overseeing operations and surveying the entire glovebox while active. A fire watch is expected to be able to either observe the signs of a growing fire (e.g., a glow or smoke) before a heat detector reaches an alarm condition or be able to respond within seconds to a fire that is indicated via the heat detector alarms. Although a fire watch has obvious advantages of providing fast response time to a fire, compared to the other protection options analyzed, the addition of this feature provides only a marginal advantage in the relative probability analysis presented in Tables F8.1 and F8.2. The reason for this is that all the analyses assumed that during operation hours, the process area will be manned, and the glovebox operators will attempt to control and/or extinguish a fire. Therefore, the advantage is only realized when the fire watch is able to spot an incipient fire before it activates a heat detector alarm.

As indicated through this discussion, Option 8 is most appropriately analyzed in light of Option 3. The primary difference that substantially changes the probability analyses is the exclusion of the HC-4 airlock. Overall, Option 8 provides for early fire detection via fire watches and/or heat detectors with instant notification to personnel of the fire location via the indicating lights or annunciation panel. This fire protection strategy allows glovebox operators to respond immediately to the source of the fire. Similar to Option 3, it is anticipated that operators in the process area will be able to respond to the fire within a minute of hearing the alarm. With a maximum alarm time of 184 seconds, personnel should be able to respond to the fire within 244 seconds. At this time, the fire would be expected to be no larger than 700 kW (see Section 5.4). This size fire is approximately 80 percent of the maximum extinguishable fire size that can be suppressed with the dry chemical extinguishers. The use of an improved bayonet design will allow personnel to directly extinguish the fire with a decreased risk of losing containment.

As a result of this relatively fast response, there is a 75 percent probability that the fire will be limited to either a single glovebox (40%) or a single glovebox and the adjacent box (35%). Each scenario is approximately equally as likely, the outcome being primarily dependent on the location of the initial fire. For example, if the fire starts near the connection of two gloveboxes, it is likely to spread to portions of both. However, a 430 kW fire could be contained within one glovebox. Compared to Option 3, this option results in a slightly larger probability of containing the fire to a single glovebox. This is due to the advantages of having operators

specifically serve as fire watches and the increased effectiveness of using a bayonet extinguisher compared to the fixed quick connect couplings.

Similar to the analysis for Option 3, there is an expected 25 percent probability that the fire may grow to a size that is not extinguishable and, therefore, could spread to other gloveboxes. However, because there is no physical means to prevent fire spread through the glovebox HC-4 (i.e., no airlock), there is a 20 percent probability that the fire could spread to all connected gloveboxes. There is a small chance (5%) that the fire could be controlled to a single glovebox line because of the fire department intervention.

For Option 8, the relative probability analysis for contamination is affected in a similar manner to the fire spread analysis. Compared to Option 3, the probability of a fire contaminating just the glovebox (25%) or the room of fire origin (40%) remains the same (65%) for Protection Option 8. However, compared to Option 3, there is a slightly larger probability of containing the fire to a single glovebox. This is due to the advantages of having operators specifically serve as fire watches and the increased effectiveness of using a bayonet extinguisher compared to the fixed quick connect couplings. Since there is an increased probability that the fire will spread through all connected gloveboxes, there is a corresponding increase in the probability that contamination will spread through all of Zone 3 (30% instead of 5% for Option 3). If a fire is not contained to one or two gloveboxes, the fire is expected to breach windows and gloves in both glovebox lines. There is only a marginal probability (5%) that the fire and contamination will be maintained to only one side of the process area.

Assuming that a fire occurs, there are no features of Option 8 that will provide additional protection over Protection Option 1 during unmanned hours. Therefore, the probabilities for the extent of fire spread and contamination are the same for Option 8 as for Option 1 during unmanned hours. As can be seen in comparing Table F8.1b to F8.1a, there is greater probability that a fire will spread to either a glovebox line or to all connected gloveboxes during unmanned hours. There is a 0 percent probability that a fire will be limited to a single glovebox or two.

F9.0 SUMMARY

Section 8 presented eight strategies for fire protection of the 94-1 Process line gloveboxes. The level of protection that each strategy provides was discussed in light of the governing factors described in Section 5, such as fire detection, ventilation, and personnel response. The probabilities presented in Tables F8.1 and F8.2 for the different levels of flame spread and contamination represent a relative ranking between all seven fire protection strategies discussed. Options 1, 'Do Nothing' and 7, 'FHA Recommendations,' represent the bounding levels of protection from which the other strategies were evaluated. For each level of damage presented in Tables F8.1 and F8.2, appears an associated cost estimate for fire damage replacement costs and contamination cleanup costs, respectively.

Risk in this document is defined as the probability of loss due to a fire times the consequences of that event. In this analysis, the consequence of a fire in a 94-1 glovebox is the

monetary cost of replacing the damaged contents in addition to the cleanup cost for the contamination. Table F9.1 presents the summary of expected monetary loss for the various protection options. These summary values reflect the estimated risk associated with each option.

Table F9.1 Summary of Expected Monetary Loss for Various Protection Options

Protection Option	Protection Strategy	Expected Loss During Manned Hours	Expected Loss During Unmanned Hours	Total Expected Loss
PO 1	- Do nothing	$1,900,000	$1,940,000	$1,915,000
PO 2	- HC-4 airlock	$1,490,000	$1,540,000	$1,510,000
PO 3	- HC-4 airlock - HC-3 and HC-4 heat detectors/lights - Quick-connect couplings	$880,000	$1,540,000	$1,145,000
PO 4	- HC-4 airlock - HC-3 and HC-4 heat detectors/lights - Quick-connect couplings - Shut down air supply	$845,000	$1,500,000	$1,105,000
PO 5	- HC-4 airlock - HC-3 and HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves	$785,000	$1,300,000	$990,000
PO 6	- HC-4 airlock - HC-3 and HC-4 heat detectors/lights - Quick-connect couplings - Cover windows and gloves - Shut down air supply	$705,000	$750,000	$720,000
PO 7	- Automatic suppression in all gloveboxes (FHA criteria)	$605,000	$605,000	$605,000
PO 8	- HC-3 & HC-4 detectors/lights - Electrical disconnect - New bayonet design/training - Fire watch	$1,010,000	$1,940,000	$1,105,000

The expected loss for each protection strategy is calculated by summing the cost of each level of fire and contamination damage by the corresponding probability of that event occurring. For example, the expected loss of Protection Option 1 during manned hours of operation is calculated as:

$$\textit{Expected Loss} = \Sigma(\textit{Probability of Damage Occuring})(\textit{Cost of Damage})$$

$$\textit{Expected Loss (1)} = \{0.75\ (\$1{,}740{,}000) + 0.20\ (\$1{,}360{,}000) + 0.00\ (\$620{,}000) + 0.05\ (\$590{,}000)\}_{\text{fire}} + \{0.65\ (\$400{,}000) + 0.30\ (\$100{,}000) + 0.05\ (\$40{,}000) + 0.00\ (\$0)\}_{\text{contamination}}$$

$$\textit{Expected Loss (1)} = \$1{,}898{,}500$$

Table F9.1 contains three columns of expected monetary losses. The first column is the expected loss during manned hours. The values reported in this column are calculated using the above equation and data from Tables F8.1a and F8.2a. The second column contains the expected loss during unmanned hours. The loss values are again calculated using the above equation but with data from Tables F8.1b and F8.2b. The third column of monetary loss data contains the total expected loss for each option. The total expected loss is a weighted combination of the expected monetary losses during manned and unmanned hours of operation. The total expected loss is calculated as follows:

Total Expected Loss =(Expected loss during manned hours)(RPFO-M) +
(Expected loss during unmanned hours)(RPFO-UM)

where RPFO-M and RPFO-UM are the relative probability of a fire occurring for a given option during manned and unmanned hours, respectively. The RPFO values are not absolute values of the probability for a fire to occur. Rather, they only reflect the expected probability between manned and unmanned hours of operation. Therefore, for each option the RPFOs for manned and unmanned hours must equal unity. Since the RPFO values are relative and particular to specific options, it is not valid to compare RPFO values for different options as a measure of which option has a greater or lesser probability of having a fire.

For Protection Options 1 through 7, the RPFO values for manned and unmanned hours of operation are the same since no fire protection features in any of these options affect the probability of a fire occurring. The RPFO for manned hours (RPFO-M) is 0.6, and the RPFO for unmanned hours (RPFO-UM) is 0.4. For Option 8, the installation of electrical disconnect switches effects the probability of a fire occurring during unmanned hours. Since the primary ignition sources in the gloveboxes potentially arise from electrical equipment failures or mechanical overheating, there is a reduced probability that a fire will occur when all power is disconnected and the conveyors and lifts are not operating. Therefore, with Option 8 the RPFO during manned hours (RPFO-M = 0.9) is much greater than the RPFO for unmanned hours of operation (RPFO-UM 0.1).

As can be seen in Table F9.1, the total expected loss decreases with the increasing levels of protection provided by Options 1 through 7. With the existing fire protection measures (i.e., Option 1), the expected loss is $1,915,000. Implementing Protection Option 3 results in a substantial reduction in risk to an expected loss of $1,145,000. With respect to the optimum strategy (i.e., Option 7, FHA criteria), implementing Option 3 results in $540,000 of additional loss. Implementing Option 8 results in an expected loss of $1,105,000. Compared to Option 7, this is an increase of $500,000. Option 8 is an alternative strategy compared to Options 2 through 6 which are all based on the protection strategy of adding the HC-4 airlock. Implementing Option 8 will result in $40,000 reduction in loss compared to Option 3, which is most similar in fire protection except for the airlock.

The relatively marginal differences between expected losses for Options 3 through 6 is primarily a result of assuming worst case replacement costs for gloveboxes. The replacement cost for glovebox HA-23S ($590,000) is very large compared to most other gloveboxes which are typically about $30,000. As a result, the expected losses may represent a conservatively high prediction of risk, particularly for Option 7 for which there is a 70 percent probability of limiting fire spread to a single glovebox.

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G. W. Grier III	B1-13	X
D. L. Jackson	G1-15	X
E. S. McGinley	H8-69	X
L. J. Olguin (Assignee)	N1-26	X
E. L. Reynolds	N1-26	X
L. K. Trent	H8-67	X
C. L. Whalen	H8-67	X
B&W Hanford Company		
W. F. Heer	H5-31	X
B&W Protec, Inc.		
D. L. Baker	L4-01	X
DynCorp Tri-Cities Services, Inc.		
R. S. Frix	H5-33	X
D. E. Good	S3-97	X

PHMC CORRESPONDENCE CONTROL
For Questions or Distribution/MSIN Corrections
Contact: Chris Hough @ 376-8111 or Glenna Lenz @ 372-3931

CC RECD: 05/07/97

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

MAY 6 1997

97-TPD-090

Mr. H. J. Hatch, President
Fluor Daniel Hanford, Inc.
Richland, Washington 99352

Dear Mr. Hatch:

CONTRACT NUMBER: DE-AC06-96RL13200 - RL COMMENTS ON THE PLUTONIUM FINISHING PLANT (PFP) COMPLEX FIRE HAZARDS ANALYSIS (WHC-SD-CP-FHA-004, REV. 0)

This letter formally provides FDH comments developed by the RL Quality, Safety, and Health Programs Division (QSH) review of the subject report. These comments were informally provided to Westinghouse Hanford Company personnel by David W. Templeton, PFP Program Manager, in September 1996. Discussions with PFP plant personnel and RL TPD and QSH staff have been occurring over the past several months. Resolution of these comments have been documented in the enclosed Review Comment Record (RCR) form. RL is in agreement with the manner in which these comments have been resolved, as indicated by the approval signature on the RCR form. When comments have been incorporated into that subject report, RL will also sign Section 11 of the RCR, indicating closure.

Also, RL is aware of the PFP 94-1 Glovebox Cost/Risk Analysis being performed and documented by BWHC, is reviewing that draft analysis, and will provide any developed comments directly to BWHC when the review is completed. FDH should ensure that when analysis is provided officially to RL for approval, it provides RL with a clear recommendation of the particular path forward that provides the most cost effective manner in which to manage the fire safety hazards of operating stabilization operations required for successful completion of 94-1 commitments.

FDH and BWHC are to be commended for the fine work they have been doing to date in developing the fire hazards analysis, and the activities to develop cost effective approaches to managing fire hazard risks at PFP.

If any direction is provided by a Contracting Officer's Representative (COR) which your company believes exceeds the COR's authority, you are to immediately notify the Contracting Officer and request clarification prior to complying with the direction.

If you have any questions, please contact Mr. Templeton, of my staff on 373-2966, or you may contact Craig Christenson, QSH Fire Protection Engineer, on 376-5367.

Sincerely,

J. E. Mecca, Director
Transition Program Division

TPD:DWT

Enclosure

cc w/encl:
E. C. Vogt, BWHC
L. G. Olguin, FDHC
D. L. McKinnis, BWHC

1RL-F-1325.6# DEF012
(04/93)

United States Government

memorandum

Department of Energy
Richland Operations Office

DATE: AUG. 27 1996
REPLY TO ATTN OF: QSH:CPC/96-QSH-033

SUBJECT: REVIEW AND APPROVAL OF FIRE HAZARD ANALYSIS (FHA)

TO: J. E. Hecca, Director
Transition Programs Division

As requested, Engineering Data Transmittal 700527, the FHA for the Plutonium Finishing Plant Complex (WHC-SD-CP-FHA-004, Rev 0), dated June 28, 1996, has been reviewed in accordance with RLID 5480.7, Section 6.1 b (13), and is approved based upon the incorporation of comments in the attached.

If you have any questions or comments, please contact Craig Christenson, of my staff, on 376-5367.

Steve J. Veitenheimer, Director
Quality, Safety, and Health
Programs Division

QSH:CPC

Attachment

cc w/attach:
W. D. Seaborg, SOD
D. W. Templeton, TPD

ATTACHMENT

**REVIEW OF FIRE HAZARDS ANALYSIS
FOR THE PLUTONIUM FINISHING PLANT COMPLEX
WHC-SD-CP-FHA-004, REV 0
DATED JUNE 28, 1996**

The following comments must be incorporated into the Fire Hazard Analysis (FHA) for the Plutonium Finishing Plant Complex (WHC-SD-CP-FHA-004, REV 0) dated June 28, 1996:

a. Executive Summary, Item 1, Introduction (page 17), of the FHA states that the FHA was "conducted in accordance with DOE 5480.7A". However this paragraph does not appropriately state that the FHA was also conducted in accordance with RLID 5480.7, Fire Protection. RLID 5480.7 is referenced several time through the FHA.

b. Executive Summary, Item 2 (page 18) and Section 2 (page 47), containing the FHA Summary and Conclusions, do not provide a conclusion whether or not the PFP facility complex meets the objectives of paragraph 4 of DOE 5480.7A, Fire Protection as required by DOE 5480.7A, Section 9 a (3).

c. Executive Summary, Item 5 (page 20) and Section 5.1 (page 62) do not state that the PFP Complex does not have redundant sources of water supply as required by RLID 5480.7, Section 8.1 c and as describe as a reliability concern in the September 1986 Factory Mutual Research Corporation fire protection report review of 200 East and 200 West Facilities (Recommendation 86-2). The FHA must address this issue as well as whether or not Hanford Project B-604, Water Utility Upgrades will provide redundant water supply of adequate pressure and capacity to the PFP Complex Facilities.

d. Section 3.1.2 (page 51) discusses combustibles in the duct level but the FHA does not discuss whether or not if ducting and other ventilation areas in the 234-5Z facility contain any hold up of plutonium bearing materials. As this has been a concern at other plutonium facilities in the DOE Complex the FHA must state whether or not this condition exists in PFP Complex Facilities.

e. Section 8, last paragraph (page 180) states that "Based on input from the PFP staff, total failure of Safety Class systems is not possible as a result of any of the MPFL scenarios". As the FHA must describe the thought process that was utilized to develop conclusions the FHA must describe the "input from the PFP staff" and explain why safety class system failure is not possible resulting from fire.

f. Section 12.1.1.1 (page 190) identifies Table 6-6 as containing clean up costs. Table 6-6 does not contain clean up areas. Table 6-5 contains clean-up areas.

g. In 1992 an order compliance assessment for fire protection was conducted for PFP facilities (Reference WHC Internal Memo R. R. Warnecke of

September 3, 1992, Self-Assessment of DOE Order 5480.7, Fire Protection 10200-RRW-021) that identified several fire protection concerns for PFP that have never been corrected and/or exemptions that have never been formally processed and approved (note that the requirements found in canceled DOE Order 5480.7 are still applicable in current DOE fire protection requirements). The FHA does not identify these items. These items include the following:

a. There is not an adequate backup water supply for PFP (a compliance schedule approval request stated that Project B-6D4 was scoped to provide the necessary separate water supply to PFP).

b. In a fire protection survey performed on 10/31/90 Butvar (a smoke producing polyurethane foam) coatings in walls in Building 242-Z were identified as materials that does not meet interior finish flame spread and smoke development requirements and an exemption request was suggested.

c. Liquid Run-Off Control (resulting from fire related run off) has not been provided for PFP and an exemption request was suggested.

d. Lack of fire barriers to limit the maximum possible fire loss was identified twice and an exemption request was suggested in both occasions. Due to the FHA utilizing fire modeling techniques for analyzing maximum possible fire losses (note that DOE 5480.7A, Section 7 k states that the maximum possible fire loss is the "value of property, excluding land, within a fire area, unless a fire hazards analysis demonstrates a lesser (or greater) loss potential") an "exemption requested" is no longer necessary for fire barriers because the MPFL values identified in FHA Table 12-1 are less than $50 million (see DOE 5480.7A, Section 9 b (4)).

e. Vertical openings (including stairways, elevators, and ducts) to control fire spread was identified as a deficiency and an exemption request was suggested.

h. A Plutonium Finishing Plant 94-1 Thermal Stabilization Process Cost/Risk Analysis of fire protection items is/has been conducted that must be incorporated as applicable into the fire hazard analysis.

i. Section 20 (page 214) contains a number of recommendations in the fire hazards analysis that requires program implementation. The contractor must be directed to develop an FHA recommendation implementation plan that addresses each recommendation item in the FHA. The FHA implementation plan should also provide schedules and appropriate action tracking needed for executing and completing the items as well.

k. RLID 5480.7, Section 6.2 e (and future DOE O 420.1, Facility Safety, Section 4.2.1.5) require the fire hazard analysis to be referenced by facility safety analysis documentation. In addition as per WHC-CM-4-41, Section 3.4, paragraph 3.2 the "fire hazard analysis must be part of the facility safety analysis report" following the requirements of WHC-SD-GN-FHA-30001, Rev.0. As facility safety documentation is updated the fire hazard analysis must be referenced by the safety documentation. (Note that when implemented by the Contracting Officer, DOE O 420.1, Facility Safety, Section 4.2.1.5 will require that, "The conclusions of the FHA shall be incorporated in the Safety Analysis Report (SAR) Accident Analysis and shall be integrated into design basis and beyond basis accident conditions.")

QSH:CPC 8/24/96

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
October 28, 1996	DOE-96-001
3. Project No.	4. Page 1 of 6

5. Document Number(s)/Title(s)	6. Program/Project/ Building Number	7. Reviewer	8. Organization/Group	9. Location/Phone
WHC-SD-FHA-004, Rev 0, "Fire Hazards Analysis for Plutonium Finishing Plant Complex"	PFP/234-5Z	C. P. Christenson / D. L. Mckinnis	DOE/QSH PFP Fac System Eng	DOE-RL/376-5367

17. Comment Submittal Approval:

Organization Manager (Optional) — Date

10. Agreement with indicated comment disposition(s)

Reviewer/Point of Contact — 8-27-98 — Date

Author/Originator

11. CLOSED

Reviewer/Point of Contact — 8-27-9 — Date

Author/Originator

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
Lea Gen 1	Any comments made within Executive Summary or Sections that effects any other portion of the FHA must be revised along with the changes (Table of Contents, Figure Index, page numbering, summary; conclusions, recommendations, etc.).		General, see all comments below and address accordingly (Lea)	
a.	Executive Summary, Item 1, Introduction (page 17), states that the FHA was "conducted in accordance with DOE 5480.7A." However this paragraph does not appropriately state that the FHA was also conducted in accordance with RLID 5480.7, Fire Protection, RLID 5480.7 is referenced several times through the FHA.		Editorial - (pg 17) Will be revised to read as follows: "The analysis was conducted in accordance with RLID 5480.7 *Fire Protection* [DOE Directive RLID 5480.7, 1/17/94] and DOE Order 5480.7A, *Fire Protection* [DOE Order 5480.7A, 2/17/93] and addresses each of the sixteen principle elements outlined in paragraph 9.a(3) of the Order.	
b.	Executive Summary, Item 2 (page 18) and Section 2 (page 47), containing the FHA Summary and Conclusions, do not provide a conclusion whether or not the PFP facility complex meets the objectives of paragraph 4 of DOE 5480.7A, Fire Protection as required by DOE 5480.7A, Section 9a (3).		Editorial - (pg 18 & 47) A statement will be added to Section 2: "The PFP Facility Complex with the incorporation of recommendations in the FHA will meet the objective of Paragraph 4 of DOE 5480.7A.	

A-6400-090.1 (03/92) WEF011

REVIEW COMMENT RECORD (RCR)	1. Date October 28, 1996	2. Review No. DOE-96-001
	3. Project No.	4. Page 2 of 6

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
c.	Executive Summary, Item 5 (page 20) and Section 5.1 (page 62) do not state that the PFP Complex does not have redundant sources of water supply as required by RLID 5480.7, Section 8.1c and as described as a reliability concern in the September 1986 Factory Mutual Research Corporation fire protection report review of 200 East and 200 West Facilities (Recommendation 86-2). The FHA must address this issue as well as whether or not Hanford Protect B-604, Water Utility Upgrades will provide redundant water supply of adequate pressure and capacity to the PFP Complex Facilities.		See attached Sheets, for corrected section. Executive Summary will be modified accordingly.	
d.	Section 3.1.2 (page 50) discusses combustibles in the duct level but the FHA does not discuss whether or not if ducting and other ventilation areas in the 234-5Z facility contain any hold up of plutonium bearing materials. As this has been a concern at other plutonium facilities in the DOE Complex the FHA must state whether or not this condition exists in PFP Complex Facilities.		(pg 50, Section 3.1.2) See attached sheets for corrected section.	
e.	Section 8, last ¶, page 180, states that "Based on input from the PFP staff, total failure of Safety Class systems is not possible as a result of any of the MPFL scenarios." As the FHA must describe the thought process that was utilized to develop conclusions the FHA must describe the "input from the PFP staff" and explain why safety class system failure is not possible resulting from fire.		See attached Sheets, for corrected section.	
f.	Section 12.1.1.1 (page 190) identifies Table 6-6 as containing clean up costs. Table 6-6 does not contain clean up areas. Table 6-5 contains cleanup areas.		Editorial - Section 12.1.1.1 (pg 190) will be revised as follows: "This yields a contaminated areas identified in Table 6-5 is approximately...."	

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
October 28, 1996	DOE-96-001
3. Project No.	4. Page 3 of 6

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
g.	In 1992 an order compliance assessment for fire protection was conducted for PFP facilities (Reference WHC Internal Memo R. R. Warnecke of September 3, 1992, Self-Assessment of DOE Order 5480.7, Fire Protection 10200-RRW-021) that identified several fire protection concerns for PFP that have never been corrected and/or exemptions that have never been formally processed and approved (note that the requirements found in canceled DOE Order 5480.7 are still applicable in current DOE fire protection requirements). The FHA does not identify these items. These items include the following:		Addressed under each item g-a through g-e.	
g-a	There is not an adequate backup water supply for PFP (a compliance schedule approval request stated that Project B-604 was scoped to provide the necessary separate water supply to PFP).		Addressed above in comment c.	

A-6400-090.1 (03/92) WEF011

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
October 28, 1996	DOE-96-001
3. Project No.	4. Page 4 of 6

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
g-b	In a fire protection survey performed on 10/31/90 Butvar (a smoke producing polyurethane foam) coatings in walls in Building 242-Z were identified as materials that does not meet interior finish flame spread and smoke development requirements and an exemption request was suggested.		Pg 124, Section 6.4.1 will be revised as follows: "Building 242-Z was not accessible at the time of the site survey because the building has been sealed shut and is inaccessible. Based on the facility staff input and FSAR, the fuel loading in the facility is similar to the miscellaneous treatment room (room 41) in Building 236-Z (see section 6.5.1). This includes gloveboxes and process equipment with little to no transient combustibles in the room. In addition to the room contents, the interior surfaces of the 242-Z were coated with Butvar prior to the area being sealed. The fire performance of the Butvar is unknown since both combustibles and noncombustibles forms of the material exist and there is no documentation stating which was used in 242-Z. However, based on the facility being sealed with welded doors and caulking, the space being unoccupied, sprinkler protection being provided and being capable of protecting the entire area of concern, and the fuel load specified by facility staff and the FSAR, the interior finish is not a concern." The use of Butvar is also discussed in Section 9.9.	
g-c	Liquid Run-Off Control (resulting from fire related run off) has not been provided for PFP and an exemption request was suggested.		See attached sheets.	

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
October 28, 1996	DOE-96-001
3. Project No.	4. Page 5 of 6

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
g-d	Lack of fire barriers to limit the maximum possible fire loss was identified twice and an exemption request was suggested in both occasions. Due to the FHA utilizing fire modeling techniques for analyzing maximum possible fire losses (note that DOE 5480.7A, Section 7k states that the maximum possible fire loss is the "value of property, excluding land, within a fire area, unless a fire hazards analysis demonstrates a lesser (or greater) loss potential") an "exemption requested" is no longer necessary for fire barriers because the MPFL values identified in FHA Table 12-1 are less than $50 million (see DOE 5480.7A, Section 9b (4)).		NO ACTION REQUIRED - The lack of fire barriers that limit MPFL to $50 million in 5480.7 compliance assessment was revised in 5480.7A. It increased the MPFL to $150 million before requiring 3 hour fire walls with automatic fire suppression. The FHA illustrates that the facility does not exceed an MPFL of $150 million.	
g-e	Vertical openings (including stairways, elevators, and ducts) to control fire spread was identified as a deficiency and an exemption request was suggested.		NO ACTION REQUIRED - The DOE requirements for protection of vertical openings 10.b.(7) do not appear in the current Order 5480.7A that replaced 5480.7 in its entirety. Building 234-5Z is in compliance with the current edition of NFPA 101 (1994) for protection of vertical openings in an industrial occupancy [D Wyatt Internal Memo date 10/28/96]. Based on this, the Order Compliance Assessment Exemption Request is inconsequential.	
h.	A Plutonium Finishing Plant 94-1 Thermal Stabilization Process Cost/Risk Analysis of fire protection items is/has been conducted that must be incorporated as applicable into the fire hazard analysis.		NO ACTION REQUIRED - As this analysis is completed and approved, it will be be added as an appendix to the FHA.	

A-6400-090.1 (03/92) WEF011

REVIEW COMMENT RECORD (RCR)

1. Date	2. Review No.
October 28, 1996	DOE-96-001
3. Project No.	4. Page 6 of 6

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
i.	Section 20 (page 214) contains a number of recommendations in the fire hazards analysis that requires program implementation. The contractor must be directed to develop an FHA recommendation implementation plan that addresses each recommendation item in the FHA. The FHA implementation plan should also provide schedules and appropriate action tracking needed for executing and completing the items as well.		NO CORRECTION TO FHA - Facility System Engineering is working with plant management in the development of the required implementation plan. Implementation will be based on Plant priority and funding identified. Work will be place on the Plant's schedule as work is prioritized and tracked through the Plant's internal tracking system.	
j.	RLID 5480.7, Section 6.2e (and future DOE 0 420.1, Facility Safety, Section 4.2.1.5) require the fire hazard analysis to be referenced by facility safety analysis documentation. In addition as per WHC-CM-4-41, Section 3.4, paragraph 3.2 the "fire hazard analysis must be part of the facility safety analysis report" following the requirements of WHC-SD-GN-FHA-30001, Rev 0. As facility safety documentation is updated the fire hazard analysis must be referenced by the safety documentation. (Note that when implemented by the Contracting Officer, DOE 0 420.1, Facility Safety, Section 4.2.1.5 will require that, "The conclusions of the FHA shall be incorporated in the Safety Analysis Report (SAR) Accident Analysis and shall be integrated into design basis and beyond basis accident conditions."		NO CORRECTION TO FHA - The FSAR will be revised as needed to include the FHA after it has been released. The plant is aware and plans to include including the FHA incorporation in the next revision of the FSAR.	
LEA 1	Page 64 Section 5.2.1 Drawing callout H2-2-26916 is incorrect.		EDITORIAL Pg 64 Section 5.2.1 - WHC Drawing No H-2-26916 identifies the fire....	
LEA 2	Pg 6 Table Of Contents 6.10 needs to be indented, no space		EDITORIAL - Pg 6, Indent 6.10 to same format of other sub-sections within that section, remove space.	
LEA 3	Page 15, Acronyms, Add DCG		EDITORIAL Pg 15 - Add DCG Derived or Design Concentration Guide	

COMMENT ITEM: c and g.a

Section 5.1 will be modified accordingly:

"5.1 FIRE PROTECTION WATER SUPPLY

INSERT ¶1 from p. 62, Section 5.1

The Sanitary Water System is a shared system providing water for sanitary, process, and fire protection uses. The Fire Protection Water Supply Analysis (WHC-SD-SQA-ANAL-30001, Rev.0, August 18, 1995) provides recommendations which if implemented will increase the reserve fire protection water supply and the reliability of the water supply system.

The water supply analysis indicates that the sanitary water system is served by the existing primary sanitary clearwell system with a water storage capacity of 400,000 gallons and the secondary system with a 1,100,000 gallon reservoir for 200 West Area. Sanitary water system pumping capabilities cited by the analysis are summarized below:

200 West:

Primary System

- three electric pumps @1,000 gpm
- one electric pump @600 gpm

Secondary System

- one electric pump @ 4,000 gpm

The water supply analysis also indicates that the current raw water system for the 200 West area is serviced by a 3,000,000 gallon reservoir in addition to the 24 in. supply line from the 100 Area. Raw water pumping capacities to 200 West facilities are summarized below:

200 West:

- one electric pump @5,000 gpm
- three electric pumps @ 3,000 gpm
- one steam pump @3,000 gpm

The water supply analysis states that the 200 Area water systems are considered to be in fair condition, however, the systems are not in compliance with DOE 5480.7A and RLID 5480.7. Project B-604 is intended to bring the systems into full compliance with DOE Orders 5480.7A, 6430.1A, and RLID 5480.7. The project scope is to upgrade the 200 West water supply in three phases. Phase I and II are estimated by the project engineer to be completed by April 30, 1997 and Phase III was canceled via DOE approved Baseline Change Request LPM-096-050, Site Control Number W96-358 [McKinnis, 1996]. The canceled portion of this project would have installed a second 24 inch export line serving 200 West. Phase I and II of the project includes upgrading the export water system, the 200 Areas raw and sanitary water systems, and related

piping and reservoirs to ensure the availability of fire protection water for simultaneous process and domestic water usage. New raw water fire pumps will be installed in each of the 200 Areas. The pumps will be capable of meeting the maximum raw and sanitary water process and fire protection demand for the areas as follows:

200 West:

- Sanitary Water Capability: 1,100 gpm sanitary water plus 2,500 gpm fire flow for a total water demand of 3,600 gpm; to be supplied via one 4,000 gpm fire pump rated at 110 psi.

Although completion of Phase III may not directly affect the PFP Facility, there will be a continued reliability issue associated with the 200 West Area water distribution system. The "Improved Risk" level of fire protection as required for 200 West Area by DOE Order 6430.1A and 5480.7A is not addressed within this facility specific FHA.

COMMENT ITEM 1-d

Section 3.1.2 provides a description of the construction features provided in Building 234-5Z, specifically fire resistance rated separations. The reference to limited combustibles in the Duct Level is intended to support the estimated 2-hour fire resistance rating of the floor/ceiling assembly. For clarification purposes, the reader will be referenced to Section 6.3.1 which discusses the fuel loading in Building 234-5Z. In Section 6.3.1., the following text shall be added as Paragraph 2:

"The Duct Level in Building 234-5Z consists primarily of non-combustible ventilation ducts, plenums, and equipment As a result of the limited fuel load, no credible fire scenarios were identified which could potentially cause damage to the structure of spread to other areas of the facility. Based on a series of in situ NDA measurements [FSAR, WHC-SD-SAR-021, Section 7.4.2], an estimated 6 kg of crystalline form (non-dispersable) plutonium is contained in the exhaust ducting. However, since a fire in the Duct Level is not expected to damage the exhaust ducts, the potential fire and contamination hazard is considered to be less severe than for other areas of the building and therefore is not considered in the MPFL and MCFL scenarios."

COMMENT ITEM: e

SECTION 8 - PROTECTION OF ESSENTIAL SAFETY CLASS EQUIPMENT (pg 180, last ¶)

The last paragraph in Section 8 will be replaced with the following:

"If the suppression systems in the buildings fail, scenarios exist that can cause damage to Safety Class Systems. PFP's Safety Equipment is described by classification of structures, components and systems in the FSAR (Chapter 4, Section 4.4) [WHC-SD-CP-SAR-021]. The FSAR describes the equipment important to Safety and necessary to control the operational risks that PFP imposes on the environs and on and off site personnel. WHC-SD-CP-OSR-010 "PFP Operating Safety Requirements" provides additional controls and information necessary for proper function of the equipment and operational responses and restrictions when the safety class equipment performance has degraded.

Based on FHA analyses, total failure of all Safety Class Systems is not possible as a result of any of the MPFL scenarios. Based on PFP staff input, failure of Safety Class equipment and subsequent consequences of their failure is addressed in the FSAR and bounds all possible scenarios in the FHA.

The following discusses the effects of failure of individual safety class equipment and systems as specified by PFP staff:

- Total failure of Plutonium Building Structural Features and HEPA Filters Safety Class systems is addressed in Chapter 9 PFP FSAR [WHC-SD-CP-SAR-021] which accepts total shutdown of all safety systems in the most severe case, the design basis earthquake. The maximum release of radioactive materials out of the facility is within the limits specified by DOE. The analysis includes loss of containment through building structure failure. PFP has designed the ventilation system to shut down in the event of an earthquake. Seismically induced concurrent criticality and fire events have also been analyzed and do not produce an unacceptable release. The two stages of the HEPA Filters are located in different locations within the facility. The Primary Filter System located in room 308 is not expected to become involved in the MPFL scenario which prevents total loss of filtration. The alternative exists to manually shut down the system without resulting in unacceptable consequences. Thus the total loss of this safety class equipment has been addressed and the resultant consequences deemed acceptable by facility staff.

- The Effluent Stack Air Monitors are located on the stacks with common alarm equipment located in rooms outside of those areas affected in MPFL scenarios. Due to the various locations of the equipment, and the stack structures being noncombustible, total failure is not addressed.

- Both the HVAC Supply Fan Seismic Shutdown System and Liquid Detection/Interlock In 26" Vacuum System have been designed with

fail safe modes that shut down both systems with any disruption to the power supply.

- Glovebox Criticality Design Features Systems are located through out the facility. These systems were designed as passive safety features that will perform as needed in any fire scenario.

- The Plutonium Storage Arrays are not addressed in MPFL scenarios because of lack of fire potential. These systems were designed as passive safety features that will perform as needed in any fire scenario.

COMMENT ITEM: g.c

SECTION 15.5 (pg 205) LIQUID RUN OFF

Liquid runoff resulting from fire protection water (e.g., automatic sprinklers, fire department hose streams) provide an additional means for contamination to spread from the facility to the outside. In order to prevent the liquid runoff from spreading off-site, the facilities within PFP are provided with sink and process drains (see Figure 15-1). The drains which have a potential for containing contaminated runoff are piped through manholes to 243-Z Building.

Based on the total water supply for fire protection requirements for the PFP complex as defined in Section 5, Table 5.2 and the Hydraulic Calculations found in Appendix A of the FHA, liquid run off will not exceed the capacity of Pump Station No 1. The flow of the automatic sprinklers and hose stream (approximately 700 gpm) for 20 minutes is within the capacity of the pump station tank capacity. Contaminated liquid run-off may escape the building causing ground contamination and cleanup. However, the release to the soil will not impact the dose consequences addressed in Chapter 9, Section 9.2.4A.8.3 of the FSAR analysis.

Rainfall adds water via the storm drains add water to Pump Station No 1. The average rainfall for Hanford Area is 6.26 inches per year based on a 30 year average from 1961 to 1991 according to Pacific Northwest Laboratory Weather Forecaster. The drains have been flow tested at up to 695 gpm without exceeding capacity.

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APPENDIX H

AUTOMATIC SUPPRESSION IN GLOVEBOXES EXEMPTION REQUEST

CONTENTS

CORRESPONDENCE DISTRIBUTION COVERSHEET

Author	Addressee	Correspondence No.
F. R. Crawford S. R. Staley	L. J. Olguin	BWHC-9851833

Subject: EXEMPTION REQUEST FOR THE REQUIREMENTS FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT (PFP) 94-1 GLOVEBOXES

DISTRIBUTION

Approval	Date	Name	Location	w/att
		Correspondence Control	A3-01	X
		FDH President's Office	H5-20	X
		B&W HANFORD COMPANY		
		G. B. Chronister	T5-15	X
		M. W. Gibson	T5-55	X
		G. A. Glover	T4-20	X
		D. R. Groth	T4-15	X
		T. E. Huber	T5-50	X
		R. J. Kobelski	R3-56	X
		C. M. Kronvall	T5-15	X
		E. M. LaRock	T5-02	X
		W. S. Lewis	T5-55	X
		D. L. McKinnis	T4-20	X
		R. D. Pickett	T4-20	X
		A. L. Ramble	T4-54	X
		R. D. Redekopp	T5-15	X
		L. L. Reed	T5-57	X
		S. R. Staley	T5-11	X
		FRC:SRS File/LB	T5-50	X
		Fluor Daniel Hanford, Inc.		
		J. R. Bell	G1-15	X
		H. M. Bucci	G1-15	X
		J. D. Martin	N1-26	X
		U.S. Department of Energy, Richland Operations Office		
		K. A. Benguiat	R3-78	X
		B. F. Burton	T5-50	X
		A. B. Joy	R3-79	X
		J. E. Mecca	R3-79	X
		W. D. Seaborg	T5-50	X
		S. A. Sieracki	A7-80	X
		J. W. Todd	R3-78	X
		PFP/LB		

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To	L. J. Olguin, Project Director Fluor Daniel Hanford, Inc.	N1-26	
From	F R Crawford F. R. Crawford, Senior Director Plutonium Finishing Plant Project	T5-50	File No. Or Ref.: BWHC-9851833
Subj	EXEMPTION REQUEST FOR THE REQUIREMENTS FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT PROJECT (PFP) 94-1 GLOVEBOXES		Date: March 11, 1998

This Exemption Request is being resubmitted (previously submitted as an Equivalency, Correspondence Number BWHC-9761991) following incorporation of comments received from Fluor Daniel Hanford, Inc, . (Correspondence Number FDH-9761991 R1).

Attachment 1 is a permanent Exemption Request for the requirement for installing automatic fire suppression systems in existing Project 94-1 gloveboxes, where the maximum expected loss exceeds $1 million. This request is based on Attachment 2, the "Plutonium Finishing Plant (PFP) 94-1 Glovebox Cost/Risk Analysis," Rev . 1 (February 5, 1997). This innovative approach weighs the costs of installing fixed fire protection systems against the overall risks and expected useful life of the process.

Of the options discussed in the Cost/Risk Analysis, PFP has selected Protection Option 8 for implementation, and requests the U.S. Department of Energy, Richland Operations Office (RL) concurrence with this approach. Attachment 3 is a detailed implementation plan for Protection Option 8.

PFP further requests RL concurrence to begin glovebox operations (e.g. Vertical Denitration Calciner (VDC), material inventory) with Protection Option 8 implemented per that attached Implementation Plan. Until the glovebox heat detection and indicating light features are installed, PFP will rely solely on the continuous, dedicated fire watch, as described in the Cost/Risk Analysis, to perform detection and initiate notification functions during operations in the subject unprotected gloveboxes. The heat detection and indicating light feature provides secondary fire detection during operation of the gloveboxes. When the gloveboxes are not in operation, electrical power inside the gloveboxes will be deenerigized per another feature of Protection Option 8 to significantly reduce the probability of a fire.

The PFP Project requests that you concur with the PFP 94-1 Glovebox Cost/Risk Analysis, the Implementation Plan, and the attached Exemption Request and forward these to RL for approval. These actions resolve all outstanding comments to the PFP Fire Hazards Analysis by RL/Quality Safety & Health Fire Protection Engineer, Mr. Craig Christenson. If you have any questions regarding this request, please contact Mr. Chuck Sadanaga on 372-1378, or Mr. Steve Staley on 372-2598.

jmw

Attachments 3

ATTACHMENT 1

BWHC-9851833

EXEMPTION REQUEST FROM THE REQUIREMENT FOR INSTALLING
AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PROJECT 94-1 GLOVEBOXES

Consisting of 5 pages, including coversheet

EXEMPTION REQUEST FROM THE REQUIREMENT FOR INSTALLING AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PROJECT 94-1 GLOVEBOXES

A. REQUEST FROM WHICH EXEMPTION IS REQUESTED

From DOE Order 5480.7A, "Fire Protection":

9.b.(3) Automatic Fire Protection. **Complete automatic fire suppression systems shall be designed in accordance with applicable NFPA standards shall be provided as follows:**

(a) In all new structures over 5,000 square feet.
(b) **In all structures having an MPFL in excess of $1,000,000. or where the maximum credible fire will result in the loss of use of a vital structures for a period longer than that specified as acceptable to the applicable PSO.**

The bold text represents the applicable requirement for which this exemption is requested. In this case, the "structures" which have an MPFL in excess of $1,000,000 are the active 94-1 process gloveboxes HC-3,HC-4, HA-28 & HA-23S.

To get to this point, the following requirement path has been followed:

DOE-RL Implementing Directive, RLID 5480.7, "Fire Protection", Section 8.2, paragraph (d) stipulates that "gloveboxes handling hazardous or radioactive materials shall be protected from the effects of fire. The level of protection required shall be determined using the Glovebox Fire Protection Criteria contained in the DOE FIRE PROTECTION RESOURCE MANUAL."

The DOE-RL FIRE PROTECTION RESOURCE MANUAL, the Glovebox Fire Protection Standard, March 1993, part 1.2 states that "these criteria shall apply to existing glovebox installations when a fire hazards analysis demonstrates conditions warrant their application, or when determined by the DOE authority having jurisdiction."

The "Fire Hazards Analysis for the Plutonium Finishing Plant Complex," HNF-SD-CP-FHA-004, Rev. 0, (PFP FHA) addressed existing active gloveboxes used for Project 94-1 for compliance with the Glovebox Fire Protection Standard. The FHA recommends automatic suppression or inerting systems for active process line gloveboxes with plastic window construction (Table 7.3). The FHA further states (Section 7):

> *Recommended fire protection features are presented as a general guide; however, other alternatives are available for specific application based on a risk/cost analysis of the protection method versus the overall hazard.*

B. REASON FOR NON-COMPLIANCE

The costs to provide full automatic fire suppression in existing gloveboxes supporting Project 94-1 are estimated at approximately $750,000 (installation only). PFP Management deemed these expenses excessive considering the limited intended useful life of the facility and the subject gloveboxes. The PFP Project Director, supported by PFP Engineering and PFP Safety, initiated an effort to review several fire protection alternatives. The objective of the "Plutonium Finishing Plant 94-1 Glovebox Cost/Risk Analysis," Rev. 1 (dated February 5, 1997), was to evaluate potential risks and develop cost effective alternatives to providing complete automatic suppression coverage while maintaining an acceptable level of risk and safety. Of the options outlined in the "PFP 94-1 Glovebox Cost Risk Analysis," **Protection Option 8** offers the best overall reduction of the risk of fire, while being most cost effective in implementation.

C. JUSTIFICATION FOR NON-COMPLIANCE

The "PFP 94-1 Glovebox Cost/Risk Analysis," outlines several protection options, ranging from "do nothing" to "provide complete automatic suppression" in the gloveboxes. The analysis provides an evaluation of risks of each protection scenario using probability factors.

The PFP has chosen to pursue **Protection Option 8**, a selection of engineered systems and administrative controls. The objective of this option is to provide prompt detection which initiates immediate manual response to extinguish a 94-1 glovebox fire. **Protection Option 8** is described in detail beginning on page 49 of the analysis report. These protective measures, when fully implemented, will provide a level of protection commensurate with the level of risk.

D. HAZARDS ANALYSIS AND PROTECTION

The gloveboxes will be used to transport stainless steel containers (boats) of the pre- and post-processed materials. Additional items that will be transported from time to time will include packages of waste (plastic, rags, paper, or cardboard), tools, equipment, and cans of cement.

In general, the combustible fuel load in PFP gloveboxes is low. The acrylic window panels and Hypalon gloves are the primary combustible fuels in the gloveboxes. The most likely ignition source of a fire would be a mechanically or electrically overheated component igniting transient combustibles or other fuels associated with the glovebox process. A fire involving these fuels may then ignite the gloves or window panels, resulting in a more serious fire and potential loss of containment.

Several protection options were evaluated in the Cost Risk Analysis (Attachment 2) to mitigate the hazards. **Protection Option 8** was selected for implementation.

Protection Option 8 consists of the following items:

1. Install listed/approved heat detectors in gloveboxes HC-3 and HC-4.

2. Install heat detector indicator lights or annunciator panel(s) to direct operators to the area where fire is detected.

3. Provide a lower temperature setting (135°F) for heat detectors in gloveboxes HC-3, HC-4, HA-28, and HA-23S.

4. Install switches to de-energize electrical power from inside the affected gloveboxes during non-operating hours.

5. Implement a new bayonet fire extinguisher design. The new design features a quick disconnect bayonet that can be disconnected from the extinguisher and left in the glove to prevent spread of radiological contamination.

6. Provide hands-on training specific to the use of the bayonet fire extinguisher.

7. Initiate continuous fire watch during conveyor glovebox operations.

8. Modify procedures consistent with the features of this option.

When there is activity in the gloveboxes, these features establish visual detection of a fire condition and immediate manual suppression response in addition to automatic detection. When the gloveboxes are unmanned, electrical power, which is the primary ignition source, is deenergized inside the gloveboxes to significantly reduce the probability of a fire.

A detailed Implementation Plan is provided with the PFP 94-1 Glovebox Cost/Risk Analysis, attached to this Exemption Request.

E. BENEFIT ANALYSIS

The PFP Glovebox Cost/Risk Analysis, Section 9, outlines the total expected loss for each option. The "do nothing" approach yields a total expected loss for a 94-1 glovebox fire at $1,915,000. By implementing Protection Option 8, at an approximate cost of $317,000, the loss is reduced to $1,105,000.

The cost of installing automatic suppression throughout these gloveboxes ($750,000 plus design) would reduce the potential loss to approximately $605,000. Section 9 of the PFP Glovebox Cost/Risk Analysis summarizes the anticipated losses for each protection option.

OPTION	PROTECTION STRATEGY	COST	LOSS
PO 1	"Do nothing"	0	$ 1,915,000
PO 7	Automatic suppression in all 94-1 gloveboxes	$ 750,000 + design cost	$ 605,000
PO 8	(See Section D above)	$ 317,000	$ 1,105,000

F. TERM OF EXEMPTION

This request is for a permanent exemption effective through the life of HC-3, HC-4, HA-28, & HA-23S process glovebox activity.

G. REFERENCES

HNF-SD-CP-FHA-004, Rev. 0, Fire Hazards Analysis for the Plutonium Finishing Plant Complex; Hughes Associates; June 28, 1996.

Plutonium Finishing Plant 94-1 Glovebox Cost/Risk Analysis, Rev. 1; Hughes Associates; February 5, 1997.

ATTACHMENT 2

BWHC-9851833

PLUTONIUM FINISHING PLANT

PFP 94-1 GLOVEBOX COST/RISK ANALYSIS

Consisting of 26 pages, including the coversheet

(FOR ATTACHMENT 2, SEE APPENDIX F, PAGE F-1, OF THIS FHA)

ATTACHMENT 3

BWHC-9851833

IMPLEMENTATION PLAN FOR THE

PFP 94-1 GLOVEBOX COST/RISK ANALYSIS

Consisting of 6 pages, including coversheet

IMPLEMENTATION PLAN
for the
PFP 94-1 GLOVEBOX COST/RISK ANALYSIS

This plan outlines the implementation of the "Plutonium Finishing Plant 94-1 Glovebox Cost/Risk Analysis." This analysis has been incorporated as Appendix F in the PFP Fire Hazards Analysis, HNF-SD-CP-FHA-004, Revision 0.

Of the alternatives presented in the analysis, PFP has chosen to pursue Protection Option 8, a selection of engineered systems and administrative controls. By implementing Protection Option 8, as modified by this plan, a significant reduction of the risk consequences of fire are met while providing significant cost savings over installing automatic suppression throughout the affected areas.

The following plan outlines how PFP intends to implement features of Protection Option 8.

1. Feature: Listed or approved automatic fire detectors shall be installed in gloveboxes HC-3 and HC-4 in accordance with NFPA 801 and NFPA 72.

Implementation: PFP Engineering has designed new detection for the HC-3 and HC-4 gloveboxes. Reference Engineering Change Notice (ECN) 616156, released 8-25-97.

In lieu of a listed/approved heat detector, PFP Safety has approved the use of a Fenwal thermoswitch (model 17021-0) set inside a Fenwal thermowell (model 11204). This design is also documented on ECN 616156. Though the devices are not UL listed or FM approved for fire protection, they offer significant advantages for applications in existing contaminated gloveboxes. PFP Safety's approval is based on past DOE-RL approval, as documented in attachments to a DSI memo, H.H. Nguyenhuu to J.B. Witt, dated 6/10/96. The use of the thermoswitch for heat detection is thoroughly addressed in a paper titled, "Fire Detection Systems in Glove Boxes," by Glen Orihood, dated March 26, 1971.

Completion Date: Engineering is complete. Installation is contingent upon funding.

2. Feature: Install heat detector indicator lights at gloveboxes and/or install heat detector annunciation panel in process area.

Implementation: The design ECN (616156) is approved and released for the installation of strobe lights on top of the conveyor gloveboxes (HC-3, HC-4, & HA-28) and the storage glovebox (HA-23S). These strobes will provide a strong visible indication of the location of the detector which has caused the alarm.

In addition to the strobes, PFP Engineering has included in the design two remote annunciators, which will provide to Operations personnel as to the location of the fire. These zone annunciators will provide local indication on either side of the wall which separates the conveyor gloveboxes. All active gloveboxes without automatic suppression (HC-3, HC-4, HA-28, & HA-23S) will be listed on each annunciator panel.

Details of the subzone arrangement will also be available at a new fire alarm control panel, located in the fire alarm control center (Corridor 14A) of Building 234-5Z. At this location, PFP Operations and Hanford Fire Department will be able to easily identify the precise location of the source of a fire alarm.

Completion Date: Engineering is complete. Installation is contingent upon funding.

3. Feature: Set the alarm temperature level to 57°C (135°F) or lower for the heat detectors in HC-3, HC-4, HA-28, and HA-23S.

Implementation: PFP Facility Systems Engineering has provided PFP Safety with technical justification for why the detector temperature rating should not be lowered. Reference memo 15510-97-RDP-096, R.D. Pickett to D.M. Wyatt, dated August 12, 1997. Based on this evaluation, PFP has chosen not to implement this feature.

The concern for lowering the detector limits was initially raised by DOE-RL to PFP, as documented in CC:Mail meeting minutes (D.L. McKinnis to D.W. Templeton, C.P. Christenson, E.C. Vogt, & G.A. Glover, dated 4/21/97).

Completion date: Not applicable.

4. Feature: Install electrical disconnect switches to de-energize the power to the interior of the gloveboxes during non-operating hours.

Implementation: Recognized in the analysis as a means of reducing the risk of ignition, this feature will provide for the isolation of all electrical services to the interior of unprotected gloveboxes. Administrative controls will be implemented to require that the electricity to the interior of the gloveboxes be isolated during process down times (i.e. when the area is unattended).

According to PFP Engineering, gloveboxes HC-3, HC-4, and HA-28 have no internal power sources. Internal power to glovebox HA-23S, including motors and power receptacles, is presently isolated. The supply to these devices has been redesigned to include an isolation switch. Reference ECN 191630 and JCS work package 2Z-95-1364.

Completion date: Internal power is currently isolated. Glovebox HA-23S operations requiring internal glovebox power, will not be allowed in until the ECN is work completed and the necessary administrative controls have been established.

5. Feature: Implement new bayonet fire extinguisher design, as specified by PFP, which features a quick disconnect bayonet that can be disengaged from the extinguisher and left in the glove to prevent spread of radiological contamination.

Implementation: The new bayonet design is based on an existing field tested design which PFP Safety found in use at Argonne West.

No design documentation has been found for existing Hanford bayonet fire extinguishers. PFP Safety discovered that the existing bayonets are a shop modification which vary in construction and quality. The new design is documented on drawing H-2-99514.

Completion date: The new design has been fabricated and is in the process of being installed in all glovebox process areas in PFP. The mounting of the bayonet fire extinguishers will be complete prior to operations in the unprotected 94-1 gloveboxes.

6. Feature: Provide hands-on training specific to the use of the bayonet fire extinguisher.

Implementation: PFP Training and the PFP Fire Protection Engineer are working together on a lesson plan that will provide "hands-on" experience for personnel who might be expected to use a bayonet fire extinguisher. Training objectives will include an overview of fire classification and the appropriate fire protection equipment to use. For example, if a Plutonium metal or scrap fire is noticed in the glovebox, Magnesium Oxide (MgO) sand is the appropriate extinguishing agent.

The design of the new bayonet fire extinguisher will be introduced and discussed. The lesson will go into detail on the appropriate use of the ANSUL(R) extinguisher and how to properly pierce a glove. Training will involve the use of bayonet fire extinguisher(s) and a mock-up glovebox, fitted with actual Hypalon gloves. Students will be given the opportunity to practice piercing a glove. Discharging a bayonet fire extinguisher will be demonstrated in the initial class. The training extinguishers will be filled with a non-regulated agent for ease of disposal.

Completion date: Hands-on bayonet fire extinguisher training will be included as a punchlist item for the startup of operations in unprotected 94-1 gloveboxes.

7. Feature: Initiate continuous fire watch during conveyor (HC-3, HC-4, and HA-28) glovebox operations or when transporting materials to or from glovebox HA-23S.

Implementation: Administrative controls will be developed for establishing a designated fire watch at all times when conveyor operations are being performed in gloveboxes HC-3, HC-4, or HA-28. During operations in an unprotected glovebox, the designated fire watch will be responsible for continuous, dedicated, surveillance of the operation with the intent to provide the earliest detection of a glovebox fire and an immediate manual response.

Completion date: Procedures which address glovebox fire watch will be validated and approved prior to startup of operations in unprotected gloveboxes.

8. Feature: Modify response to glovebox fire procedure(s), as required.

Implementation: Prior to Project 94-1 start up, PFP will be thoroughly evaluating all procedures which may be impacted by the project and the Glovebox Cost/Risk Analysis, Protection Option 8. Of most importance, PFP is completely rewriting Operations Procedure ZO-200-010, "Respond to Plutonium Metal/Scrap Fires." This existing procedure will be expanded to include response actions for all types of glovebox fires (e.g., ordinary combustibles, metal, electrical).

Completion date: Procedures which address responses to fires in a glovebox will be revised, validated, and approved prior to startup of operations in unprotected gloveboxes.

CONCURRENCE:

E.M. LaRock, Manager
PFP Maintenance — Date: 3/4/98

E.M. Kronvall, Manager
PFP Engineering — Date: 3/4/98

M.D. Talbot, Manager
PFP Operations — Date: 3/4/98

L.L. Reed, Manager
PFP ESH&Q — Date: 3/4/98

R.D. Redekopp
PFP Plant Director — Date: 3/9/98

CORRESPONDENCE DISTRIBUTION COVERSHEET

Author	Addressee	Correspondence No.
F. R. Crawford	L. J. Olguin	BWHC-9851833 R1

Subject: REQUEST FOR ADDITONAL REFERENCES FOR THE EXEMPTION REQUEST FOR THE REQUIREMENTS FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PFP 94-1 GLOVEBOXES.

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		C. T. Sadanga	T4-20	X
		FRC:SRS File/LB	T5-50	X
		Fluor Daniel Hanford, Inc.		
		J. R. Bell	G1-15	X
		H. M. Bucci	G1-15	X
		J. D. Martin	N1-26	X
		U.S. Department of Energy, Richland Operations Office		
		K. A. Benguiat	R3-78	X
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		S. A. Sieracki	A7-80	X
		J. W. Todd	R3-78	X

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To	L. J. Olguin, Project Director Fluor Daniel Hanford, Inc.	N1-26	
From	F. R. Crawford, Senior Director Plutonium Finishing Plant Project FR Crawford	T5-50	File No. Or Ref.: BWHC-9851833 R1
Subj	REQUEST FOR ADDITIONAL REFERENCES FOR THE EXEMPTION REQUEST FOR THE REQUIREMENTS FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PFP 94-1 GLOVEBOXES		Date: March 19, 1998

Reference: Letter F. R. Crawford, BWHC, to L. J. Olguin, FDH, *Exemption Request for the Requirements for Automatic Fire Suppression Systems in Existing Plutonium Finishing Plant (PFP) 94-1 Gloveboxes,* BWHC-9851833, dated March 11, 1998.

Fluor Daniel Hanford, Inc. has requested additional documents to be provided in support of the Implementation Plan for the PFP 94-1 Glovebox Cost/Risk Analysis, submitted as Attachment 3 of the Exemption Request. The requested documents are attached.

Also, as a clarification, installation of the detector and indicator light, as described in the Implementation Plan, is contingent upon the U.S. Department of Energy, Richland Operations Office approval of the plan and subsequent approval of a funding change.

If there are any questions on this matter, please contact Chuck Sadanaga of my staff at 372-1378.

jmw

Attachment

B&W Hanford Co.

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D. M. Wyatt, Fire Protection Engineer PFP Safety	T5-11	
From R. D. Pickett, Cognizant Engineer PFP Facility Systems Engineering	T4-20	File No. Or Ref.: 15510-97-RDP-096
Subj DISCUSSION OF TEMPERATURE SETTING FOR HA-23S, HC-4, AND HC-3		Date: August 12, 1997

References:
(1) PFP 94-1 Glovebox Cost/Risk Analysis
(2) Fire Hazard Analysis for Plutonium Finishing Plant Complex, WHC-SD-CP-FHA-004 (FHA)
(3) Plutonium Finishing Plant Criticality Prevention Specification, Controlled Atmosphere Storage, Glovebox HA-23S, CPS-Z-165-80090
(4) Plutonium Finishing Plant Final Safety Analysis Report, WHC-SD-CP-SAR-021 (FSAR)
(5) ASHRAE Handbook 1981 Fundamentals
(6) Engineering-In Training Reference Manual, 8th edition
(7) Calciner Heat Transfer/Flow Analysis, Calc. No. K6137-1

Currently, an equivalency request is being written to accept Reference 1 and 2. The cost/risk analysis of Reference 1 is being submitted along with an equivalency request, because some of our gloveboxes do not have automatic fire suppressions. The facility has chosen option 8 outlined in Reference 1 that has us lower our fire alarm point for gloveboxes HA-23S, HC-4, and HC-3 from 165°F to 135°F along with other actions. The purpose of lowering the set point was to provide a quicker response to a fire, but the lower set point makes the facility more susceptible to spurious fire alarms. The following discussion will show that the lower set point could cause spurious alarms.

The following calculations are for glovebox HA-23S because of its inventory, and is a very basic calculation to show that conditions could cause a spurious alarm if the set point is 135°F. The temperature of concern is actually 130°F, since the thermoswitch used has a 5°F accuracy.

Assumptions:

1. No air flow through glovebox HA-23S. This is a good assumption based on discussions with the ventilation cognizant engineer, John Dick.

2. The sides of the glovebox with water walls will not conduct heat when compared to the other walls of the box. The only areas considered conduction heat is the top, bottom, and one end.

3. The rate of heat transfer is equal for all conducting surfaces.

4. All conducting surfaces are .25 inch thick stainless steel.

5. Dimensions are 170 x 48 x 138 inches.

6. There is no convection.

7. Inventory is 44,000 g of fissile material per Reference 3.

8. Room ambient temperature, To, is 105°F.

9. The thermoswitch sees the ambient temperature inside the glovebox.

Calculation:

The equation used to calculate the heat transfer rate from the inventory is found in section 9.2.4A.6.3.1.1 of the FSAR (Reference 4). The heat rate was calculated to be 3263.6 BTU/h based on an inventory inside glovebox HA-23S of 44,000 g (Reference 3). The next step was to determine the inside temperature using the following equation:

$$q = UA(Ti - To)$$

The overall thermal transmittance U, was calculated using the following equation from Reference 5, with the associated thermal conductivity (k) and thermal conductance (hi and ho) values from References 5 and 6.

$$U = 1/(1/hi + L/k + 1/ho)$$

These equations were re-arranged and input into an Excel spreadsheet to solve for the inside air temperature Ti, which was calculated to be 130°F. The actual numbers used and the spreadsheet layout are attached.

Another concern with spurious alarms comes from Reference 7 which calculates a skin temperature on the top of the calciner glovebox reaching 135°F. This glovebox will conduct heat to a heat detector near it and cause it to see an elevated temperature, but is not calculated here.

Conclusion:

The calculations show that it is possible to get spurious alarms if the set point is set at 135°F since the tolerance on the thermoswitch is 5°F. Several other factors were not considered which would affect the above calculation

like convection, other routes of heat transfer, and air stratification, but the calculations here show that spurious alarms associated with a set point of 135°F are possible and a real concern. The higher temperature set point of 165°F would avoid this concern and further analysis.

klm

Attachment

Distribution

G. A. Glover	T4-20
D. L. McKinnis	T4-20

Material	Thermal Conductivity, k	Thermal Conductance, C	Thermal Resistance, R
	BTU/(h * ft * F)	BTU/(h * ft2 * F)	ft2 * F * h/BTU
Inside Air layer		1.63	0.613496933
Stainless Steel, .25"	9.4		0.002216312
Outside Air layer		1.63	0.613496933
Total R			1.229210177
Thermal Transmittance, U			0.813530524
Heat Transfer Rate per unit area, q		q = U * (Ti - To)	
Solve for Ti		Ti = (q/U) + To	130.0728146
Solve for T at inside air to metal interface, Tm		Tm = Ti - (q/Uair)	117.5590109
Assume	To =	105	F
Heat Transfer Rate for Inventory, Qi		3263.6	BTU/h
Surface Area, Ai		160	sq. ft.
q = Qi/Ai		20.3975	BTU/(h * ft2)

DON'T SAY IT --- Write It!

DATE: 06/04/96

TO: James B. Witt

FROM: Huey H. Nguyenhuu
Telephone: 373-3993

cc: R.D. Keck T4-20
D.M. Wyatt T5-11
G.A. Glover T4-20
D.L. McKinnis T4-20
C.M. McGough B4-40

Ref: (1) Memo, C.M. Mcgough, 05/27/97.
(2) Kaiser Engineers Hanford Letter, B.A. Kendall, 05/05/84.
(3) Fire Detection Systems in Gloveboxes, G.M. Orihood, 03/26/71.

SUBJECT: FENWALL THERMOSWITCH (Cat. No. 17021).

Jim,

In response to the preliminary design of the fire protection system upgrade in glovebox HA-23 and conveyors HC-3,4 and HA-28, FDNW will proceed with the design utilizing the FENWAL THERMOSWITCH as means of fire detection.

Per Ref. (1), the UL listed heat detectors are not available for our application. In addition, after a thorough review of Ref. (2) and (3), I determine that the use of Thermoswitches is adequate for our current design based on the following reasons:

1. Uniformity: Fenwall Thermoswitches have used in gloveboxes on site and especially in our facility for many years.

2. Cost Effective / ALAR consideration: No modifications are required to the existing systems and devices are easily tested, repaired or replaced without breaking the containment.

3. Compatibility: The thermowells are made of corrosion resistant stainless steel needed for high acid atmosphere, i.e. gloveboxes.

4. Compliance: Fenwall Thermoswitches (17201) are UL listed as recognized components.

If I could provide you with additional information, please give contact me.

Sincerely,

Huey H. Nguyenhuu.

Comments on Fenwal thermowell heat detectors
by C. Mcgough
FDNW
5-27-97

This is in regard to the matter of the Fenwal thermoswithches which have been used in gloveboxes on site for many years. David Wyatt brought up the fact that these thermoswitches are not UL listed, so I called Fenwal to see if they make a detect-a-fire that will work in a thermowell.

According to Marv Charney of Fenwal, they don't make a detect-a-fire for a thermowell because if the detector is put in a well it lowers the listed temperature rating, so that UL won't approve them.

He said that even though the thermoswitches are not UL listed, they work very well in glovebox thermowells. He wanted to know if we want it to work or if we want it UL listed.

Since they don't make a detector that will work in the thermowells without voiding out the UL listing, we have no choice but to stick with the thermoswitches.

KAISER
ENGINEERS
HANFORD

KAISER ENGINEERS HANFORD COMPANY
POST OFFICE BOX 888
RICHLAND, WASHINGTON 99352

November 5, 1984

Rockwell Hanford Operations
ATTN: L. H. Jones
Cognizant Engineer
231-Z-200 West Area
Richland, WA 99352

Gentlemen:

B-569, RMC LINE FIRE SUPPRESSION SYSTEM

On October 31, 1984 Kaiser Engineers Hanford (KEH) met with Mr. Dave Evans - Department of Energy, Safety to discuss the use of the Fenwall Thermoswitch type heat detectors presently installed in wells to detect fires in gloveboxes. Prior to the meeting a copy of "Fire Detection Systems in Gloveboxes", a study performed by Hanford Engineering Services, was given to Mr. Evans for his review. (see attached)

Mr. Evans' main concern with the thermoswitch type heat detector is the fact that it is not UL listed for fire protection use. This was discussed with Mr. Evans and it was pointed out that the use of heat detectors in gloveboxes is a unique application. In addition, the above referenced study had discussed the advantages and disadvantages of various types of heat detectors and had determined that the thermoswitch type heat detector in a well was the most operationally cost efficient and feasible unit to use in radioactively contaminated gloveboxes.

The advantages that the thermoswitch unit provides are as follows:

- Easily tested, repaired or replaced without breaking containment.
- The wells are made of corrosion resistant stainless steel needed for high acid atmospheres.
- UL listed as a recognized component.

L. H. Jones
November 5, 1984
Page 2

In conclusion Mr. Evans agreed, that although the unit was not UL listed for fire protection, the thermoswitch unit could be used to detect fires in gloveboxes on the project. To facilitate their use the units must be preset at the factory for the temperature range necessary and equipped with an available temperature locking device to prevent the temperature setting from being inadvertently changed.

Should you have any questions and/or require any additional information, please advise.

Very truly yours,

B. A. Kendall

B. A. Kendall
Project Engineer

BAK/ss

Attachment

cc: D. A. Danch - Rockwell
C. J. Denson - KEH
A. G. Minister
G. H. Sudikatus
Central Files
BAK File
LB

ATTACHMENT 1

BWHC-9851833 R1

Don't Say It---Write It-including 3 references

Consisting of 21 pages, including the coversheet

FIRE DETECTION SYSTEMS
IN
GLOVE BOXES

Glenn M. Orihood
Fire Protection and Safety Engineer

March 26, 1971

HANFORD ENGINEERING SERVICES
Richland, WA 99352

FIRE DETECTION SYSTEMS IN GLOVE BOXES

Glenn M. Orihood
Fire Protection and Safety Engineer
Hanford Engineering Services, Richland, WA

Introduction

This paper is presented to discuss the use and application of a new detector system. This system is primarily intended for installation in glove boxes which have a high acid environment, but it also has features which make it desirable where containment of radioactive materials is a necessity. In addition, this paper will also discuss the modifications of a well known detector, which makes it desirable for this same use.

These problems of containment and chemical atmospheres were no doubt the factors evaluated by the Fire Protection and Safety Engineers in the early 60's at the Hanford Project. At that time, they selected a continuous line fire detector for installation in many of their glove boxes. This type of system has an advantage over the spot type, which may have dead areas in its span of coverage.

The unit chosen was the Fenwall Continuous Fire Detection System, which utilizes a tubing containing a eutectic salt mixture. This salt mixture melts at a predetermined elevated temperature and becomes electrically conductive. In this state it can then conduct a current between its central conductor and the outer metallic sheath. Figure 1 shows the sensing element for this system.

An open circuit voltage of 24 volts is impressed on the central conductor and the sheath. When fire or heat fuses the salt, the electrical circuit is completed in a fashion similar to the closing of a set of contacts. The current flow then activates a zone alarm and other alarm functions as desired. An additional desirable feature of the eutectic salt detector system is that it is self-restoring upon resolidification of the salt.

The choice of this system might not be questioned today if it were not for corrosion and its effect on the sheath of this detector. The jacket is Inconel, and Figure 2 shows a small section of one of these systems as it is installed and in service today. Figure 3, however, shows a typical section of a system which has corroded so badly that it is removed from serice. This unit is installed in a glove box used for Pu recovery operations. In an environment such as this, when the concentrations of nitric acid are 35% and more, the Inconel Sheath has a usable operating life of about five years. The failures cause shorting of the detector and it can no longer perform its intended functions.

At the first few signs of these failures, the operating contractor (Atlantic Richfield Hanford Company) requested Vitro/Hanford Engineering Services to investigate and recommend a course of action. We then initiated an in-depth study to determine the most acceptable and economical solution.

Factors Governing Selection of a Fire Detection System for Pu Recovery Glove Boxes

Our study disclosed that stainless steel was an optimum material for satisfactory operating life in the concentrated acid environment of the glove boxes. The boxes themselves are of stainless construction; and, if the detector system could be of the same base material, we would have a high system integrity. At the same time, the operating life would be extended greatly beyond the five years of the Inconel.

A check with Fenwall, however, soon disclosed that the Continuous Strip Detection System was not available with a stainless sheath. Since simple replacement was precluded, we continued our study of the factors pertinent to installation of another type of system. Containment of radioactive material and ease of installation were important additional factors. Added to this, we wished to provide rate of temperature rise detection in addition to fixed temperature detection ability. We also wished to secure automatic resetting of our detectors so that they could be periodically tested in place.

One of the UL Inc. listed devices which met these requirements was the stainless model of the Fenwall Detect-a-Fire. It is a combination fixed temperature and rate compensated detector with several fixed temperature settings available. The brass hex head and soldered plug in the bottom, however, would be affected by the acid environment and these conditions made it unsuitable for our use.

The New Glove Box Detector Systems

A modification of this system soon evolved. It provided for a combination fixed temperature, rate-or-rise type of detection system which was fully compatible with our operating requirements. The system, as developed, used

a Fenwall Thermoswitch in a stainless steel well. These components are shown in Figure 4. The thermoswitch is Model No. 17021-0 and is adjustable over a range of -100°F to 400°F. Its internal operating mechanism is shown in Figure 5. The initial installations were made with units calibrated to 160°F. The stainless steel sheath is Model No. 11201-0 and is 321 stainless. The current cost of these components is approximately $35 and compares favorably with the present unit price of $22 for the UL listed Detect-a-Fire.

The well-type units were installed on 8-ft centers in the longer glove boxes thus giving us a very favorable cost compared to the replacement costs for the continuous strip system. The mounting details for a unit are shown in Figure 6; and, from this, you will note the simplicity and yet the means by which containment is achieved. Figure 7 shows an installation in an operating glove box and is one unit in a line of four. The electrical circuit we are using is that of normally open alarm contacts and end-of-line resistor for complete electrical supervision of the system.

Fire tests were conducted to ascertain the response characteristics of the thermoswitch in a well as compared to a standard Detect-a-Fire. Two series were planned so that both fixed temperature and rate-of-rise performance could be evaluated in a glove box of 6 ft^3 volume.

The results of these tests are shown in Figure 8, which is Test No. 1. Test A was planned with a slow heat build up to simulate a Class A type of fire and thus require the detector to operate at its fixed temperature setting. You will note that the response of the well type unit compares very favorably with the standard unit experiencing a lag in the range of only 10-20%.

In Tests B and C, we prepared tests to determine response characteristics with a faster acting hydrocarbon fire. For these tests, we used a small alcohol pan fire of only .08 ft^2 area, 15cc of fuel, and the same detectors mounted at top center of the box. These two series of tests were identical except that the fire pan was moved from the extreme inlet side to the extreme outlet side. During these tests, we had an air exchange rate of almost four air changes per minute which is a rather stringent requirement.

Test No. 2 was conducted in a larger glove box of 30 ft^3 volume, which is more nearly a typical operating size. The results of these tests are shown in Figure 9. In Tests A and B, we wished to again determine response characteristics with a fast acting hydrocarbon fire. For these tests, we used a fire pan of 0.88 ft^2 with 50cc and 60cc of fuel for each test respectively. The smaller quantity of fuel was used for the fire directly under the detectors, and the larger quantity with the fire pan at the far end of the glove box. In both series, the detectors were directly in front of the vent at one end of the box as it was impossible to mount the units at top center of the box. One of the four glove ports on the box was left open and no forced ventilation was provided. The test was conducted outside, however, and a breeze blowing into the open port affected the response time of Unit No. 1 in the last two tests.

In Tests No. 1 and No. 2, a standard Fenwall Detect-a-Fire with a 160°F setting (Test Unit No. 2) and a Fenwall Thermoswitch, set at 150°F, in a well (Test Unit No. 1) were utilized for testing.

This data shows that the well-type detector performs reliably for either the slow build-up type of fire or the more rapid developing flammable liquid type fire. It has a time lag inherent to the use of the insulating well, but within the necessary limits of maximum temperature in our Pu recovery glove boxes, since the replaced units had a fixed operating temperature of 255°F. The thermoswitch itself is adjustable over a wide range, and any desired setting may be obtained by simulated test and simple adjustment of the unit. It can therefore be set and calibrated for its desired application by lowering its fixed temperature rating and thereby decreasing its operating time.

The second type of detector to discuss is the standard Fenwall Detect-a-Fire in a stainless jacket. Conversations with the manufacturer regarding some of our special requirements persuaded him to "remodel" his standard stainless production model. He has assigned this new unit a model number of 28021-S-140. The only significant changes are that of heliarc welding a cap on the end of the sensing sheath and replacing the brass hex head with a stainless steel unit. These replacements should overcome any objection to its use in high acid environments, which could cause deterioration and degradation of the thermoswitch. Its life expectancy should, therefore, be equal to the assembled well-type unit described earlier and which we have had in service for two years or more.

Figure 10 shows a picture of the standard detector. The new unit, not yet manufactured, will have the same physical size and will perform, we expect, in an identical fashion to this standard run unit. The cost is reported to be in the order of $35. The first lot of 100 will be utilized in a glove box installation in a Pu r&d laboratory managed by WADCO at the Hanford Project. The design for these systems has just been completed by Vitro/Hanford Engineering Services. In addition, we are currently in design for a second glove box system in another Pu facility operated by this contractor and will utilize this same new detector for that installation.

Summary

The investigation described here served to develop two new devices for inclusion in an already extensive line of fire detection units. Both have the inherent resistivity necessary for installation in high acid environments. We also feel that they have the necessary capability for reliable fire detection under these circumstances, as they have demonstrated in the tests that they will reliably detect both Class A and Class B fires before glove box integrity becomes a factor.

The new model Detect-a-Fire will have an advantage of shorter response time and should be selected where that is of paramount importance. The well-type unit, however, has an added advantage of ease of installation in existing contaminated equipment. Its thermoswitch can be removed, tested, or recalibrated in a clean area without removal of the well itself. Thus it has a higher degree of integrity for contamination control.

With a choice of two units, the Fire Protection Engineer can specify the unit or combination of units which will be most desirable for a particular application. Production-type glove boxes, where standard conditions exist, can utilize the new model Detect-a-Fire in a selected temperature range. R&d-type glove boxes, which could be subject to wide temperature ranges, may best utilize the well-type with its features of recalibration while retaining contamination control. Both devices deserve consideration for future special hazard fire detection systems.

Fig. 1

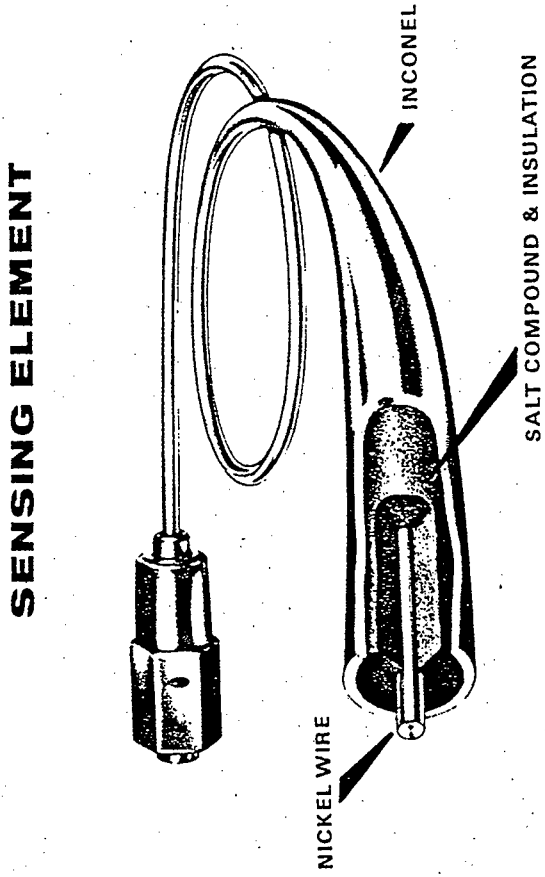

SENSING ELEMENT
NICKEL WIRE
INCONEL
SALT COMPOUND & INSULATION

Fig. 2

Fig. 3

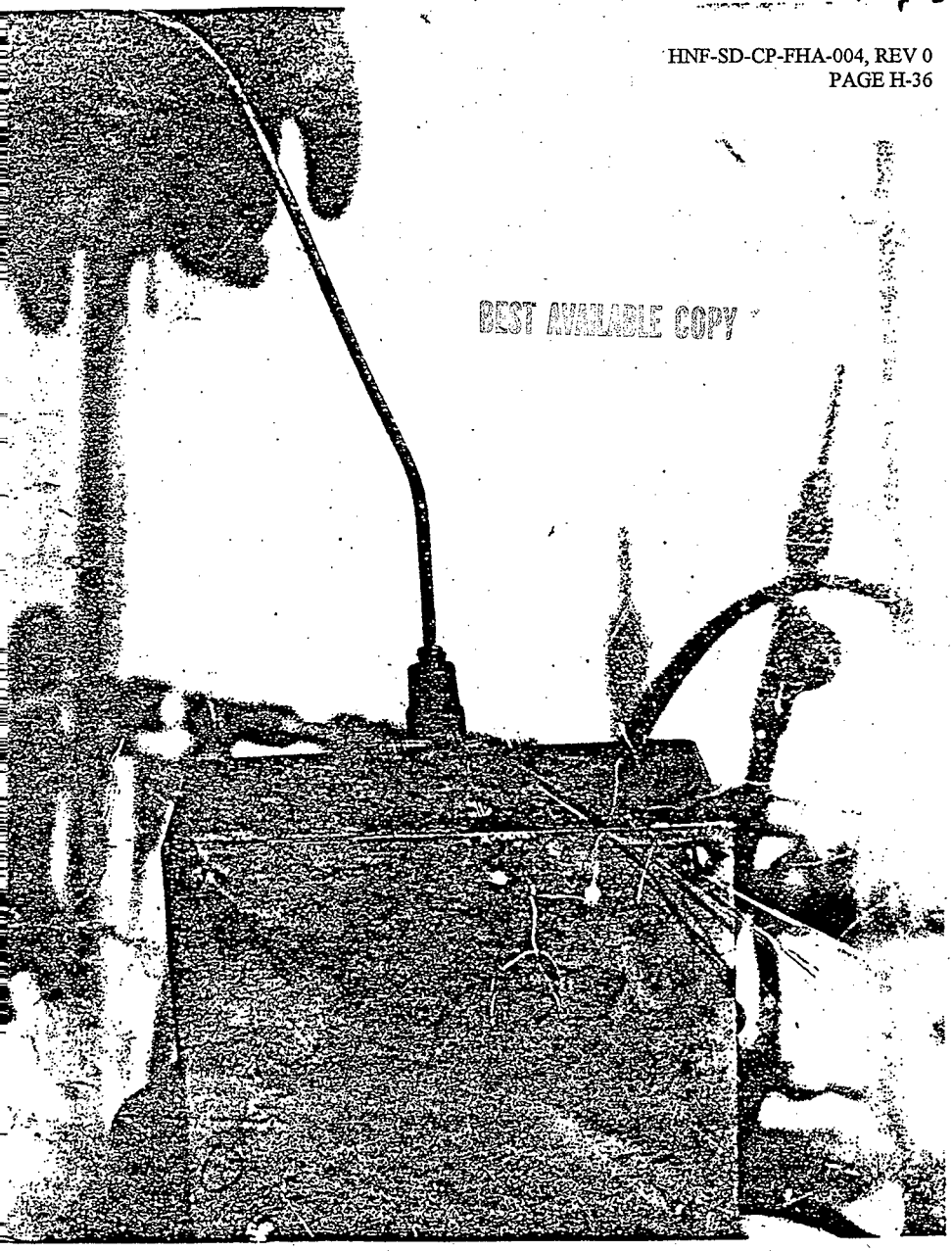


Fig.4

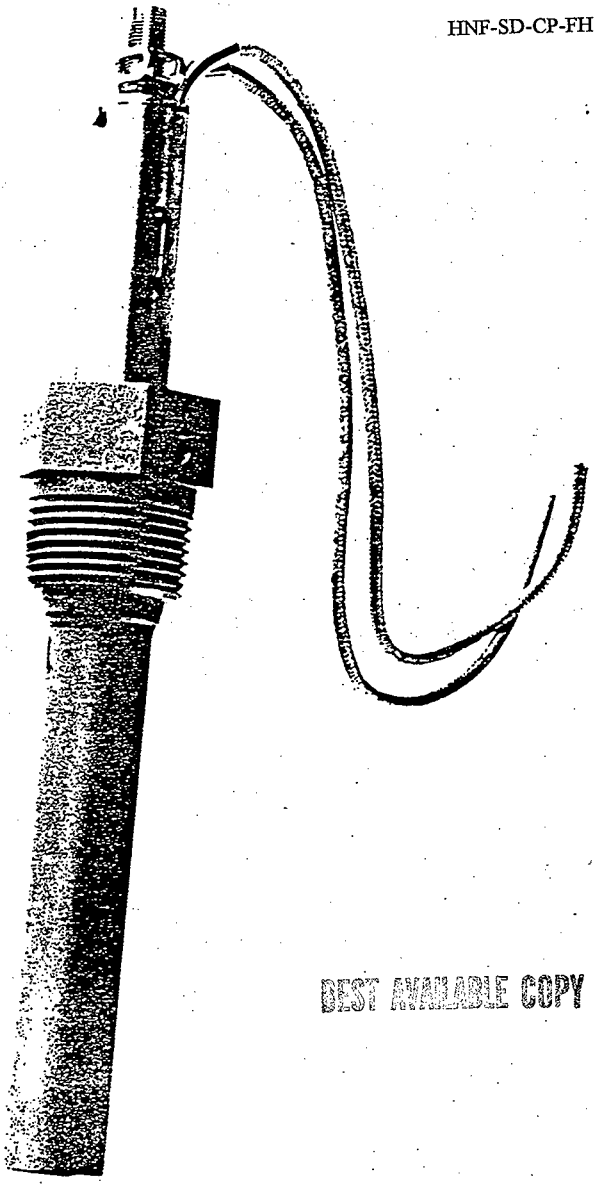
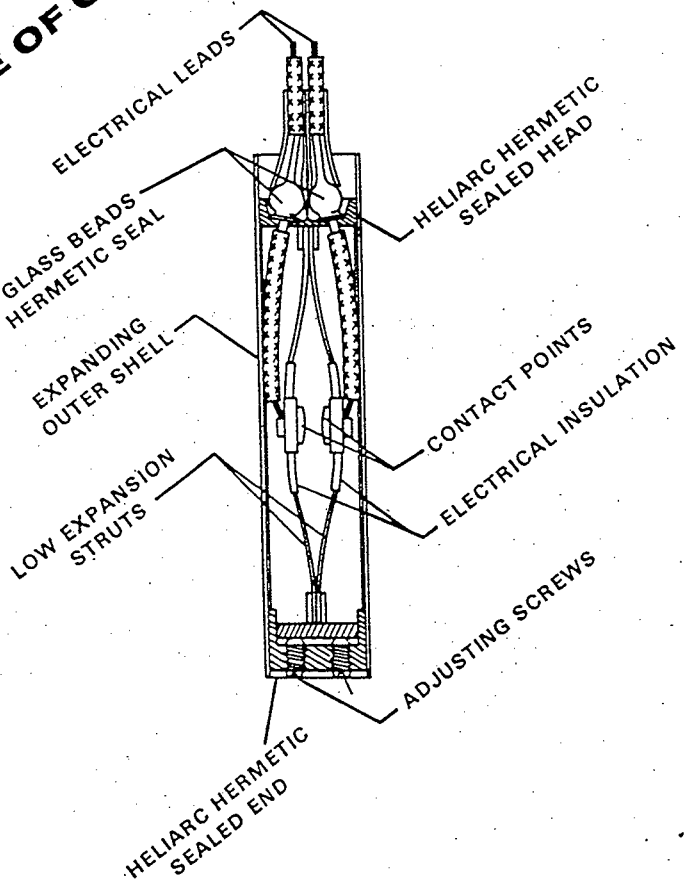


Fig. 5

INCIPLE OF OPERATION



TYPICAL GLOVE BOX INSTALLATION OF WELL TYPE DETECTOR

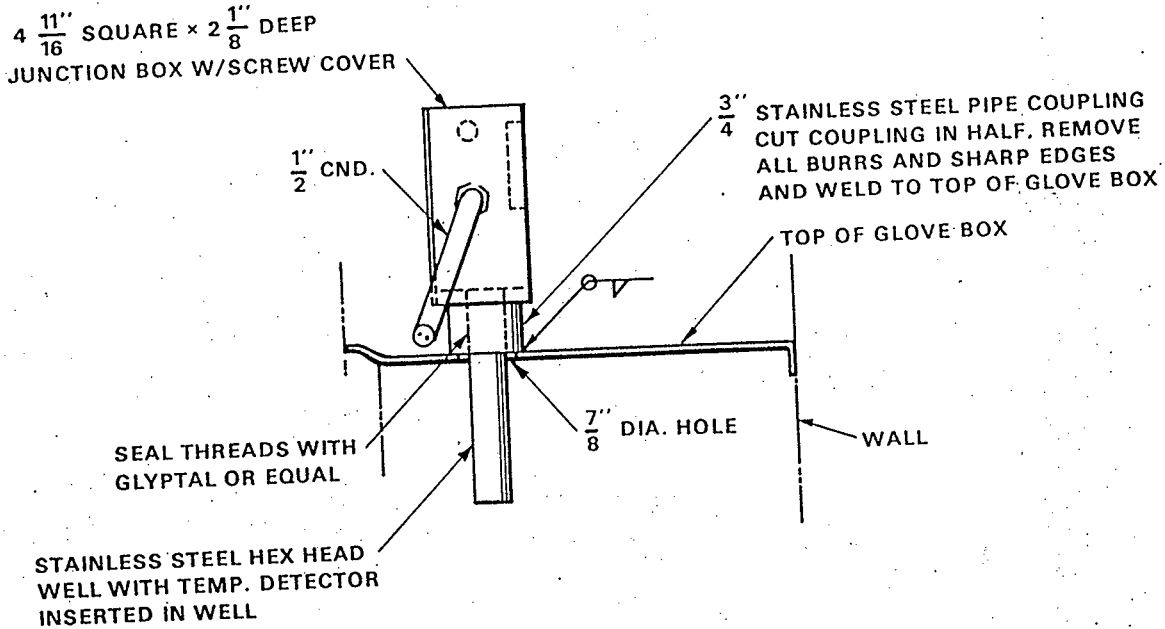
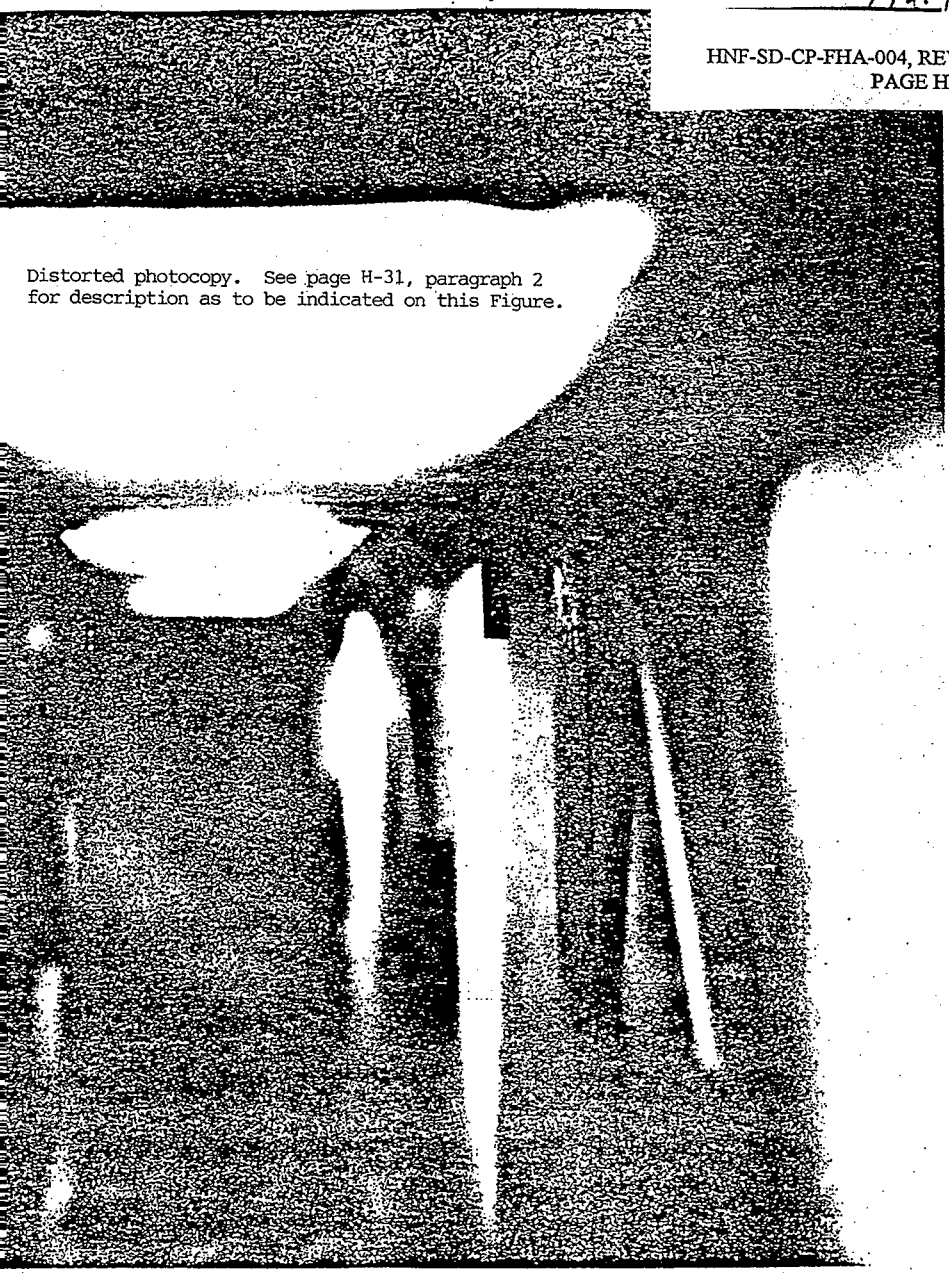


Fig. 6.1

Distorted photocopy. See page H-31, paragraph 2 for description as to be indicated on this Figure.



HEAT DETECTOR TEST (No. 1)

	UNIT	TIME	ACT. TEMP.	FINAL BOX TEMP.
TEST A	#1	7' 25"	195°F	
	#2	6' 45"	182°F	
		BOX SEALED AGAINST LEAKAGE		
	#1	4' 25"	195°	
		4' 10"	197°	
	#2	3' 35"	185°	
		3' 45"	185°	
TEST B	#1	1' 50"	210°F	210°
		1' 55"	205°	210°
	#2	0' 31"	120°	210°
		0' 30"	115°	210°
TEST C	#1	1' 0"	215°F	250°F
		1' 15"	220°	250°F
	#2	0' 21"	110°	250°F
		0' 13"	90°	250°F

NOTE: Box Allowed to Cool to 75°F Prior to Start of Each Test

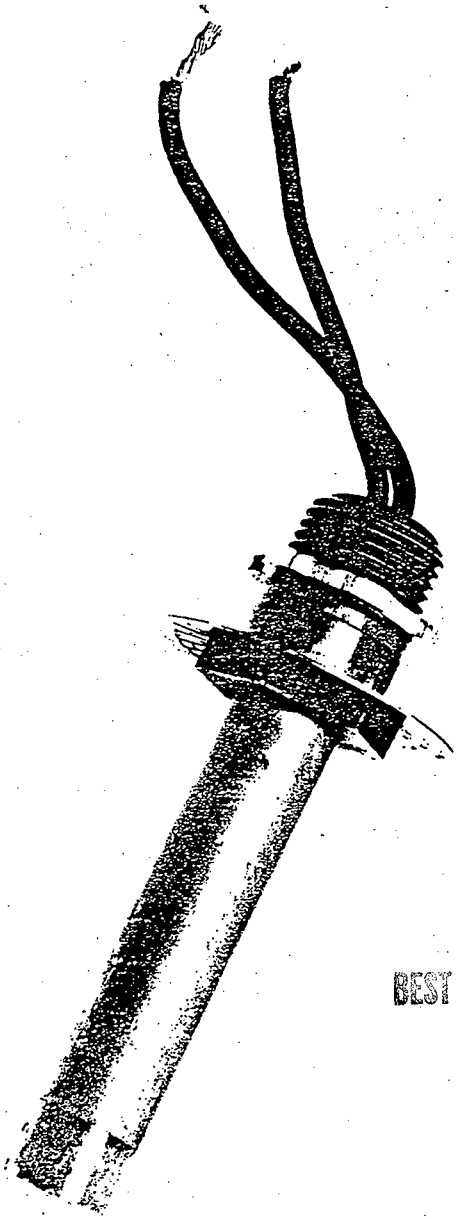
Fig. 8

HEAT DETECTOR TEST (No. 2)

	UNIT	TIME	ACT. TEMP.	FINAL BOX TEMP.
TEST A	#1	0' 56''	265°F	284°F
		0' 53''	240°	311°
		0' 26''	240°	311°
		1' 14''	294°	311°
	#2	0' 13''	109°F	284°F
		0' 14''	122°	311°
		0' 11''	107°	311°
		0' 14''	135°	311°
TEST B	#1	1' 1''	270°F	275°F
		1' 2''	266°	280°
		1' 58''	257°	260°
		1' 48''	250°	261°
	#2	0' 14''	115°F	275°F
		0' 14''	119°	280°
		0' 16''	126°	260°
		0' 17''	126°	261°

NOTE: BOX ALLOWED TO COOL TO 70° BETWEEN TESTS

Fig. 10



PF 3 & 10

CPF 11 & 11A

ESSENTIAL
ENGINEERING CHANGE NOTICE

FILE COPY

Page 1 of 8

1. ECN 191630

Proj ECN

ECN Category	3. Originators Name, Organization, MSIN, and Telephone No.	3a. USQ Required ?	4. Date
Supplemental ☐	D.L. ANDERSON,15520,T4-20,3-4690	■ Yes ☐ No	05/19/97
Direct Revision ☐	5. Project Title/No./Work Order No.	6. Bldg./Sys./Fac. No.	7. App. Designator
Change ECN ☐	Receptacle Circuits for Hood HA-23S, ~~K6003~~ PW 5/22/97	234-5Z/12	N/A
Temporary ☐	8. Document Numbers Changed by this ECN (includes sheet no. and Rev.)	9. Related ECN No(s)	10. Related PO No.
Standby ☐	See Block 12	630515 626102	N/A
Supersedure ■			
Cancel/Void ☐			

11a. Modification Work	11b. Work Package No.	11c. Modification Work Completed	11d. Restored to Original Condition (Temp. or Standby ECN Only.)
■ Yes (do blk 11b)	~~95-1364~~ PW 2Z-~~97-0309~~ 5/22/97 96-2456	Cog. Engineer Signature & Date	N/A Cog. Engineer Signature & Date
☐ No (NA Blks 11b 11c, 11d)			

12. Description of Change

13b: DESIGN BASELINE DOCUMENT: [x] Yes [ ] No.

Block 8:H-2-29026, Sh 1, Rev 1
H-2-99550, Sh 40, Rev 0

This ENC supersedes ECN 630515 in it's entirety.

INSTRUCTIONS:
General:

1. Existing conduit, wire, receptacles, and junction boxes may be used. New equipment and materials may be field routed and located to facilitate construction, installation, and maintenance.
2. Rewire circuits that were wired to PA3-9 to panel XX (circuit XX-15) as shown on pages 3 through 6 of this ECN.
3. Rewire circuits that were wired to PA3-10 to panel XX (circuit XX-17) as shown on pages 3 through 6 of this ECN.
4. Add circuits 15 and 17 to the panel schedule for panel XX as shown on page 7 of this ECN.
5. Install switch assy. (P/N #16) and label "HA-23S RCPTS" per "PFP LABELING STANDARD" (H-2-89710).

13a. Justification

- Criteria Change ☐
- Design Improvement ■
- Environmental ☐
- As-Found ☐
- Facilitate Const. ☐
- Const. Error/Omission ☐
- Design Error/Omission ☐

13b. Justification Details

2Z-97-0309
This ECN powers receptacles in hood HA-23S that were deactivated when MCC-A2 was deenergized during Project 94-1demolition.

USQ for ECN 626102 applies. No unreviewed safety question exists.

Design verification performed using Independent review per EP 4.1

14. Distribution

GP Wilson	T4-20	DR Groth	T4-15
~~GB Merrick~~	~~T4-20~~	AO Anderson	T4-19
RD Keck	T4-20	PK Aardal	T5-54
JM Morley	T4-20	GA Johnston	T5-50
MW Gibson	T5-54	JL Reed	R4-05
EP Lively	R4-05	J WITT	T5-50
JM Isdell	R4-05	FDCDC	S2-53
RS Foreman	T5-21	PROJECT FILES	R1-29

D.WYATT T5-11

Release Stamp

MAY 23 1997
DATE:
HANFORD RELEASE
STA: 5
ID: 55

Engineering Change Notice	Page 2 of 8	1. ECN (use number from pg. 1) 191630

15. Design Verification Required	16. Cost Impact		17. Schedule Impact (Days)
	ENGINEERING	CONSTRUCTION	
■ Yes	Additional ☐ $ N/A	Additional ☐ $ N/A	Improvement ☐
☐ No	Savings ☐ $	Savings ☐ $	Delay ☐ N/A

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on page 1) That will be affected by the change describe in block 12. Enter the affected document number in block 19.

☐ SSD/DD	☐ Seismic/Stress Analysis	☐ Tank Calibration Manual
☐ Functional Design Criteria	☐ Stress/Design Report	☐ Health Physics Procedure
☐ Operating Specification	☐ Interface Control Drawing	☐ Spare Multiple Unit Listing
☐ Criticality Specification	☐ Calibration Procedure	☐ Test Procedures/Specification
☐ Conceptual Design Report	☐ Installation Procedure	☐ Component Index
☐ Equipment Spec.	☐ Maintenance Procedure	☐ ASME Coded Item
☐ Constuction Spec.	☐ Engineering Procedure	☐ Human Factor Consideration
☐ Procurement Spec.	☐ Operating Instruction	☐ Computer Software
☐ Vendor Information	■ Operating Procedure	☐ Electric Circuit Schedule
☐ OM Manual	☐ Operational Safety Requirement	☐ ICRS Procedure
☐ FSAR / SAR	☐ IEFD Drawing	☐ Process Control Manual/Plan
☐ Safety Equipment List	☐ Cell Arrangement Drawing	☐ Process Flow Chart
☐ Radiation Work Permit	☐ Essential Material Specification	☐ Purchase Requisition
☐ Environmental Impact Statement	☐ Fac. Proc. Samp. Schedule	☐
☐ Environmental Report	☐ Inspection Plan	☐
☐ Environmental Permit	☐ Inventory Adjustment Request	☐

19. Other Affected Documents: (Note: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number / Revision	Document Number / Revision	Document Number / Revision
Z0-200-010		

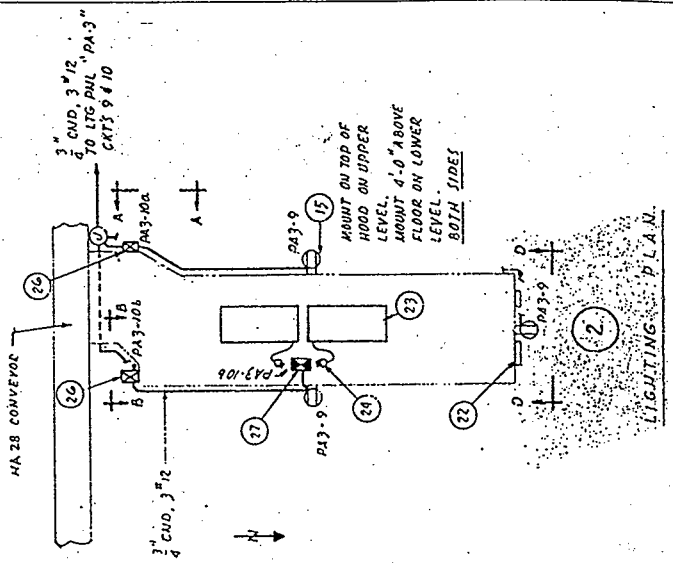
20. Approvals

OPERATIONS and ENGINEERING		ARCHITECT-ENGINEER	
Signature	Date	Signature	Date
RDIGH	5/22/97		
Cog. Engineer	5/22/97	PE	
Cog. Mgr.		QA	
QA David M. Ryan	5/23/97	Safety	
Safety		Design	
Security		Environ.	
Environ.		Other.	
Projects/Program Gerald R. Wilson	5/19/97		
Design Eng. Mgr.	5/19/97	DEPARTMENT of ENERGY Signature or a control number that tracks the approval signature.	
Independent Review			
Checking H Nguyen	5/20/97	Additional	
Other	5/19/97		
ORIGINATOR			

INEERING CHANGE NOTICE CONTINUATION SHEET	PAGE 3 OF 8	1. ECN 191630

REPLACE CIRCUIT PA3-9 WITH CIRCUIT XX-15.
REPLACE CIRCUIT PA3-10 WITH CIRCUIT XX-17.

WAS:



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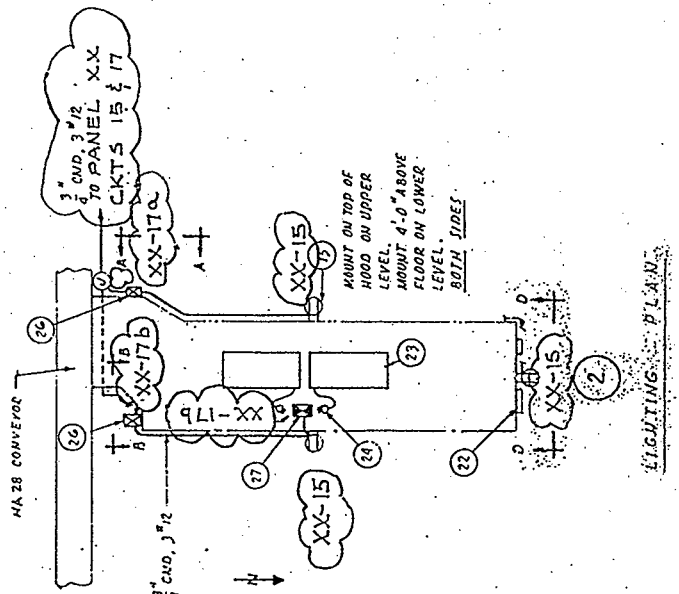
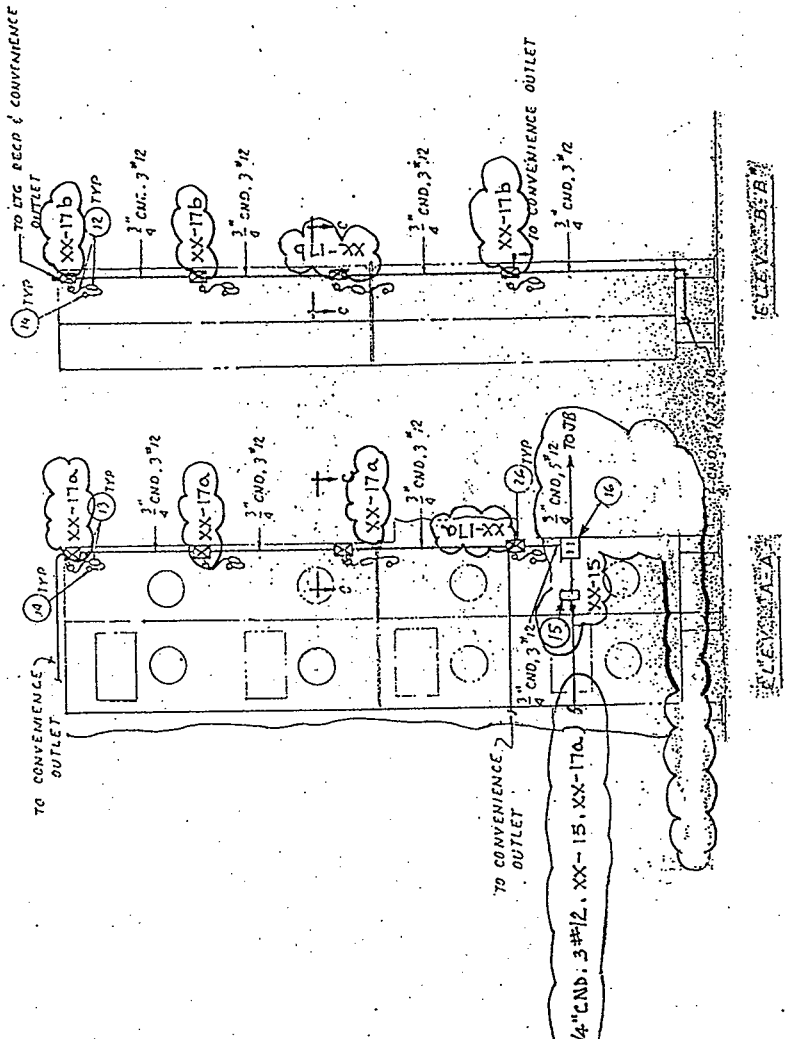


ENGINEERING CHANGE NOTICE CONTINUATION SHEET	PAGE 4 OF 8	1. ECN 191630

H-2-29026, SH 1 : MAKE CHANGES AS SHOWN BELOW.
REPLACE CIRCUIT PA3-9 WITH XX-15.
REPLACE CIRCUIT PA3-10 WITH XX-17.

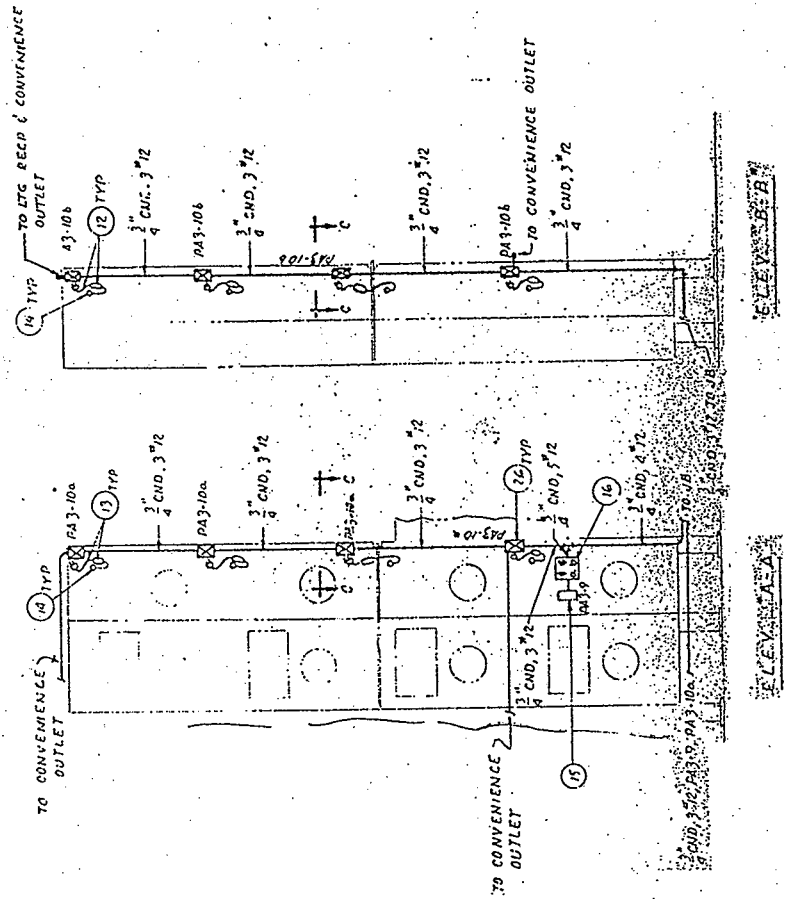
IS:



ENGINEERING CHANGE NOTICE CONTINUATION SHEET	PAGE 5 OF 8	1. ECN 191630

H-2-29026, SH 1

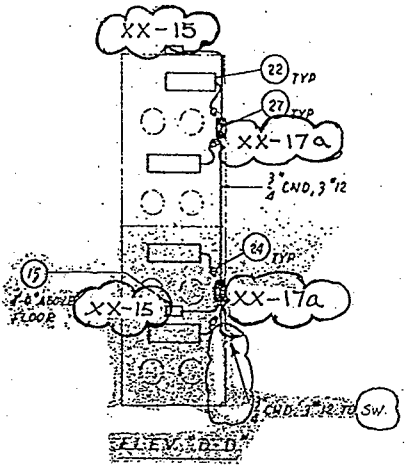
WAS:



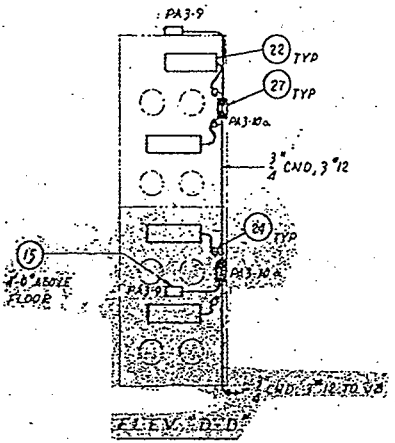
ENGINEERING CHANGE NOTICE CONTINUATION SHEET	PAGE 6 OF 8	1. ECN 191630

H-2-29026, SH 1: MAKE CHANGES AS SHOWN BELOW:
REPLACE CIRCUIT PA3-9 WITH XX-15.
REPLACE CIRCUIT PA3-10 WITH XX-17.

IS:



WAS:



GINEERING CHANGE NOTICE CONTINUATION SHEET	PAGE 7 OF 8	1. ECN 191630

2-99550, SH 40, REV 0: ADD CIRCUITS 15 AND 17 AS SHOWN BELOW:

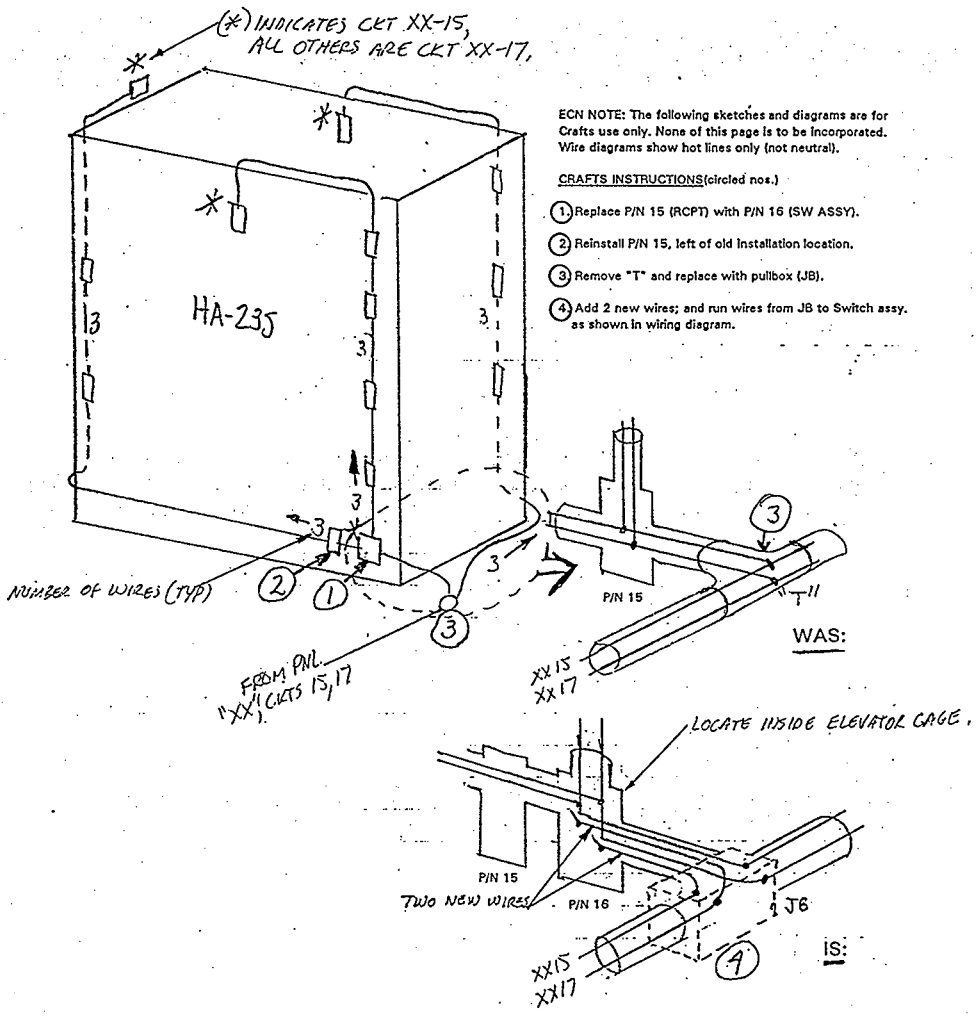
PANELBOARD XX
LOCATION 234-5Z, RM 235C
NEMA TYPE 1
☒ SURFACE MOUNTED
☐ FLUSH MOUNTED
☒ TOP ☐ BOT FEEDER

☒ MAIN BRKR
☐ LUGS ONLY
100 AMP PWR BUS
100 AMP NEUT BUS
☒ NEUTRAL BUS
☒ GROUND BUS

VOLTS 208Y/120 VAC, 3Ø
FED FROM PP-A1
ONE LINE DWG H-2-26538/30
PNL SCHED DWG H-2-99550/40
PNL LAST REV ----

SERVICE	BRKR AMPS	NO.	H1 H2	NO.	BRKR AMPS	SERVICE
SPACE USED BY MAIN BREAKER		1		2		
		3		4	100	SPACE USED BY MAIN BREAKER
		5		6		
SPACE		7		8		SHUNT TRIP UNIT (NOT WIRED)
RECEPTACLES, GLOVEBOX 235-2	15	9		10	15	LIGHTING UNDER MEZZANINE RM 235B
RECEPTACLES, GLOVEBOX 235-2	15	11		12	15	LIGHTING UNDER MEZZANINE RM 235C
RECEPTACLES, GLOVEBOX 235-2	15	13		14	15	LIGHTING UNDER MEZZANINE RM 235C
RECEPTACLES, HOOD HA-23S	15	15		16	20	LIGHTING IN RADTU AIRLOCK
RECEPTACLES, HOOD HA-23S	15	17		18	45	HEATER IN RADTU AIRLOCK
SPARE	15	19		20		
SPARE	15	21		22	15	SPARE
SPARE	15	23		24	15	SPARE
SPARE	15	25		26	15	SPARE
SPARE	15	27		28	15	SPARE

ENGINEERING CHANGE NOTICE CONTINUATION SHEET	PAGE 8 OF 8	1. ECN 191630



ECN NOTE: The following sketches and diagrams are for Crafts use only. None of this page is to be incorporated. Wire diagrams show hot lines only (not neutral).

CRAFTS INSTRUCTIONS(circled nos.)

1. Replace P/N 15 (RCPT) with P/N 16 (SW ASSY).
2. Reinstall P/N 15, left of old installation location.
3. Remove "T" and replace with pullbox (JB).
4. Add 2 new wires; and run wires from JB to Switch assy. as shown in wiring diagram.

F #11, #11F, #11A
F #3, #10

ENGINEERING CHANGE NOTICE

Page 1 of 14

1. ECN № 616156

~~FILE COPY~~

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [X] Direct Revision [ ] Change ECN ~~[X]~~ Temporary [ ] Standby [ ] Supersedure [ ] Cancel/Void [ ]	C. McGOUGH, FDNW, B4-40, 376-1847	[X] Yes [ ] No	7-29-97
	6. Project Title/No./Work Order No. K6003 UPGRADE FIRE PROTECTION HA-28, HC-3, HC-4, HA-23S	7. Bldg./Sys./Fac. No. 234-5Z/26	8. Approval Designator SQ
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) SEE BLOCK 13a	10. Related ECN No(s). 639659 621184	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[X] Yes (fill out Blk. 12b) [ ] No (NA Blks. 12b, 12c, 12d)	~~15933~~ 2Z-97-421	Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [X] Yes [ ] No

H-2-24176	H-2-97481	H-2-99550
SH 1 REV 15	• SH 1 REV 10	SH 17 REV 0 ••
	• SH 2 REV 10	
	• SH 3 REV 7	
	• SH 9 REV 3	
	• SH 16 REV 3	
	• SH 17 REV 4	

DESCRIPTION OF CHANGE
See page 3

14a. Justification (mark one)

Criteria Change	[ ]	Design Improvement	[X]	Environmental	[ ]	Facility Deactivation	[ ]
As-Found	[ ]	Facilitate Const	[ ]	Const. Error/Omission	[ ]	Design Error/Omission	[ ]

14b. Justification Details

Heat detectors and indicator lights are needed in conveyors and gloveboxes per PFP 94-1 Glovebox Cost Risk Analysis Revision 1.
Changes incorporated into the Fire Protection Essential Drawings.

USQ PFP-96-14

15. Distribution (include name, MSIN, and no. of copies)

A.O. ANDERSON	T4-19	R.D. KECK	T4-20	M. BUCKMASTER	H0-19
J.D. DICK	T4-20	S.M. KORSLUND	S3-96	GA Blunt	H0-09
J.F DURNIL	T5-55	R.D. PICKET	T4-20		
L.E EDVALSON	T5-48			Project Files	R1-29
G.A. GLOVER	T4-2	C.A. SALINAS	T5-17	FDNW cbc	S2-53
D.R. GROTH	T4-15	G.P. WILSON	T4-20		
J.M. ISDELL	R4-05	D.M. WYATT	T5-11		
		J.M. WITT	T5-50		
		D.L. McKINNIS	T4-20		

RELEASE STAMP
DATE: AUG 25 1997
STA: 5
HANFORD RELEASE
ID: 12

ENGINEERING CHANGE NOTICE	Page 2 of 14	1. ECN (use no. from pg. 1) 616156

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[X] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision

21. Approvals

	Signature	Date		Signature	Date
Design Authority	[signature]	8/1/97	Design Agent	C. D. Eggen	7/29/97
Cog. Eng.	[signature]	8/1/97	PE		
Cog. Mgr.	[signature]	8/4/97	QA	NA	
QA	A. B. Porulerov	8/4/97	Safety	NA	
Safety	[signature]	8/22/97	Design	C. D. Eggen	7/29/97
Environ.			Environ.		
Other	BHI		Other		
	D. McInnis for Mark Buckmaster per phone 8/25/97	8/25/97			

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

ENGINEERING CHANGE NOTICE CONTINUATION SHEET

Page 3 of 14

ECN 616156
Date 7-4-97

ESCRIPTION OF CHANGE
ield work:

- Install new Fire alarm control panel FCP1412-2 in corridor 14A. Wire control panel as shown on new drawing H-2-97481 SH 63 Rev 0. Tie new control panel into zone 20 on existing panel FCP1412-1, and tie trouble circuit to zone 131 on Supervisory panel. Reuse existing detectors in GB HA-23-S and HA-28A but remove from zone 19 and rewire to sub-zones 20-1, 20-2, 20-3 & 20-4. Run new wires for each sub-zone to gloveboxes via new terminal box (TBX-2). See page 13 & 14 of this ECN.

- Install two new annunciator panels. One in room 235B, and one in room 230C. Run wire from new control panel FCP1412-2 located in corridor 14A to annunciator panels. as shown on page 13 and 14 of this ECN.

- Install new terminal box (TBX-2) on mezzanine wall in room 235B. Run wires from new fire alarm control panel (FCP1412-2) in corridor 14A to new terminal box. SEE PAGE 13 and 14 of this ECN.

rawing changes:
-2-24176 SH 1 REV 15 SEE PAGE 4 OF THIS ECN.
evise drawing to show new panel, annunciators, and terminal box configuration on block iagram.

-2-97481 SH 1 REV 10 SEE PAGE 5 OF THIS ECN.
evise drawing to show reference to new sheet 61.

-2-97481 SH 2 REV 10 SEE PAGE 6 OF THIS ECN.
evise drawing to show new FCP1412-2 control panel.

-2-97481 SH 3 REV 7 SEE PAGE 7 OF THIS ECN.
evise drawing to show new FCP1412-2 control panel and battery box location.

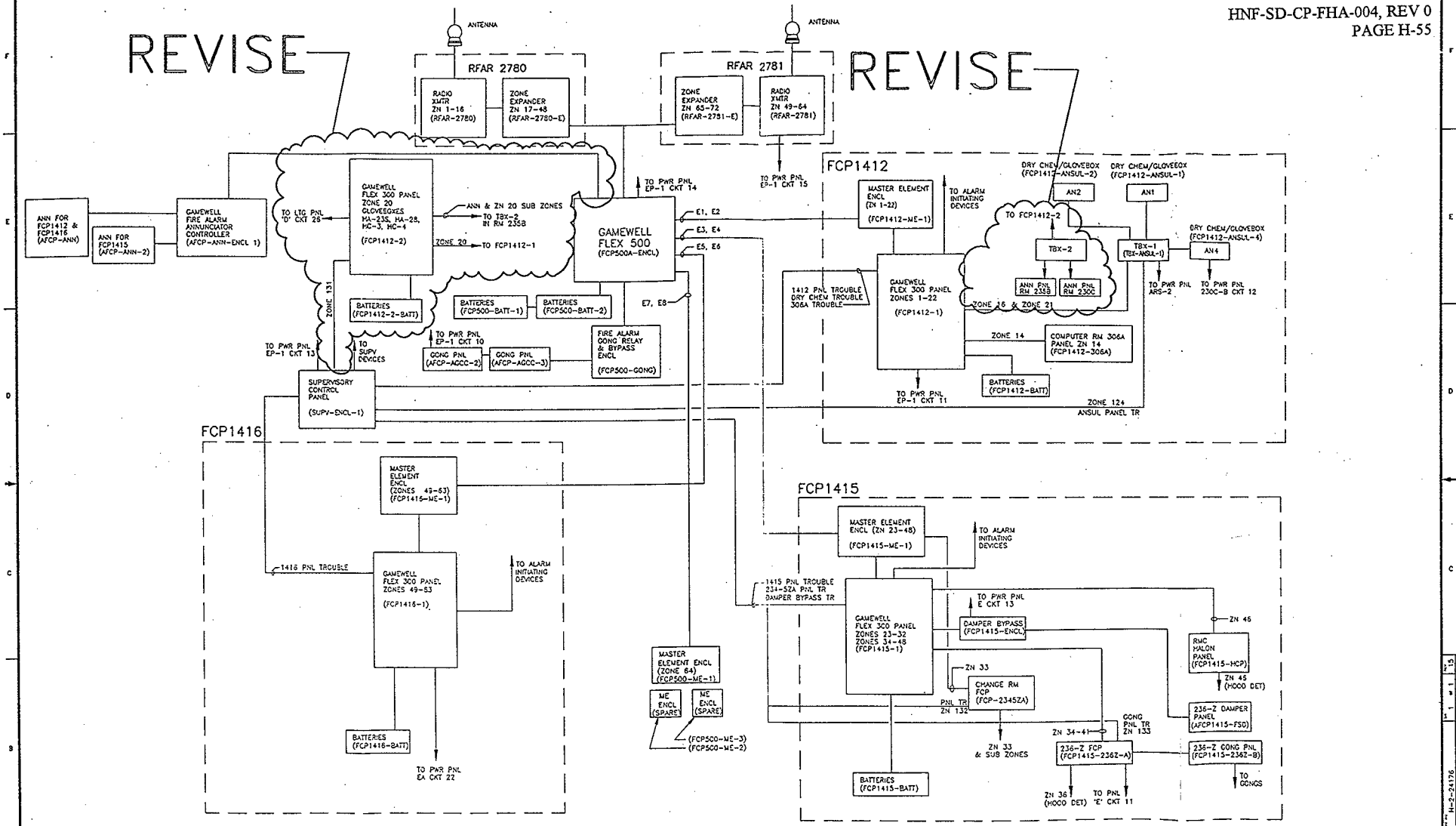
-2-97481 SH 9 REV 3 SEE PAGE 8 OF THIS ECN.
evise drawing to show new control panel on "Supervisory Device Floor Plan".

-2-97481 SH 16 REV 3 SEE PAGE 9 OF THIS ECN.
evise drawing to show new zone configuration for supervisory connection to new ANSUL ontrol panel.

-2-97481 SH 17 REV 4 SEE PAGE 10 OF THIS ECN.
evise drawing to show new wiring configuration of supervisory panel to new control anel.

-2-99550 SH 17 REV 0 SEE PAGE 11 OF THIS ECN.
evise drawing to show circuit 26 on lighting panel D to be used for new Alarm Panel CP1412-2.

EW DRAWINGS:
. Add sheets 61, 62, & 63 to drawing series H-2-97481 for field changes shown on pages 2, 13 & 14 of this ECN. D&m 8/22/97
. On new sheet 61 show sheets 59 and 60 which were added by other ECN's. ~~(MODIFIES ECN 639669 & 621184)~~.



ESSENTIAL DRAWING

15	REV PER ECN 636108	JLR 09/96	
REV	DESCRIPTION	REVISIONS	

DWG NO	TITLE	REFERENCES	
		H-2-97421 SH 1	FA SYS DWG INDEX
		PO NUMBER	TITLE

DRAWING TRACEABILITY LIST — NEXT USED ON H-2-97451 SH 1

FIELD VERIFIED PER ECN 195119 4/93 REV 12

CADFILE B024176A — CADCODE WIN95-ACD2-12-SS

DRAWN NOLAND	03/24/93	U.S. DEPARTMENT OF ENERGY, DOE Field Office, Richland, Westinghouse Hanford Company
CHECKED		
DESIGN APPROVAL M JACQUES	03/25/93	FIRE PROTECTION FIRE ALARM SYSTEM RFAR 2780/2781 BLOCK DIA
DOE QA		
DOE APPROVAL MC PETERSON	05/25/93	

SIZE F | SCALE NONE | SYSTEM 234-5Z | WBS NO 7702 | DWG NO H-2-24176 | REV 15 | SHEET 1 OF 1

ECN No. 616156 | Page 4 of 14 | Ref. Dwg. H-2-24176 | Sh. 1 | Rev. 15 | Prep. By C. McGOUGH | Chkd. By C. A. Eggen

H-2-24176 15

DRAWING INDEX

DWG NUMBER	SH NO	TITLE	DESCRIPTION	REFERENCE DWG	RFAR
H-2-24174	1	FIRST FLOOR PLAN	ZONING AREAS; DETECTORS & MANUAL PULL STATIONS	H-2-29747	2780/2781
H-2-24174	2	BASEMENT PLAN	ZONING AREAS; DETECTORS, GONGS & MANUAL PULL STATIONS	H-2-25944, H-2-815434 SH 1	2780/2781
H-2-24174	3	DUCT LEVEL PLAN	ZONING AREAS; DETECTORS & MANUAL PULL STATIONS	H-2-24175 SH 1, H-2-29743, 49	2780/2781
H-2-24174	4	SECOND FLOOR PLAN	ZONING AREAS; DETECTORS & MANUAL PULL STATIONS	H-2-24176 SH 1, H-2-29750	2780/2781
H-2-24174	5	SUPV DEVICES SITE PLAN	SUPV DEVICES ON RISERS & PIV	H-2-25920	2780/2781
H-2-24174	6	GONG LOCATIONS	CONDUIT, WIRE & GONG LOCATIONS ON 1ST FLOOR	H-2-815434 SH 2	2780/2781
H-2-24174	7	GONG LOCATIONS	CONDUIT, WIRE, GONG & GONG PANEL LOCATIONS ON DUCT LEVEL	H-2-815434 SH 3	2780/2781
H-2-24174	8	GONG LOCATIONS	CONDUIT, WIRE & GONG LOCATIONS ON 2ND FLOOR	H-2-815434 SH 4	2780/2781
H-2-24175	1	HOOD & GLOVE BOX LOC	KEY PLAN OF HOOD & GLOVE BOX LOC FOR FIRE ALARM SYS		2780/2781
H-2-24175	2	LIMITED WATER BOTTLE STATIONS (LWBS)	LOCATION & ZONES OF LP SWITCHES , N2 SYS SCHEM.	H-2-25923,54 H-2-28871,72	2780/2781
H-2-24175	3	NITROGEN SYSTEM FOR LWBS	NITROGEN SYSTEM DETAIL		2780/2781
H-2-24176	1	BLOCK DIAGRAM	BLDG 234-5Z RFAR 2780 & 2781 BLOCK DIAGRAM	H-2-26918, H-2-25919	2780/2781
H-2-97481	1	DWG INDEX & LEGEND	DWG INDEX LEGEND, GEN NOTES & ZONING SCH		2780/2781
H-2-97481	2	CONTROL PNL LOCATIONS	MAIN FIRE ALARM EQUIPMENT LOCATIONS	H-2-25921,22,23,24; H-2-97481 SH 1	2780/2781
H-2-97481	3	CONTROL PNL ELEVATIONS	MAIN FIRE ALARM EQUIPMENT LOCATIONS	H-2-25921,22,23,24; H-2-97481 SH 1	2780/2781
H-2-97481	4	RFAR SYSTEM WIRING DIAG	RFAR 2780 & 2781	H-2-97481 SH 7	2780/2781
H-2-97481	5	FLEX 500 DIAG	GAMEWELL FLEX 500 & BELLS OFF RELAY & VOLTAGE REGULATOR ENCL	H-2-97481 SH 6, 7	2780/2781
H-2-97481	6	ANN CONTROL DIAL	FIRE ALARM ANNUNCIATOR CONTROLLER	H-2-97481 SH 6, 8	2780/2781
H-2-97481	7	MASTER ELEMENT DIAG	MASTER ELEMENT ENCL	H-2-97481 SH 2	2780/2781
H-2-97481	8	FCP1412 ME INTERFACE	FCP1412 MASTER ELEMENTS & K24 RELAY	H-2-97481 SH 3	2780/2781
H-2-97481	9	SUPERVISORY FLOOR PLAN	SUPERVISORY DEVICE LOCATIONS	H-2-97481 SH 4	2780/2781
H-2-97481	10	F.A. SYS INTLK DR SCTY SYS	SECURITY DOOR WIRING DIAGRAM & F.A. INTERCONNECT	H-2-97481 SH 5	2780/2781
H-2-97481	11	ANN ELEM DIAG & TERM BOXES	ANNUNCIATOR ELEMENTARY DIAG & ZONE TERMINATIONS	H-2-25945	2780/2781
H-2-97481	12	ALARM GONG WIRING DIAG	ALARM GONG CABINETS WIRING DIAG	H-2-26929	2780/2781
H-2-97481	13	FCP1412 WIRING DIAG	GAMEWELL FLEX 300 PANEL WIRING DIAG	H-2-26926, 27, 28	2780/2781
H-2-97481	14	FCP1415 WIRING DIAG	GAMEWELL FLEX 300 PANEL WIRING DIAG	H-2-26928, 42	2780/2781
H-2-97481	15	FCP1416 WIRING DIAG	GAMEWELL FLEX 300 PANEL WIRING DIAG	H-2-26946, 50	2780/2781
H-2-97481	16	SUPERVISORY DETAILS	SPRINKLER SYS SUPV PNL WIRING DETAILS	H-2-26925 SH 1,2,3; H-2-26944	2780/2781
H-2-97481	17	SUPV PNL WRG DIAG	SUPERVISORY PANEL WIRING DIAGRAM	H-2-26925 SH 1,2,3; H-2-26929	2780/2781
H-2-97481	18	ANN 'A' & 'B' WIRING DIAG	SUPV ANN PNL 'A' & 'B'	H-2-26925 SH 1,2,3; H-2-26943,45	2780/2781
H-2-97481	19	TBX & TBX-1 WIRING DIAG	TERM BOX TBX & TBX-1	H-2-26940, 41	2780/2781
H-2-97481	20	TBX-2, TBX-3 & PBX-3 WIRING DIAG	TERM BOXES TBX-2, TBX-3 & PBX-3	H-2-25940, 41	2780/2781
H-2-97481	21	COMPUTER RM 306A	FCP1412-306A PLAN & WIRING DIAG	H-2-28855, H-2-28856, H-2-77571	2780/2781
H-2-97481	22	E3 & E4 FILTER DIAG	FILTER FIRE PROT CONTROL SYS DIAGRAM	H-2-27416, 18, 10, 24; H-2-28294	2780/2781
H-2-97481	23	FILTER CONTROL PANEL	FILTER FIRE PROT CONTROL PNL WIRING DIAG	H-2-27417	2780/2781
H-2-97481	24	DAMPER RELAY & ANN PNL	FILTER & DAMPER SYS RELAY PANELS		2780/2781
H-2-97481	25	DAMPER ELEM & BLOCK DIAG	FILTER FIRE PROT ELEM & WIRING BLOCK DIAG	H-2-27417	2780/2781
H-2-97481	26	RMC HALON SYSTEM	HALON CONTROL PNL, MS, STROBES & HOOD DET PLAN	H-2-80381 SH 1	2780/2781
H-2-97481	27	RMC HALON SYSTEM	HALON CONTROL PNL, MS, STROBES & HOOD DET PLAN	H-2-80381 SH 5	2780/2781
H-2-97481	28	RMC HALON SYSTEM	HALON CONTROL PNL DET & CND ROUTING SECTIONS	H-2-80381 SH 1, 2, 5	2780/2781
H-2-97481	29	RMC HALON SYSTEM	HALON CONTROL PNL WIRING DIAG	H-2-80381 SH 4	2780/2781
H-2-97481	30	SALT LOOP PLAN	SALT LOOP PLAN FOR HOODS	H-2-19921	2780/2781
H-2-97481	31	SALT LOOP PNL	SALT LOOP CONTROL PNL FCP1412-SALT WIRING DIAG	H-2-19922	2780/2781
H-2-97481	32	ANSUL SYS HOOD HA-211	ANSUL SYSTEM FOR GLOVE BOX HA-211	H-2-96393, H-2-97897	2780/2781
H-2-97481	33	GLOVE BOX DETECTORS	ANALYTICAL & R&E LAB GLOVE BOX DET	H-2-25827,H-2-26543SH1-3,H-2-25175	2780/2781
H-2-97481	34	GLOVE BOX DETECTORS	STANDARD LAB & MISC GLVOE BOX DET	H-2-80200, H-2-25773, H-2-91165	2780/2781
H-2-97481	35	FCP1415-234-5ZA WIRING	CHANGE ROOM FCP & FIELD DEVICES WIRING DIAG	H-2-81324 SH 1, 2; H-2-81322	2780/2781
H-2-97481	36	FCP1415-236Z-A WIRING	BLDG 236-Z FCP'S & FIELD DEVICES WIRING DIAG	H-2-26948	2780/2781
H-2-97481	37	1415 DAMPER SYS & FCP	FIRE/SMOKE DAMPER SYS DIAG & FCP DET & ELEVATION	H-2-26943, H-2-76972	2780/2781
H-2-97481	38	HOOD DETECTOR LOC	BLDG 236-Z HOOD DETECTOR LOCATION PLANS	H-2-26600, H-2-29749, H-2-29755	2780/2781
H-2-97481	39	FCP1415-236Z-B WIRING	BLDG 236-Z FCP & FIELD DEVICES WIRING DIAG	H-2-813620 SH 1, SH 2	2780/2781
H-2-97481	40	RFAR 2830 & FCP1413	BLDG 232-Z PLAN & ELEVATIONS	H-2-26952, H-2-26913	2830
H-2-97481	41	RFAR 2830 & FCP1413	BLDG 232-Z RFAR & FCP WIRING DIAG	H-2-97482, H-2-26952, H-2-23129	2830
H-2-97481	42	RFAR 2775 & FCP-270Z	BLDG 270-Z RFAR & FCP PLAN & WIRING DIAG	H-2-97942	2775
H-2-97481	43	RFAR 2760 & FCP-2701ZA	BLDG 2701-ZA RFAR, FCP & HCP PLANS & ELEVATION	H-2-80577	2760
H-2-97481	44	RFAR 2760 & FCP-2701ZA	BLDG 2701-ZA RFAR, FCP & HCP WIRING DIAG	H-2-97485	2760
H-2-97481	45	RFAR 2762 & FCP-2701ZD	BLDG 2701-ZD RFAR & FCP PLAN & ELEVATION	H-2-81290	2762
H-2-97481	45	RFAR 2762 & FCP-2701ZD	BLDG 2701-ZD RFAR & FCP WIRING DIAG		2762
H-2-97481	47	RFAR 2850 & FCP-2704Z	BLDG 2704-Z RFAR & FCP PLAN & ELEVATION	H-2-80577	2850
H-2-97481	48	RFAR 2850 & FCP-2704Z	BLDG 2704-Z RFAR & FCP WIRING DIAG	H-2-97480	2850
H-2-97481	49	RFAR 2810 & FCP1414	BLDG 291-Z, 2731-Z, 2736-Z, 2736-ZA SITE PLAN & ELEVATION	H-2-27972, H-2-27968	2810
H-2-97481	50	FCP1414 WIRING DIAGRAM	BLDG 291-Z, FCP1414 WIRING DIAG	H-2-97483, H-2-27972	2810
H-2-97481	51	FCP1414 WIRING DIAG	ZONE DIAG, RFAR WIRING AND FCP WIRING DIAG	H-2-27972	2810
H-2-97481	52	FCP1414 FLOOR PLANS	BLDG 291-Z, 2731-Z, 2736-Z, DEVICE LOCATION PLANS	H-2-26661, H-2-26943, 49, 50, 51	2810
H-2-97481	53	RFAR 2820 & FCP1421	BLDG 2721-Z, 2731-ZA, 2736-ZB, 2736-ZC PLAN	H-2-80137	2820
H-2-97481	54	FCP1421 WIRING DIAG	FCP1421 & BYPASS CABINET WIRING DIAG	H-2-80138, H-2-97485	2820
H-2-97481	55	RFAR 2820 & FCP1421	RFAR 2820 & FIELD DEVICE WIRING DIAG & ELEVATION	H-2-97486	2820
H-2-97481	56	TC-66 BLDG PLAN	TC-66 BLDG PLAN	H-2-78205 SH 2	
H-2-97481	57	RFAR 2787 & FCP-2432-1	BLDG 243-Z RFAR & FCP PLAN & ELEVATION	H-2-82763	2787
H-2-97481	58	RFAR 2787 & FCP-2432-1	BLDG 243-Z RFAR & FCP WIRING DIAGRAM	H-2-82764	2787

FOR NEW SHEETS SEE DWG H-2-97481 SH 61

ADD

234-5Z ZONING SCHEDULE

MASTER ELEMENT	ZONE	OLD ZONE	RFAR	OLD FCP	ZONING DWG/REMARK
1-1	1	1	2780	1412	H-2-24174 SH 1, SH 3
1-2	2	2	2780	1412	H-2-24174 SH 1
1-3	3	4	2780	1412	H-2-24174 SH 1
1-4	4	12	2780	1412	H-2-24174 SH 1
1-5	5	19	2780	1412	H-2-24174 SH 3
1-6	6	20	2780	1412	H-2-24174 SH 3
1-7	7	21	2780	1412	H-2-24174 SH 3
1-8	8	27	2780	1412	H-2-24174 SH 3
1-9	9	30	2780	1412	H-2-24174 SH 4
1-10	10	31	2780	1412	H-2-24174 SH 4
1-11	11	32	2780	1412	H-2-24174 SH 4
1-12	12	34	2780	1412	H-2-24174 SH 1
1-13	13	35	2780	1412	H-2-24174 SH 1, SH 4
1-14	14	37	2780	1412	H-2-24174 SH 4
1-15	15	38	2780	1412	H-2-24174 SH 2
1-16	16	39	2780	1412	SPARE
1-17	17	40	2780	1412	H-2-24174 SH 1
1-18	18	41	2780	1412	H-2-24175 SH 2
1-19	19	42	2780	1412	H-2-24174 SH 1
1-20	20	43	2780	1412	H-2-97481 SH 34
1-21	21	45	2780	1412	SPARE
1-22	22		2780	1412	H-2-24174 SH 1,5 H-2-97481 SH 9
2-1	23	8	2780	1415	H-2-24174 SH 1 H-2-97481 SH 34
2-2	24	9	2780	1415	H-2-24174 SH 1
2-3	25	10	2780	1415	H-2-24174 SH 1
2-4	26	15	2780	1415	H-2-24174 SH 1
2-5	27	16	2780	1415	H-2-24174 SH 1
2-6	28	17	2780	1415	H-2-24174 SH 1
2-7	29	23	2780	1415	H-2-24174 SH 3
2-8	30	24	2780	1415	H-2-24174 SH 3
2-9	31	25	2780	1415	H-2-24174 SH 3
2-10	32	49	2780	1415	H-2-24174 SH 1
2-11	33	50	2780	1415	H-2-24174 SH 1 H-2-97481 SH 9
2-12	34	51	2780	1415	H-2-24174 SH 1, SH 3
2-13	35	52	2780	1415	H-2-24174 SH 1
2-14	36	53	2780	1415	H-2-24174 SH 1, SH 3
2-15	37	54	2780	1415	H-2-24174 SH 1, SH 3, SH 4
2-16	38	55	2780	1415	H-2-24174 SH 3
2-17	39	56	2780	1415	H-2-24174 SH 4
2-18	40	57	2780	1415	H-2-24174 SH 3
2-19	41	58	2780	1415	H-2-24174 SH 3
2-20	42	59	2780	1415	H-2-24174 SH 1
2-21	43	60	2780	1415	H-2-24174 SH 1
2-22	44	62	2780	1415	H-2-24174 SH 1 H-2-97481 SH 9
2-23	45	63	2780	1415	H-2-24174 SH 1
2-24	46	64	2780	1415	H-2-24174 SH 1
2-25	47	65	2780	1415	H-2-24174 SH 4, H-2-97481 SH 38
2-26	48	RISER 8	2780	1415	H-2-24174 SH 1 H-2-97481 SH 9
3-1	49	3	2781	1416	H-2-24174 SH 1
3-2	50	5	2781	1416	H-2-24174 SH 1
3-3	51	6	2781	1416	H-2-97481 SH 34
3-4	52	7	2781	1416	H-2-24174 SH 1 H-2-97481 SH 32
3-5	53	11	2781	1416	H-2-24174 SH 1
3-6	54	12	2781	1416	H-2-24174 SH 1
3-7	55	13	2781	1416	H-2-24174 SH 1
3-8	56	14	2781	1416	H-2-24174 SH 1
3-9	57	22	2781	1416	H-2-24174 SH 3
3-10	58	25	2781	1416	H-2-24174 SH 3
3-11	59	33	2781	1416	H-2-24174 SH 1, SH 4
3-12	60	44	2781	1416	H-2-24174 SH 3
3-13	61	48	2781	1416	H-2-24174 SH 3
3-14	62	61	2781	1416	H-2-24174 SH 1
3-19	63	SPARE	2781	1416	H-2-97481 SH 34
4-1	64		2780	1416	H-2-24174 SH 5/RISER 11 FAS
	116 119 120 125 126			1412	H-2-97481 SH 9 SUPERVISORY ZONES
	100 101 113 114 115 116 117 123 126 132			1415	H-2-97481 SH 9 SUPERVISORY ZONES
	102-112 121 122 127			1416	H-2-97481 SH 9 SUPERVISORY ZONES

GENERAL NOTES

(UNLESS OTHERWISE SPECIFIED)

1. PURPOSE OF M94 CARDS IS TO RELAY ZONE WIRING TROUBLE SIGNAL TO MASTER ELEMENTS. M84 (MOTHER BOARD) CARDS ARE GAMEWELL 30427. Z48 (ALARM) CARDS ARE GAMEWELL 30428.

2. ALL FIRE ALARM AND DETECTION FIELD COMPONENTS THAT ARE LISTED IN THE TABLE BELOW SHALL BE TAGGED IN THE FIELD WITH THE COMPONENT INDEX NUMBER. THE NUMBER SHALL CONSIST OF A PREFIX (FOR TYPE OF COMPONENT), A BASE NUMBER (WITH ZONE, SUB-ZONE (IF APPLICABLE) AND SEQUENTIAL NUMBER, AS SHOWN ON THE DWG), AND SUFFIXED WITH A BLDG NUMBER, PER THE FOLLOWING:

COMPONENT TYPE	PREFIX	BASE NUMBER			BLDG NUMBER
		ZONE	SUB-ZONE	SEQUENTIAL NUMBER	
DETECTOR	DET	2		1	234-5Z
MANUAL PULL STATION	MS	33	2	3	234-5Z
GONG (BELL)	B	1*		1	234-5Z
FLOW ALARM SWITCH	FAS	12		1	234-5Z
POST INDICATOR VALVE W/ TAMPER SWITCH	PIVTS	100		1	234-5Z
LOW PRESSURE SWITCH	PS	200		1	234-5Z
OS&Y VALVE W/ TAMPER SWITCH	OS&Y	101		1	234-5Z
VANE TYPE FLOW SWITCH	FS	27		1	234-5Z

* FOR GONGS UTILIZE CKT NUMBER IN PLACE OF ZONE NUMBER

COMPLETED EXAMPLES: DET-2-1-23452 PIVTS-100-1-23452
MS-33-2-2-23452 FS-27-1-23452
B-1-1-23452 OS&Y-121-1-23452
FAS-12-1-23452

3. ALL FIRE ALARM CONTROL PANELS, HALON CONTROL PANELS, RELAY PANELS, AUX CONTROL PANELS, TERMINAL BOXES AND ASSOCIATED ANNUNCIATORS SHALL HAVE A COMPONENT INDEX NUMBER AS SHOWN ON THE DWG.

GENERAL NOTES CONTINUED ON SHEET 22

LEGEND

SYMBOL	DESCRIPTION
	FIRE ALARM GONG
	MANUAL PULL STATION
	HALON SYS PULL STATION
	SMOKE DETECTOR (IONIZATION)
	SMOKE DETECTOR (PHOTOELECTRIC)
	THERMAL DETECTOR
	THERMAL DETECTOR (IN HOOD) OR GLOVE BOX
FCP	FIRE ALARM CONTROL PANEL
RFAR	RADIO FIRE ALARM REPORTER
ANN	ANNUNCIATOR PANEL
HCP	HALON CONTROL PANEL
	MASTER SHUTDOWN SWITCH
	VALVE W/TAMPER SWITCH
	FLOW ALARM PRESSURE SWITCH (FAS) OR LOW PRESS SW (PS)
J	JUNCTION BOX
	FLOW SWITCH (VANE TYPE)
	EXCESS PRESSURE PUMP
	GONG W/STROBE LIGHT
	FIRE ALARM STROBE LIGHT
	FIRE ALARM CHIME WITH LIGHT
	RISER
LW	LIMITED WATER BOTTLE STATION
1 2 3	END OF LINE (EOL) RESISTOR (EOLR)
K	CAPACITOR

SEE LEGEND (CONT) ON THIS SHEET

FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1

BLDG: 232-Z, 234-5Z, 234-5ZA, 234-ZC, 236-Z, 267-Z, 270-Z, 2701-ZA, 2701-ZD, 2704-Z, 2725-Z, 2727-Z, 2729-Z, 2731-Z, 2734-ZA, 2734-ZC, 2736-Z, 2736-ZA, 2736-ZB, 2736-ZC

LEGEND (CONT)

	FIRE ALARM LOCATOR LIGHT (REQ)	MS	MANUAL PULL STATION		
	BUZZER	SD	SMOKE DETECTOR	PIV	POST INDICATING VALVE
	WRING MATCH LINE POINT (WHEN USED ON WIRING DIAG)	TS	TAMPER SWITCH	WR	WIRE RUN
			ZONE DESIGNATION	LP	HALON CYL LOW PRESSURE SWITCH
	LOW TEMPERATURE SWITCH	OS&Y	OUTSIDE SCREW & YOKE	SD	SMOKE DETECTOR
HD	HEAT DETECTOR (THERMAL)	LS	LIMIT SWITCH	MSD	MASTER SHUTDOWN
ME	MASTER ELEMENT	EV	ELECTRICALLY OPERATED VALVE		
FA	FIRE ALARM				

FIELD VERIFIED PER ECN 195119 4/93 REV 4

DWG NO	TITLE
DRAWING TRACEABILITY LIST	

REF NUMBER	TITLE
REFERENCES	
NEXT USED ON H-2-24174 SH 1	

NO	DATE	DESCRIPTION	DRN	CHK	DES ENG	DES MGR	APPROVALS
10		ADD ECN 625803 REVISED PER ECN 639561	JLR				

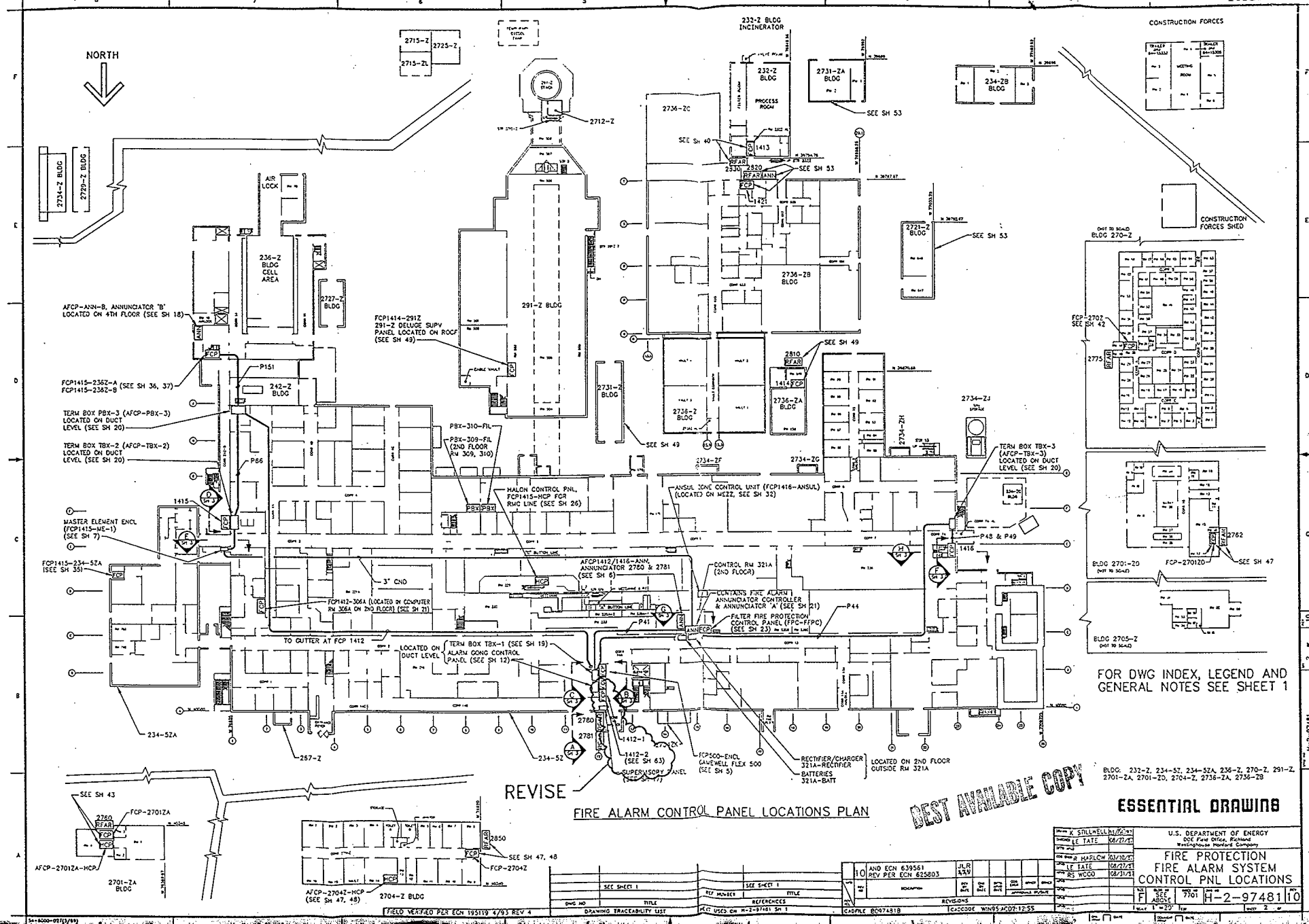
REVISIONS

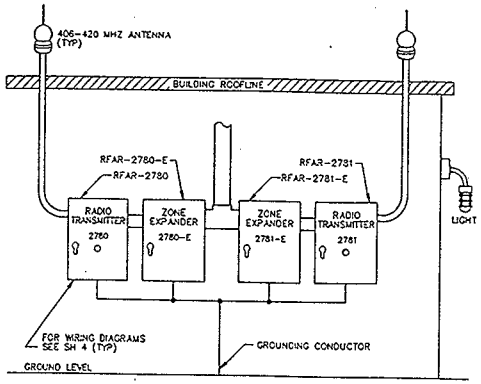
CADFILE B:\TAPIA ECADCODE WIN95/ACD2-12-95

DRAWN K STILLWELL	11/7/87	U.S. DEPARTMENT OF ENERGY DOE Field Office, Richland Westinghouse Hanford Company
CHECKED LE TATE	3/10/87	
DES ENG		
DES MGR R MARLOW	3/10/87	FIRE PROTECTION FIRE ALARM SYSTEM DWG INDEX & LEGEND
ENG LE TATE	3/10/87	
CHK RG WOOD	3/21/87	
APPROVALS		
SCALE NONE		SIZE F / SCALE SEE ABOVE / CODE IDENT NO 7702 / DWG NO H-2-97481 / REV 10 / SHEET 1 OF 58

ESSENTIAL DRAWING

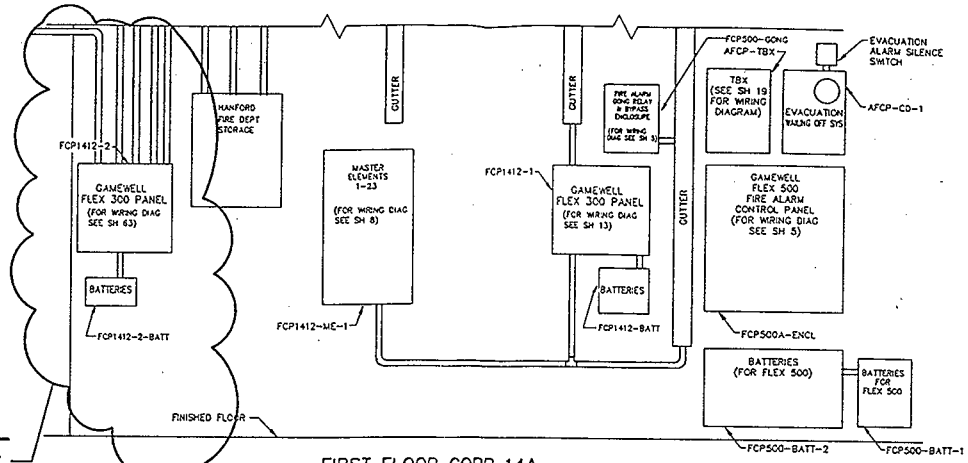
ECN No. 616156 | Page 5 of 14 | Ref. Dwg. H-2-97481 | Sh. 1 | Rev 10 | Prep. By C. McGOUGH | Ckd. By C. D. Eggen


NORTH
2715-Z
2725-Z
2715-ZL
2734-Z BLDG
2720-Z BLDG
AIR LOCK
236-Z BLDG CELL AREA
2727-Z BLDG
242-Z BLDG
291-Z BLDG
2712-Z
232-Z BLDG INCINERATOR
232-Z BLDG
PROCESS ROOM
2736-ZC
SEE SH 40
1413
2930
2820
SEE SH 53
1421
2731-ZA BLDG
234-ZB BLDG
2721-Z BLDG
2736-ZB BLDG
2731-Z BLDG
2736-Z BLDG
2736-ZA BLDG
2810
1414
SEE SH 49
2734-ZJ
2734-ZH
2734-ZF
2734-ZG
CONSTRUCTION FORCES
CONSTRUCTION FORCES SHED
BLDG 270-Z
FCP-2702 SEE SH 42
2775
2762
SEE SH 47
BLDG 2701-Z0
FCP-2701Z0
BLDG 2705-Z
AFCP-ANN-B, ANNUNCIATOR 'B' LOCATED ON 4TH FLOOR (SEE SH 18)
FCP1415-236Z-A (SEE SH 36, 37)
FCP1415-236Z-B
P151
TERM BOX PBX-3 (AFCP-PBX-3) LOCATED ON DUCT LEVEL (SEE SH 20)
TERM BOX TBX-2 (AFCP-TBX-2) LOCATED ON DUCT LEVEL (SEE SH 20)
P66
1415
MASTER ELEMENT ENCL (FCP1415-ME-1) (SEE SH 7)
FCP1415-234-5ZA (SEE SH 35)
FCP1414-291Z 291-Z DELUGE SUPV PANEL LOCATED ON ROOF (SEE SH 49)
PBX-310-FIL
PBX-309-FIL (2ND FLOOR RM 309, 310)
HALON CONTROL PNL, FCP1415-HCP FOR RMC LINE (SEE SH 26)
ANSUL ZONE CONTROL UNIT (FCP1416-ANSUL) (LOCATED ON MEZZ, SEE SH 32)
TERM BOX TBX-3 (AFCP-TBX-3) LOCATED ON DUCT LEVEL (SEE SH 20)
P48 & P49
1416
3" CND
AFCP1412/1416-ANN, ANNUNCIATOR 2780 & 2781 (SEE SH 6)
CONTROL RM 321A (2ND FLOOR)
CONTAINS FIRE ALARM ANNUNCIATOR CONTROLLER & ANNUNCIATOR 'A' (SEE SH 21)
FCP1412-306A (LOCATED IN COMPUTER RM 306A ON 2ND FLOOR) (SEE SH 21)
FILTER FIRE PROTECTION CONTROL PANEL (FPC-FFPC) (SEE SH 23)
P44
P41
TO GUTTER AT FCP 1412
LOCATED ON DUCT LEVEL
TERM BOX TBX-1 (SEE SH 19)
ALARM GONG CONTROL PANEL (SEE SH 12)
2780
2781
1412-1
1412-2 (SEE SH 63)
SUPERVISORY PANEL (SEE SH 17)
FCP5CO-ENCL GAMEWELL FLEX 500 (SEE SH 5)
RECTIFIER/CHARGER 321A-RECTIFIER
BATTERIES 321A-BATT
LOCATED ON 2ND FLOOR OUTSIDE RM 321A
234-5ZA
257-Z
234-5Z
FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1
BLDG: 232-Z, 234-5Z, 234-5ZA, 236-Z, 270-Z, 291-Z, 2701-ZA, 2701-Z0, 2704-Z, 2736-ZA, 2736-ZB
SEE SH 43
FCP-2701ZA
2760
AFCP-2701ZA-HCP
2701-ZA BLDG
2850
SEE SH 47, 48
FCP-2704Z
AFCP-2704Z-HCP (SEE SH 47, 48)
2704-Z BLDG
REVISE
FIRE ALARM CONTROL PANEL LOCATIONS PLAN
BEST AVAILABLE COPY
ESSENTIAL DRAWING
FIELD VERIFIED PER ECN 195119 4/93 REV 4
DRAWING TRACEABILITY LIST
REFERENCES
REVISIONS
10 AND ECN 639561 REV PER ECN 625803
U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company
FIRE PROTECTION
FIRE ALARM SYSTEM
CONTROL PNL LOCATIONS
H-2-97481 10
ECN No. 616156
Ref. Dwg. H-2-97481
Prep. By C. McGOUGH
Page 6 of 14
Sh. 2
Rev. 10
Ckd. By C. D. Fogg

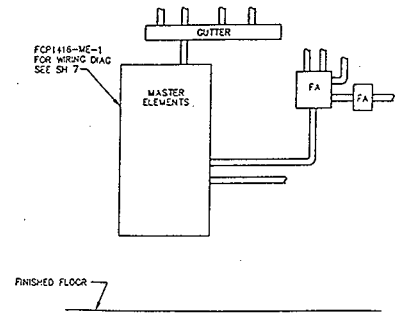


OUTSIDE WALL CORR 14A AIRLOCK
(A SH 2) ELEVATION

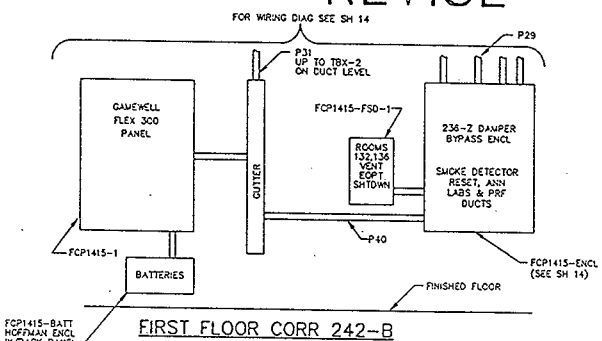
REVISE



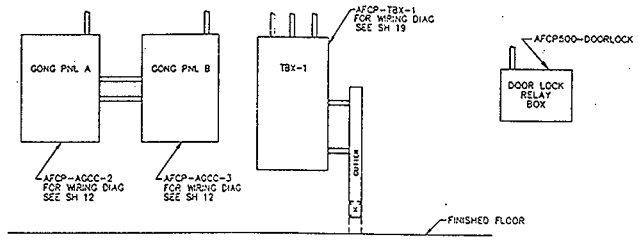
FIRST FLOOR CORR 14A
(B SH 2) ELEVATION



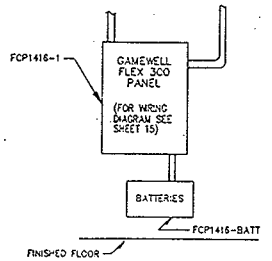
FIRST FLOOR CORR 7A
(F SH 2) ELEVATION



FIRST FLOOR CORR 242-B
(D SH 2) ELEVATION

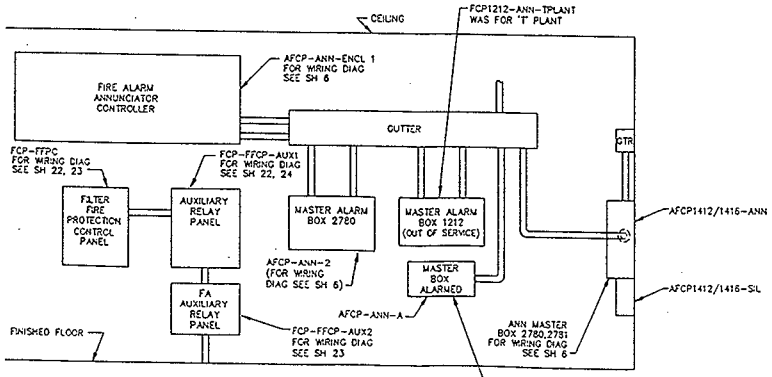


DUCT LEVEL
(C SH 2) ELEVATION
(REF DWG H-2-93532, H-2-81543)



FIRST FLOOR CORR 7A
(H SH 2) ELEVATION

FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1



CONTROL ROOM 321A
(G SH 2) ELEVATION

ESSENTIAL DRAWING

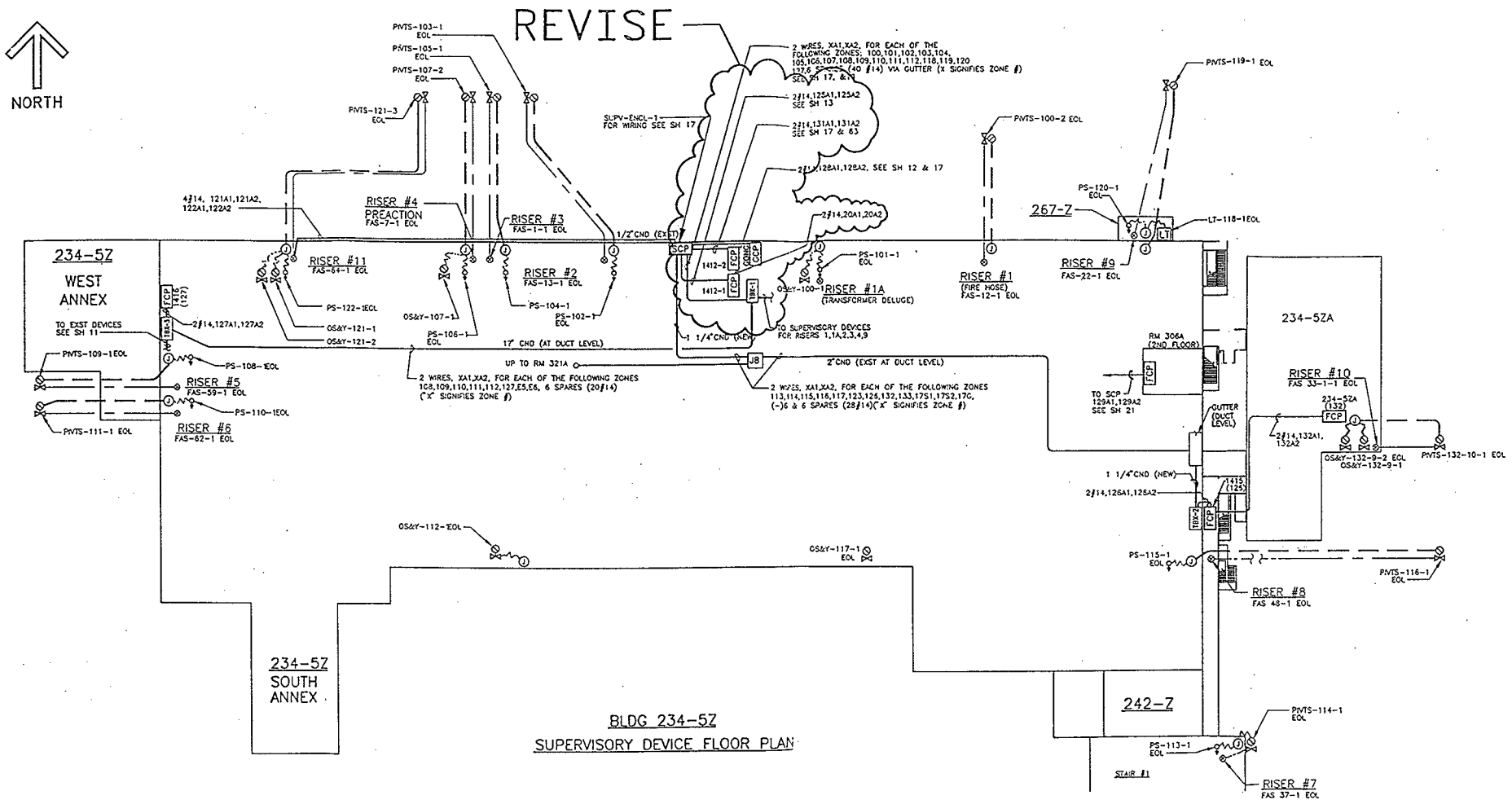
DWG NO	TITLE	REF NUMBER	TITLE
SEE SHEET 1		SEE SHEET 1	
DRAWING TRACEABILITY LIST		REFERENCES	

REV	DESCRIPTION		
7	REV PER ECN 636108	JLR 09/96	
REVISIONS			

DRAWN LE TATE	04/24/86	U.S. DEPARTMENT OF ENERGY DOE Field Office, Richland Westinghouse Hanford Company
CHECKED LE TATE	04/28/86	
SYS ENGR LE TATE	04/28/86	FIRE PROTECTION FIRE ALARM SYSTEM CONTROL PNL ELEVATIONS
LE TATE	04/28/86	
RS WOCO	12/13/86	
SIZE F	SCALE 254-52	CODE IDENT NO 7702
DWG NO H-2-97481	REV 7	

FIELD VERIFIED PER ECN 193119 4/93 REV 4

ECN No. 616156 | Ref. Dwg. H-2-97481 | Prep. By C. McGOUGH | Page 7 of 14 | Sh. 3 | Rev. 7 | Chkd. By C.D. Eggers



FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1

ESSENTIAL DRAWING

DRAWN J ARCHIBALD	03/01/93	U.S. DEPARTMENT OF ENERGY	
CHECKED C LONG	06/30/93	DOE Field Office, Richland	
SYS ENGR JM ISDELL	09/13/93	Westinghouse Hanford Company	
SUB DISC LD JOHNSON	06/30/93	FIRE PROTECTION	
SUPV SB MERRICK	06/31/93	FIRE ALARM SYSTEM	
		SUPERVISORY FLOOR PLAN	
		SIZE F	SUB-SYS 234-5Z
		SYSTEM 7702	DWG NO H-2-97481
		SHT 3	SCALE NONE
		ECN 195119	SHEET 9 OF

REV	DESCRIPTION	REV BY DATE	CHK BY DATE	WTS BY DATE	CDS BY DATE	APPROVALS BY/DATE	
3	REV PER ECN 621002	JLR 9/7/9					

REVISIONS

DWG NO	TITLE	REF NUMBER	TITLE
SEE SHEET 1		SEE SHEET 1	

DRAWING TRACEABILITY LIST — REFERENCES

NOT USED ON H-2-97481 SH 1

CADFILE B097481J — CADCODE WHS5-ACD2-12-SS

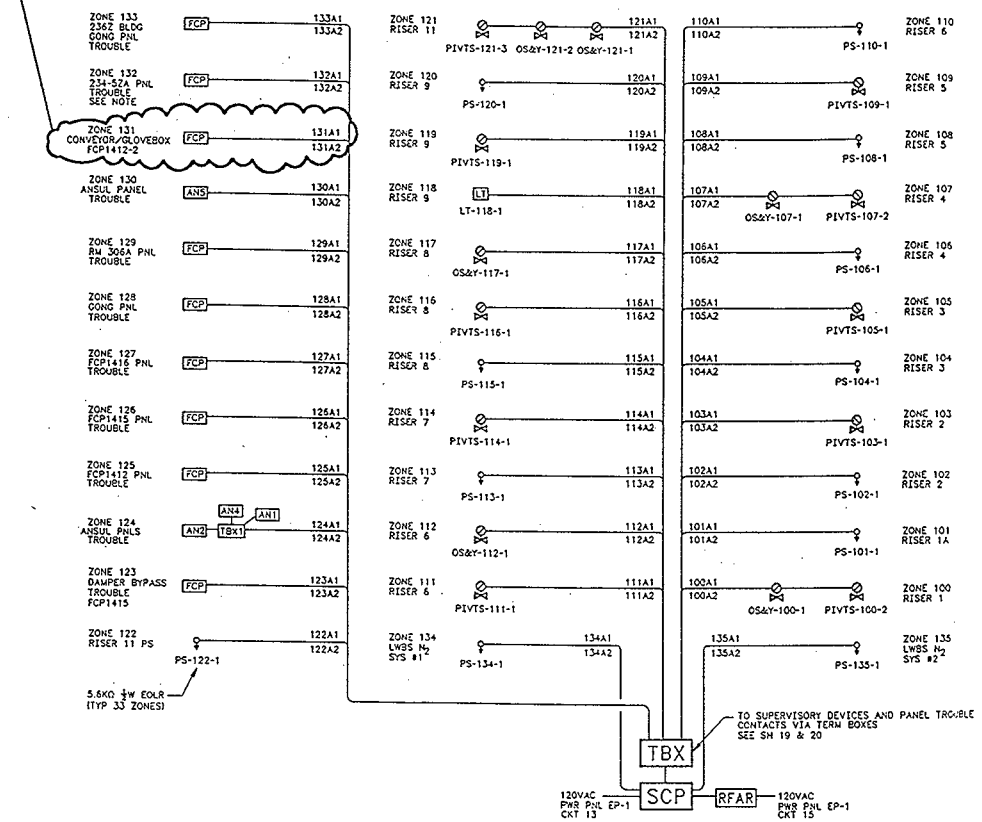
FIELD VERIFIED PER ECN 195119 4/93 REV 0

ECN No. 616156 | Page 8 of 11 | Sh. 9 | Rev. 3
Ref. Dwg. H-2-97481
Prep. By C. McGOUGH | Ckd. By C. J. Long

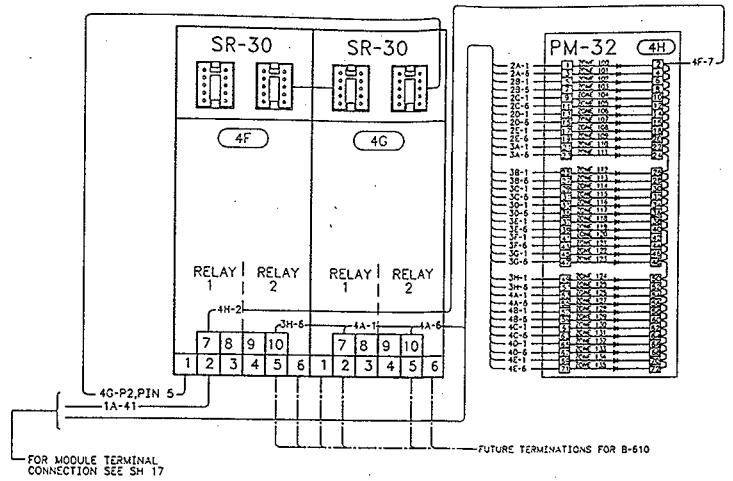
H-2-97481

54-9000-027(5/89)

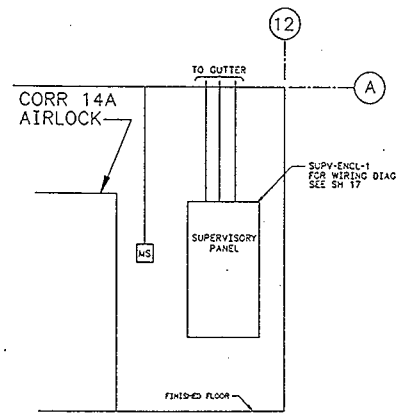
REVISE



DEVICE RISER DIAGRAM
SCALE: NONE
NOTE: FOR RISER 10 SUPERVISORY DEVICES SEE SH 35



SR-30 & PM-32 WIRING DIAGRAM



NORTH WALL ELEVATION
SEE SH 3 & 9

FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1

ESSENTIAL DRAWING

3	REV PER ECN 636108	JCR 09/96

REVISIONS

U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

FIRE PROTECTION
FIRE ALARM SYSTEM
SUPERVISORY DETAILS

F 234-52 7702 H-2-97481 3

SCALE NONE ECN 195119 Sheet 16 of

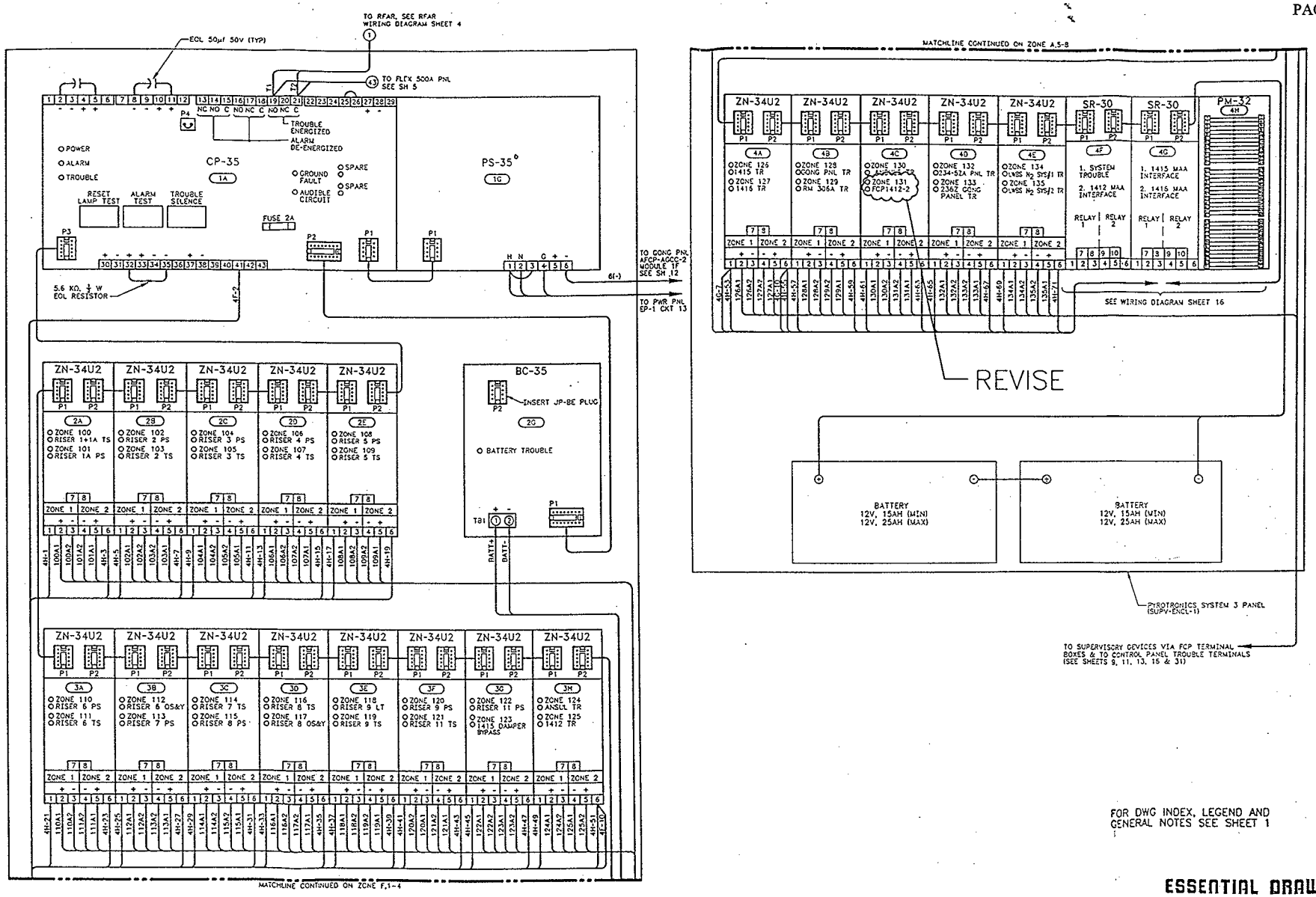
ECN No. 616156 Ref. Dwg. H-2-97481 Prep. By C. McGOUGH Chkd. By C. D. Sigmon Page 9 of 14 Sh. 16 Rev. 3

FIELD VERIFIED PER ECN 195119 4/93 REV 0

DRAWING TRACEABILITY LIST

REFERENCES

CADFILE B0974515 CADCODE W*495-AC02-12-55



FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1

SUPERVISORY PANEL
WIRING DIAGRAM

ESSENTIAL DRAWING

4	REVISED PER ECN 639616	JLR 11/93

U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

FIRE PROTECTION
FIRE ALARM SYSTEM
SUPV PNL WRG DIAG

F | 234-52 | 7702 | H-2-97481 | 4

SCALE NONE | ECN 195119 | SHEET 17 OF

FIELD VERIFIED PER ECN 195119 4/93 REV 0

DRAWING TRACEABILITY LIST | SEE SHEET 1 | REFERENCES | SEE SHEET 1 | H-2-97481 SH 1

CAD/AE BC97481T | CADCODE WH95ACD2-12 SS

ECN No. 616156 | Ref. Dwg. H-2-97481 | Prep. By C. McGOUGH | Chkd. By | Page 10 of 14 | Sh. 17 | Rev. 4

PANELBOARD D LTG
LOCATION 1ST FL, CORR 2, COL C/12
NEMA TYPE 1
☐ SURFACE MOUNTED
☒ FLUSH MOUNTED
☐ TOP ☒ BOT FEEDER
☒ MAIN BRKR
☐ LUGS ONLY
100 AMP PWR BUS
100 AMP NEUT BUS
☒ NEUTRAL BUS
☐ GROUND BUS
VOLTS 208Y/120VAC, 3Ø
FED FROM F8X310
ONE LINE DWG H-2-26538/40
PNL SCHED DWG H-2-99550/17
PNL LAST REV 8/24/95 REV 0

SERVICE	BRKR AMPS	NO.	NO.	BRKR AMPS	SERVICE
RCPT: 5 ⊖ 240 LOCATION: RM 202	15	1	2	15	RCPT: 9 ⊖ 100 LOCATION: CORR 14a
RCPT: 5 ⊖ 240 LOCATION: RM 202	15	3	4	20	RCPT: 8 ⊖ 100 LOCATION: RM 205, STR 2
RCPT: 5 ⊖ 240 LOCATION: RM 202	15	5	6	15	RCPT: 3 ⊖ 240 2 ⊖ 100 LOCATION: RM 199,200,201
RCPT: 5 ⊖ 240 LOCATION: RM 202	15	7	8	15	RCPT: 4 ⊖ 40 LOCATION: CORR 14a, CORR 2 EXIT LITES
RCPT: 12 ⊖ 100 LOCATION: RM 208	15	9	10	15	RCPT: 11 ⊖ 100 LOCATION: RM 210,211
RCPT: 12 ⊖ 100 LOCATION: RM 208	15	11	12	15	RCPT: 8 ⊖ 100 LOCATION: RM 211
RCPT: 10 ⊖ 100 LOCATION: RM 209	15	13	14	15	RCPT: 7 ⊖ 100 LOCATION: RM 212,213,214
RCPT: 6 ⊖ 100 LOCATION: RM 209	15	15	16	15	RCPT: 12 ⊖ 100 LOCATION: TUNNEL 5
PORTAL RADIATION MONITOR	20	17	18	15	RCPT: 12 ⊖ 100 LOCATION: TUNNEL 5-6
HAND & FEET & COUNTER	15	19	20	15	RCPT: 12 ⊖ 100 LOCATION: TUNNEL 5
RCPT: 1 ⊖ 2400 LOCATION: RM 111	20	21	22	15	SPARE
RCPT: 1 ⊖ 2400, 2 ⊖ 180 LOCATION: RM 216, RM 211, CORR 13	20	23	24	15	SPARE
CRIT RELAY BOX LOCATION: CORR 14A	15	25	26	15	FIRE ALARM CONTROL PANEL FCP1412-2, CORRIDOR 14A
RCPT: 3 ⊖ 100 LOCATION: RM 208	15	27	28	20	FUTURE AIR CONDITIONER RM 208
RCPT: 2 ⊖ 100 LOCATION: RM 208	15	29	30		

H1 H2 H3 100

THIS PANELBOARD HAS BEEN VISUALLY VERIFIED FOR BREAKER SIZES AND NUMBER OF CIRCUITS. ELECTRONIC TRACING OF INDIVIDUAL CIRCUITS WAS PREVIOUSLY DONE.

REVISE

PANELBOARD D RCPT
LOCATION 1ST FL, CORR 2, COL C/12
NEMA TYPE 1
☐ SURFACE MOUNTED
☒ FLUSH MOUNTED
☐ TOP ☒ BOT FEEDER
☒ MAIN BRKR
☐ LUGS ONLY
100 AMP PWR BUS
100 AMP NEUT BUS
☒ NEUTRAL BUS
☒ GROUND BUS
VOLTS 208Y/120VAC, 3Ø
FED FROM F8X310
ONE LINE DWG H-2-26538/40
PNL SCHED DWG H-2-99550/17
PNL LAST REV 8/24/95 REV 0

SERVICE	BRKR AMPS	NO.	NO.	BRKR AMPS	SERVICE
RECEPTACLE: 5 ⊖ 250 LOCATION: TUNNEL	15	1	2	15	RECEPTACLE: 3 ⊖ 250 LOCATION: ROOM 202
RECEPTACLE: 5 ⊖ 200 LOCATION: ROOM 250 AND 251	15	3	4	15	SPARE
RECEPTACLE: 5 ⊖ 200 LOCATION: RM 251, 252 AND 253	20	5	6	15	SPARE
RECEPTACLE: 1 ⊖ 250 LOCATION: ROOM 202	20	7	8	15	SPARE
RECEPTACLE: 1 ⊖ 2000 LOCATION: ROOM 202 MEZZANINE	20	9	10	15	RECEPTACLE: LOCATION: ROOM 250 AND 251
RECEPTACLE: 1 ⊖ 330, 1 ⊖ 200 LOCATION: ROOM 208	15	11	12	20	RECEPTACLE: 4 ⊖ 250 LOCATION: ROOM 208, CORR 14
RECEPTACLE: 1 ⊖ 330 LOCATION: ROOM 208	15	13	14	20	RECEPTACLE: 3 ⊖ 250 LOCATION: ROOM 209
RECEPTACLE: 4 ⊖ 250 LOCATION: ROOM 208 AND 208A	15	15	16	15	RECEPTACLE: 4 ⊖ 250 LOCATION: ROOM 209
SPARE	15	17	18	15	RECEPTACLE: 4 ⊖ 250 LOCATION: ROOM 212, 212A & 215
RECEPTACLE: 1 ⊖ 330 LOCATION: RM 211, 202, 1/4HP DP	15	19	20	15	RECEPTACLE: 3 ⊖ 25 LOCATION: ROOM 209 AND 210
RECEPTACLE: 3 ⊖ 250 LOCATION: ROOM 209 AND 210	15	21	22	15	RECEPTACLE: 1 ⊖ 750 LOCATION: RM 211
RECEPTACLE: 6 ⊖ 250 LOCATION: RM 205 AND 213 CORRIDOR 13 AND 14	15	23	24	15	RECEPTACLE: 6 ⊖ 250 LOCATION: ROOM 233, CORR 2
RECEPTACLE: 7 ⊖ 200 LOCATION: ROOM 233	15	25	25	15	RECEPTACLE: 5 ⊖ 250 LOCATION: RM 212,212A,215 & 216
RECEPTACLE: 6 ⊖ 200 LOCATION: ROOM 253 AND 254	15	27	28	15	SPARE
RECEPTACLE: 1 ⊖ 2000 LOCATION: ROOM 202	15	29	30	15	SPARE

H1 H2 H3 100

THIS PANELBOARD HAS BEEN VISUALLY VERIFIED FOR BREAKER SIZES AND NUMBER OF CIRCUITS. ELECTRONIC TRACING OF INDIVIDUAL CIRCUITS WAS PREVIOUSLY DONE.

PANELBOARD DA
LOCATION DUCT LVL, RM 256, COL D/8
NEMA TYPE 1
☒ SURFACE MOUNTED
☐ FLUSH MOUNTED
☐ TOP ☒ BOT FEEDER
☒ MAIN BRKR
☐ LUGS ONLY
100 AMP PWR BUS
100 AMP NEUT BUS
☒ NEUTRAL BUS
☐ GROUND BUS
VOLTS 125VDC
FED FROM PANELBOARD PD
ONE LINE DWG H-2-26538/13
PNL SCHED DWG H-2-99550/17
PNL LAST REV 8/24/95 REV 0

SERVICE	BRKR AMPS	NO.	NO.	BRKR AMPS	SERVICE
OUTLETS: 5 ⊖ 40, 2 ⊖ 100 LOAD: 400W, 4 EXITS LOCATION: CORRIDOR 12, 13 & 14A	15	1	2	15	OUTLETS: 3 ⊖ 40, 2 ⊖ 100 LOAD:320W, 4 EXITS LOCATION: ROOM 169
OUTLETS: 2 ⊖ 40, 4 ⊖ 100 LOAD: 480W, 2 EXITS LOCATION: CORRIDOR 3 AND 5	15	3	4	15	OUTLETS: 2 ⊖ 40, 3 ⊖ 100 LOAD: 380W, 2 EXITS LOCATION: ROOM 132, CORRIDOR 4
OUTLETS: 3 ⊖ 40, 5 ⊖ 100 LOAD: 620W LOCATION: ROOM 109, CORRIDOR 2	15	5	6	15	OUTLETS: 3 ⊖ 40, 2 ⊖ 100 LOAD: 320W LOCATION: CORRIDOR 4
OUTLETS: 1 ⊖ 40, 5 ⊖ 100 LOAD: 620W LOCATION: STAIR 12	15	7	8	15	OUTLETS: 7 ⊖ 100 LOAD: 700W LOCATION: ROOM 262, 263 & 264
OUTLETS: 2 ⊖ 40, 5 ⊖ 100 LOAD: 580W; LOCATION ROOM 266, 260	15	9	10	15	OUTLETS: 1 ⊖ 40, 8 ⊖ 100 LOAD: 840W, LOCATION: STAIR 12, ROOM 308, CORRIDOR 3
OUTLETS: 1 ⊖ 40, 3 ⊖ 100 LOAD: 340W LOCATION CORRODOR 1, STAIR 1	15	11	12	15	SPARE
SPARE	15	13	14	15	SPARE
SPARE	15	15	16	15	SPARE

POS NEG 100

THIS PANELBOARD HAS BEEN VISUALLY VERIFIED FOR BREAKER SIZES AND NUMBER OF CIRCUITS. ELECTRONIC TRACING OF INDIVIDUAL CIRCUITS WAS PREVIOUSLY DONE.

PANELBOARD DB
LOCATION DUCT LVL, RM 252, COL E/17
NEMA TYPE 1
☒ SURFACE MOUNTED
☐ FLUSH MOUNTED
☐ TOP ☒ BOT FEEDER
☒ MAIN BRKR
☐ LUGS ONLY
100 AMP PWR BUS
100 AMP NEUT BUS
☒ NEUTRAL BUS
☐ GROUND BUS
VOLTS 125VDC
FED FROM PANELBOARD PD
ONE LINE DWG H-2-26538/13
PNL SCHED DWG H-2-99550/17
PNL LAST REV 8/24/95 REV 0

SERVICE	BRKR AMPS	NO.	NO.	BRKR AMPS	SERVICE
SPARE	15	1	2	15	SPARE
SPARE	15	3	4	15	SPARE
SPARE	15	5	6	15	SPARE
SPARE	15	7	8	15	SPARE
SPARE	15	9	10	15	SPARE
SPARE	15	11	12	15	SPARE

POS NEG 100

THIS PANELBOARD HAS BEEN VISUALLY VERIFIED FOR BREAKER SIZES AND NUMBER OF CIRCUITS. ELECTRONIC TRACING OF INDIVIDUAL CIRCUITS WAS PREVIOUSLY DONE.

SEE SHEET 1 FOR GENERAL NOTES.

PANELBOARDS ON THIS DRAWING:

D LTG
D RCPT
DA
DB

ESSENTIAL DRAWING

DWG NO	TITLE
SEE SHEET 1	

DRAWING TRACEABILITY LIST

REF NUMBER	TITLE
SEE SHEET 1	
NEXT USED ON H-2-26538	

REFERENCES

REV	DATE	DESCRIPTION	DRAWN DATE	CHKD DATE	APPD DATE	CODE APPROVAL	DATE	OTHER	OTHER

REVISIONS

CADFILE B099550T CADCODE COS-6.0-AC02-12-SS

Drawn KBK 6-27-95
CHECKED
DATE APPD
CON DWG
APPD
APPD
APPD
APPD
APPD

U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

PANEL SCHEDULES

SIZE	CODE IDENT NO	DWG NO	REV
F	234-52	7304 H-2-99550	0

SCALE NONE | CODE 602461 | SHEET 17 OF

ECN No. 616156
Ref. Dwg. H-2-99550
Prep. By C. McGOUGH
Chkd. By C. McGough
Page 11 of 14
Sh. 17 Rev. 0

34-8000-027(5/89)

DRAWING INDEX

DWG NUMBER	SH NO	TITLE	DESCRIPTION	REFERENCE DWG	RFAR
H-2-97481	59	RFAR 2840	HS-046/HS-047 RFAR WIRING DIAGRAM	H-2-99550 SH 75, H-2-818133 SH 1	2840
H-2-97481	60	DRY CHEMICAL SUPPR HC-7C	DRY CHEMICAL SUPPRESSION SYSTEM FOR GLOVEBOX		2780/2781
H-2-97481	61	DWG INDEX AND LEGEND SHEET 2	DWG INDEX LEGEND, GEN NOTES & ZONING SCH		2780/2781
H-2-97481	62	GLOVEBOX DETECTOR/STROBE PLAN	PLAN VIEW OF ZONE 20 DETECTORS IN GLOVEBOXES		2780/2781
H-2-97481	63	FCP1412-2 WIRING DIAG	GAMEWELL FLEX 300 PANEL WIRING DIAG		2780/2781

234-5Z ZONING SCHEDULE

MASTER ELEMENT	ZONE	OLD ZONE	RFAR	OLD FCP	ZONING DWG/REMARK
	130		1412		H-2-97481 SH 9 SUPERVISORY ZONES
	131		1412		

FOR DWG INDEX, LEGEND AND GENERAL NOTES SEE SHEET 1

ECN No. 616156 Page 12 of 14
Ref. Dwg. H-2-97481 Sh. 61 Rev. 0
Prep. By C. McGOUGH Ckd. By C. McGough

FIELD VERIFIED PER ECN 195119 4/93 REV 4

DWG NO	TITLE
	DRAWING TRACEABILITY LIST

REF NUMBER	TITLE
REFERENCES	
NOT USED ON H-2-24174 SH 1	

NO	DESCRIPTION	REV DATE	REV BY	REV CHK	DES CHK	APVD	APVD
REVISIONS							

CADFILE 97481RB CADCODE WIN95-ACD7-12-SS

C. McGOUGH 6/27/97

U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

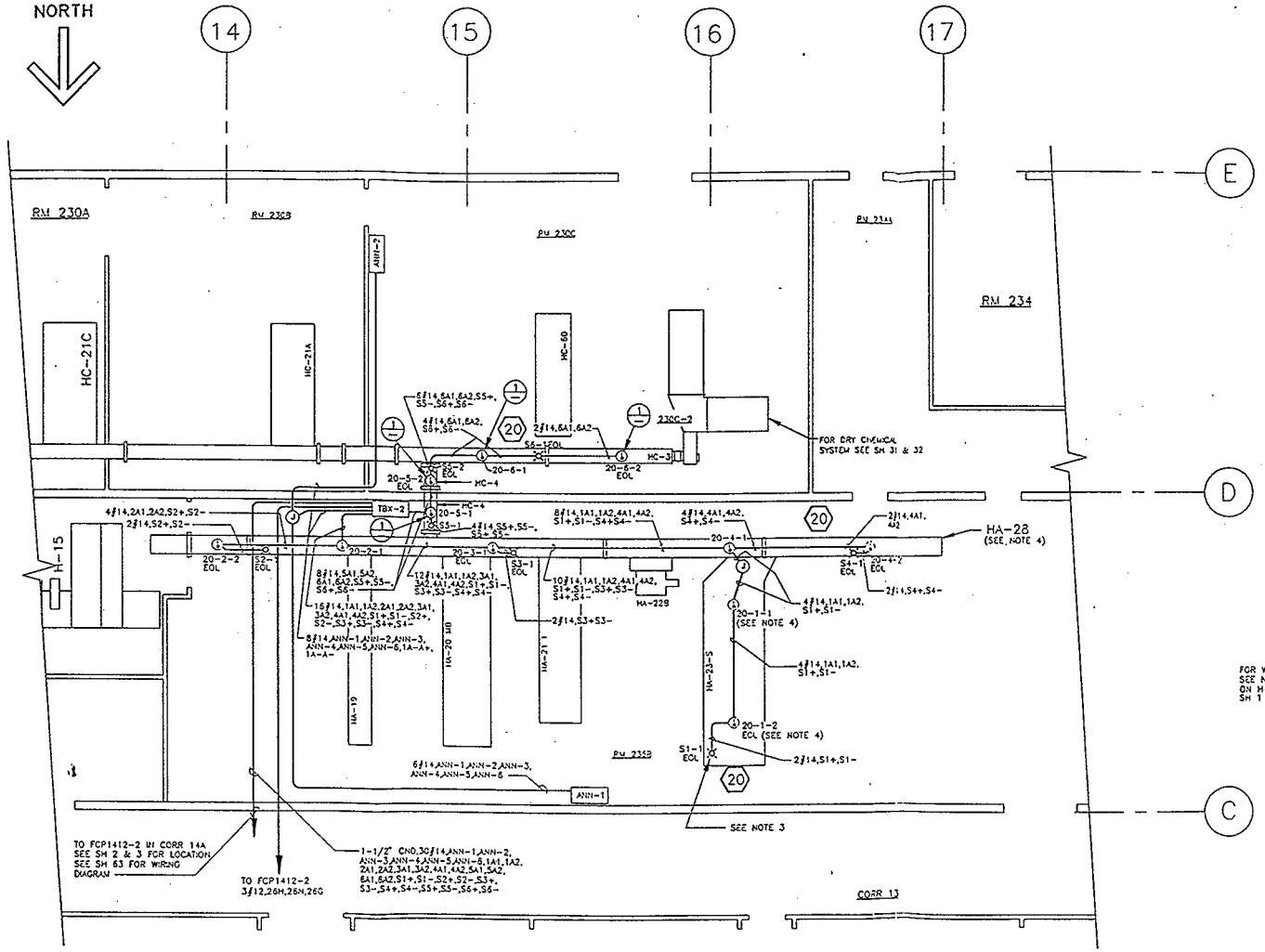
FIRE PROTECTION
FIRE ALARM SYSTEM
DWG INDEX/LEGEND CONT

SIZE F | SCALE SEE ABOVE | BLDG NO 7703 7701 | DWG NO H-2-97481 | REV 0
SCALE NONE | TYP | SHEET 61 OF

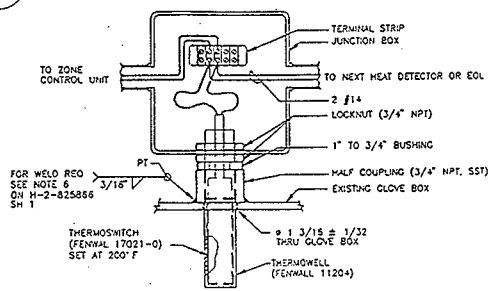
54-6000-027(3/93)

ECN NOTES: (DO NOT INCORPORATE ON DRAWINGS)

1. CONDUIT SHOWN DIAGRAMMATICALLY. FIELD ROUTE NEW CONDUIT
2. REUSE EXISTING CONDUIT OR WIRE OR INSTALL NEW. NEW CONDUIT SHALL BE 3/4" MINIMUM UNLESS NOTED OTHERWISE.
3. STROBE HEIGHT TO BE DETERMINED IN FIELD. VISIBILITY OF STROBE WILL BE DETERMINED BY HEIGHT OF GLOVEBOX HA-23-S.
4. REUSE EXISTING HEAT DETECTORS. REWIRE & RENUMBER TO NEW SUB-ZONE FOR NEW WIRING SEE H-2-97481 SH 63.
5. ACTUAL FIELD LOCATION OF THE INDICATOR LIGHT ON HA-23S WILL BE DETERMINED BY THE FIRE SYSTEM COGNIZANT ENGINEER.



ZONE 20 CONVEYOR/GLOVEBOX FIRE DETECTION SYSTEM
SCALE: NONE



1 TYPICAL GLOVE BOX HEAT DETECTOR ASSY
WIRING DIAGRAM
SCALE: NONE

ECN No. 616156 | Ref. Dwg. H-2-97481 | Prep. By C. McGOUGH | Page 13 of | Sh. 62 | Rev. 0 | Chkd. By

DRAWING TRACEABILITY LIST			
DWG NO	TITLE	REFERENCES	
SEE SHEET 1		REF NUMBER	TITLE
		SEE SHEET 1	

NOT USED ON H-2-97481 SH 1

REVISIONS

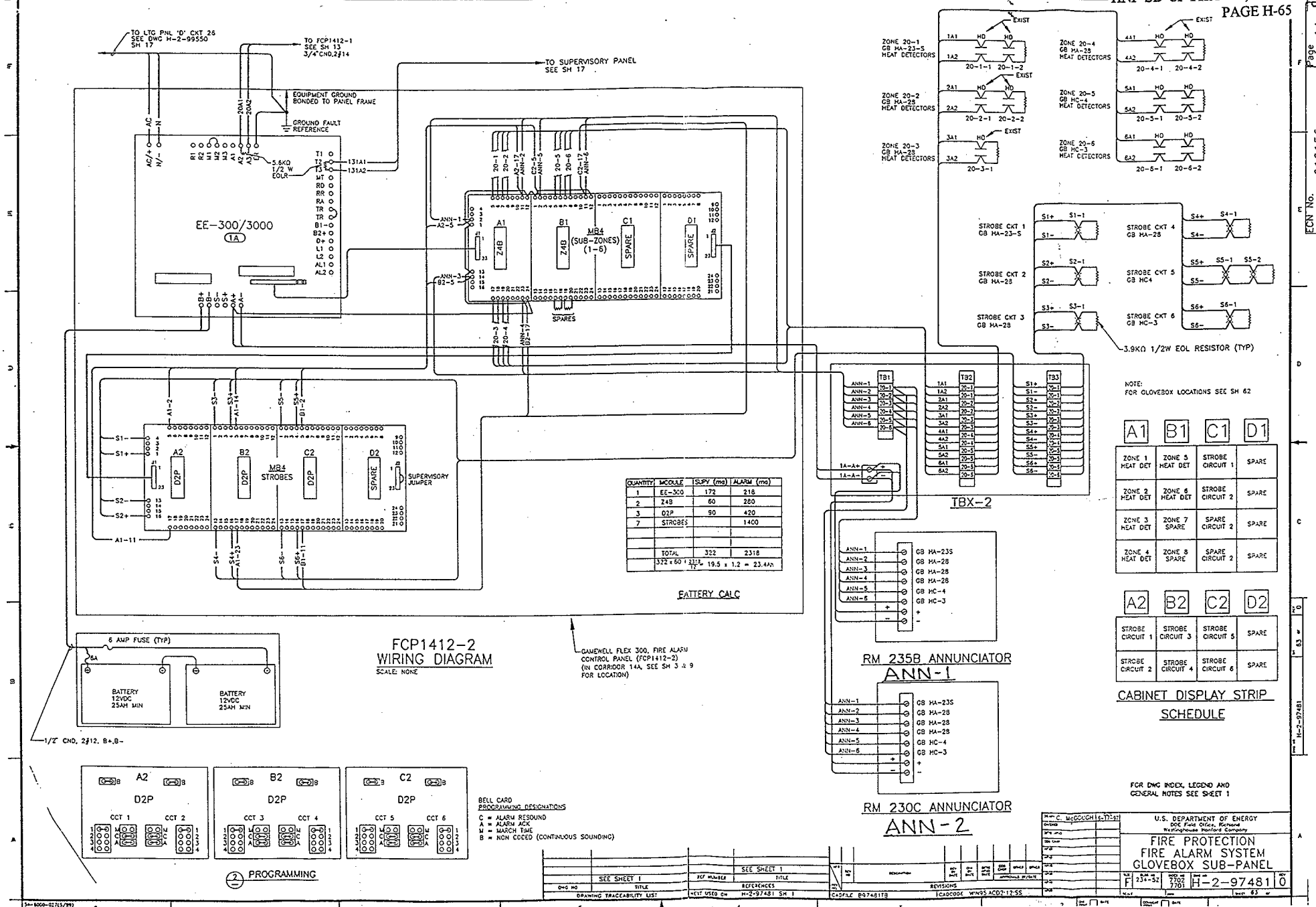
CADFILE 897481S8 | CADCODE WIN95-ACD3-12-SS

U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

FIRE PROTECTION
FIRE ALARM SYSTEM
CONVEYOR/GLOVEBOX DET

FCTS 234-52 | SUB-SYS 7003 7701 | H-2-97481 | 0

SHEET 63

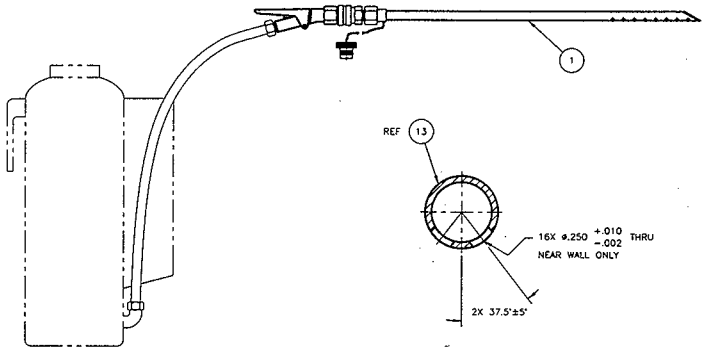


QUANTITY	MODULE	SUPV (ma)	ALARM (ma)
1	EE-300	172	218
2	Z4B	60	280
3	D2P	90	420
7	STROBES		1400
	TOTAL	322	2318
	$322 \times 60 + \frac{2318}{12} = 19.5 \times 1.2 = 23.4$AH		

A1	B1	C1	D1
ZONE 1 HEAT DET	ZONE 5 HEAT DET	STROBE CIRCUIT 1	SPARE
ZONE 2 HEAT DET	ZONE 6 HEAT DET	STROBE CIRCUIT 2	SPARE
ZONE 3 HEAT DET	ZONE 7 SPARE	SPARE CIRCUIT 2	SPARE
ZONE 4 HEAT DET	ZONE 8 SPARE	SPARE CIRCUIT 2	SPARE

A2	B2	C2	D2
STROBE CIRCUIT 1	STROBE CIRCUIT 3	STROBE CIRCUIT 5	SPARE
STROBE CIRCUIT 2	STROBE CIRCUIT 4	STROBE CIRCUIT 6	SPARE

CABINET DISPLAY STRIP SCHEDULE

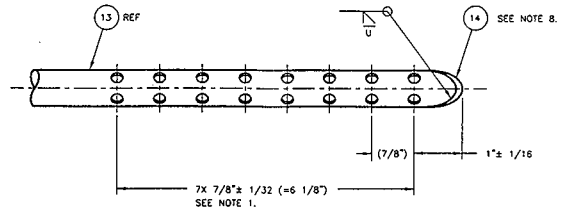


(ANSUL CARTRIDGE OPERATED FIRE EXTINGUISHER)

SCALE: 1/4

SECTION A–A

SCALE: 2/1



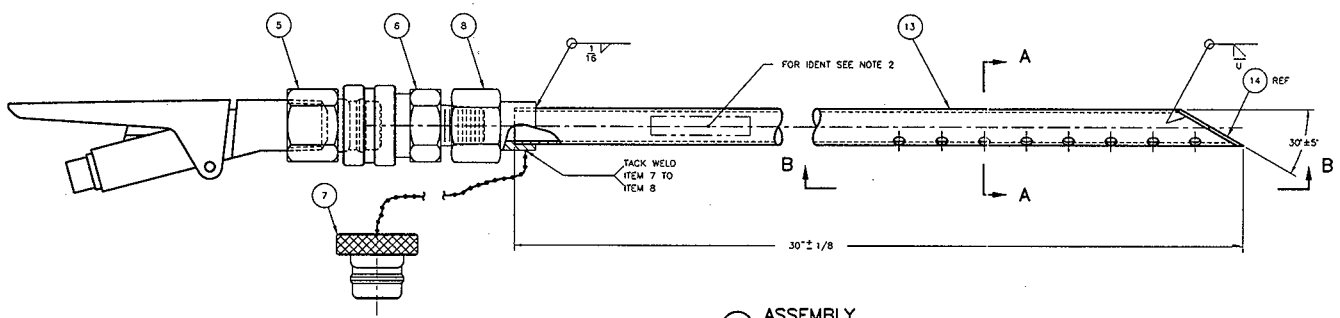
VIEW B–B

SCALE: 2/1

QTY REQD -020	QTY REQD -010	PART/DASH NUMBER	DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
	X	-010	ASSEMBLY			1
X		-020	ASSEMBLY			2
						3
						4
1	1	ANSUL DWG # 11338	NOZZLE ASSEMBLY W/ MALE NIPPLE	ANSUL SEE NOTE 10 & 11		5
	1	APHC 12-12 M	QUICK DISCONNECT 3/4" COUPLER FEMALE	SNAP-TITE (SEE NOTE 10 & 11)		6
1	1	AMPH-12 W/BC-8	METAL DUST PLUG	SNAP-TITE (SEE NOTE 10 & 11)		7
	1	SS-12-TSW-7-12	FEMALE CONNECTOR	CAJON		8
1		SS-1210-1-12	MALE CONNECTOR (TAPERED THREAD)	SWAGELOK		9
1		APHC-12-12-F	QUICK DISCONNECT 3/4" COUPLER FEMALE	SNAP-TITE (SEE NOTE 10 & 11)		10
						11
	1		COUPLING 7/8" THREADED CL 3000	ASTM A 182 GR F 304 L SST		12
1	1		TUBING ø 3/4" X (.065) WALL SMLS	ASTM A 269 GR TP 304 L SST		13
AR	AR		SHEET 11 GA (.1200)	ASTM A 240 GR TP 304 L SST		14

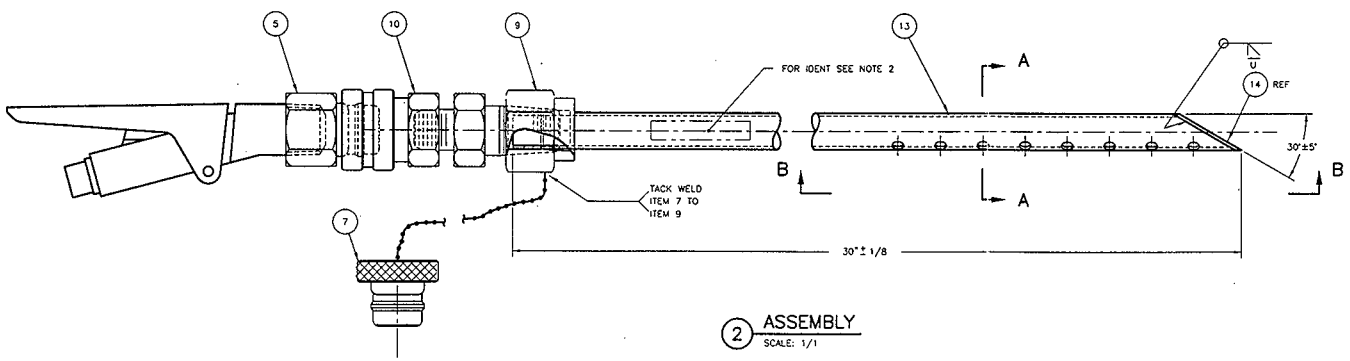
GENERAL NOTES (UNLESS OTHERWISE SPECIFIED)

1. REMOVE ALL BURRS AND BREAK SHARP EDGES TO HOLES ONLY.
2. IDENTIFY ASSEMBLY 1 AND 2 PER HS-BS-0015 TYPE 5 (ELECTRO CHEMICAL ETCH), WITH DRAWING NUMBER, PART NUMBER AND DRAWING REVISION NUMBER IN LOCATION INDICATED USING 0.1" MINIMUM HIGH CHARACTERS.
3. WELD AND INSPECT PER B31.1. VT WELDS AT FINAL PASS. DOCUMENT WELDS PER APPROVED INSPECTION PLAN. WELDING QUALIFICATIONS PER ASME SECTION IX ARE ACCEPTABLE.
4. METAL DUST PLUG ITEM 7 IS TO BE FIELD INSTALLED FOR EXACT LOCATION OF TACK WELD. THE PLUG MUST BE ABLE TO SNAP INTO THE FEMALE COUPLER ITEM 6 OR 9 AFTER DISENGAGING BAYONET FROM EXTINGUISHER.
5. APPLY THREAD LUBRICANT "ALCOA" 9127 OR EQUAL TO ALL THREADED PARTS PRIOR TO ASSEMBLY.
6. TUBING ITEM 13 TO BE BUTTED UP TIGHTLY INSIDE OF FEMALE CONNECTOR ITEM 8 PRIOR TO WELDING IN PLACE, ASSEMBLY 1 ONLY.
7. BAYONET WAS DESIGNED FOR 20 OR 30 POUND ANSUL EXTINGUISHERS ONLY.
8. HONE THE BAYONET TIP ENOUGH TO ALLOW THE BAYONET TO EASILY PUNCTURE THE GLOVEBOX GLOVE. PERFORM A PRACTICAL/FUNCTIONAL TEST PUNCTURING THE GLOVE AND ENSURE THE TIP SHARPNESS IS ADEQUATE.
9. TWO ASSEMBLIES VARY IN PARTS TO ACCOMMODATE THE LONG PROCUREMENT LEAD TIME NEEDED FOR FABRICATION.
10. ANSUL DRAWING PART NUMBER 5 AS INDICATED MAY BE REVISED AND A NEW DRAWING NUMBER GIVEN. THE PART CAN BE SUBSTITUTED FOR THE LATEST ANSUL BAYONET NOZZLE ASSEMBLY WITH A SNAP-TITE MALE NIPPLE FITTING ONLY. FIRE SYSTEM COG ENGINEER APPROVAL REQUIRED PRIOR TO ORDERING ANSUL SUBSTITUTED PART. IF SNAP-TITE MALE NIPPLE IS NOT BEING USED BY ANSUL, THE OTHER PARTS MUST BE REVISED TO FIT THE SELECTED MANUFACTURERS QUICK DISCONNECT FITTINGS.
11. PART NUMBER 10 (IN ADDITION TO PART NUMBER 5) MAY BE ORDERED DIRECTLY FROM ANSUL BASED ON ANSUL'S PART AVAILABILITY. PART NUMBER 10 IS A LONG LEAD PROCUREMENT ITEM FROM SNAP-TITE.



1 ASSEMBLY

SCALE: 1/1



2 ASSEMBLY

SCALE: 1/1

		H-2-24734	FIRE EXTINGUISHER LOCATIONS	2	REVISED PER ECN 643213.	EPL 9/97	
		REF NUMBER	TITLE	REV	DESCRIPTION	DRAWN DATE	CHECKED DATE
DWG NO	TITLE	REFERENCES		REVISIONS			
DRAWING TRACEABILITY LIST		NEXT USED ON AS ALLOCATED		CADFILE B099514A	CADCODE WIN95-AC02:12.0:SS		

DRAWN BY ROBERT E MITCHELL 11-20-97
CHECKED LARRY J. ROBINSON 11/21/97
STD APVD JANICE M ISDELL 11/21/97
COG CHCK HUEY NGUYEN HUI 12/4/97

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
B&W Hanford Co.

GLOVE BOX BAYONET
DRY CHEMICAL
FIRE EXTINGUISHER

SIZE	BLDG NO	SHEET NO	DWG NO	REV
A	234-52	9901	H-2-99514	2

SCALE SHOWN CAD 703218 SHEET 1 OF 1

2 PLOT SCALE: 1=1

CORRESPONDENCE DISTRIBUTION COVERSHEET

Author	Addressee	Correspondence No.
G. M. MCGrath FDH	J. E. Mecca RL	FDH-9851833 R2

Subject: CONTRACT NO. DE-AC06-96RL13200 - EXEMPTION REQUEST FOR THE REQUIREMENTS FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT 94-1 GLOVEBOXES

DISTRIBUTION

Approval	Date	Name	Location	w/att
		Correspondence Control	A3-01	
		Fluor Daniel Hanford, Inc.		
		P. T. Jewell	B3-70	
		E. S. McGinley	H8-68	
		GMM File/LB		X
		B&W Hanford Company		
		D. B. Cartmell	R3-50	
		F. R. Crawford	T5-50	
		R. D. Redekopp	T5-15	
		RL		
		K. A. Benguiat	R3-78	
		B. F. Burton	T5-50	
		P. M. Knollmeyer	A5-11	
		W. D. Seaborg	T5-50	
		S. A. Sieracki	A7-80	
		J. W. Todd	T5-50	

NO ATTACHMENTS RECEIVED

FLUOR DANIEL

Fluor Daniel Hanford, Inc.
P.O. Box 1000
Richland, WA 99352

March 26, 1998 FDH-9851833 R2

Mr. J. E. Mecca, Director
Transitions Program Division
U.S. Department of Energy
Richland Operations Office R3-79
Post Office Box 550
Richland, Washington 99352

Dear Mr. Mecca:

CONTRACT NO. DE-AC06-96RL13200 - EXEMPTION REQUEST FOR THE REQUIREMENTS FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT 94-1 GLOVEBOXES

References: (1) Letter, F. R. Crawford, BWHC, to L. J. Olguin, FDH, "Request for Additional References for the Exemption Request for the Requirements for Automatic Fire Suppression Systems in Existing PFP 94-1 Gloveboxes", BWHC-9851833 R1, dated March 19, 1998.

(2) Letter, F. R. Crawford, BWHC, to L. J. Olguin, FDH, same subject, BWHC-9851833, dated March 11, 1998.

Fluor Daniel Hanford, Inc. (FDH) has reviewed both reference letters and the supplied supporting documentation for the exemption requested by B&W Hanford Company (BWHC) from the DOE requirements for installation of automatic fire suppression systems in the existing (PFP) Project 94-01 gloveboxes, where the maximum expected loss exceeds $1 million.

The supporting documentation provided with Reference 1 includes the Exemption Request, a "Plutonium Finishing Plant (PFP) 94-1 Glovebox Cost/Risk Analysis" and a detailed Implementation Plan for Protection Option 8, which was evaluated in the cost/risk analysis. The supporting documentation provided with Reference 2 includes the justification for the use of the Fenwal thermoswitch for this application.

FDH concurs with the Exemption Request, the cost/risk analysis, and agrees with the proposed Implementation Plan for Protection Option 8. We request that you approve the Exemption Request and Implementation Plan so that BWHC can proceed with submittal of change requests to implement the system modifications for the glovebox heat detection and indicating lights. Should system operation be authorized prior to the completion of the system modifications, the Implementation Plan allows for establishment of continuous, dedicated fire watches to perform detection and initiate notification functions during operations.

FLUOR DANIEL

Mr. J. E. Mecca
March 26, 1998
Page 2

FDH-9851833 R2

If you have any questions, please contact me at 372-8233 or George McGrath at 376-8119 of my staff.

Sincerely,

L. J. Olguin, Project Director
Facility Stabilization

LJO/gmm/bao

Attachment

NO ATTACHMENTS RECEIVED

A 6002 100 1

CORRESPONDENCE DISTRIBUTION COVERSHEET

Author	Addressee	Correspondence No.
J. E. Mecca/RL	President/FDH	Incoming: 9855795 A DOE-RL: 98-TPD-113 CC Recd: 07/08/98

Subject: CONTRACT NO. DE-AC06-96RL13200 - EXEMPTION REQUEST FOR THE REQUIREMENT FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT 94-01 GLOVEBOXES

DISTRIBUTION

Name	Location	w/att
Correspondence Control	A3-01	
<u>Fluor Daniel Hanford, Inc.</u>		
FDH President's Office	H5-20	
J. T. Curtis	B3-15	
C. R. Forrester	H8-69	
G. W. Grier III	B1-13	
T. J. Harper	H8-69	
D. L. Jackson	H6-32	
C. C. Little	H8-69	
E. S. McGinley	H8-68	
L. J. Olguin (Assignee)	N1-26	
E. L. Reynolds	N1-26	
R. L. Shoup	H8-67	
C. L. Whalen	A3-02	
<u>B&W Hanford Company</u>		
A. Clark	H5-31	
<u>B&W Protec, Inc.</u>		
D. L. Baker	G3-40	
<u>DynCorp Tri-Cities Services, Inc</u>		
R. S. Frix	H5-33	
D. E. Good	S3-97	

PHMC CORRESPONDENCE CONTROL

For Questions or Distribution/MSIN Corrections

Contact: Chris Hough @ 376-8111 or Glenna Lenz @ 372-3931

CC:MAIL ADDRESS: ^CORRESPONDENCE CONTROL-PHMC

A-6001-5387 (11/97) WEF008

9855795 A

CC RECD: 07/08/98

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

98-TPD-113

JUL 7 1998

Mr. R. D. Hanson, Acting President
Fluor Daniel Hanford, Inc.
Richland, Washington 99352

Dear Mr. Hanson:

CONTRACT NO. DE-AC06-96RL13200 – EXEMPTION REQUEST FOR THE REQUIREMENT FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT 94-01 GLOVEBOXES

FDH letter, L. J. Olguin to J. E. Mecca, same subject, dated March 26, 1998, seeks approval of a permanent exemption to automatic fire suppression systems in Project 94-01 gloveboxes HC-3, HC-4, HA-28, and HA-23S in Building 234-5Z.

RL review of this request has determined that the fire suppression systems in these gloveboxes are not required for life safety or nuclear safety purposes. A thorough cost/risk analysis was done which analyzed the property loss associated with a range of options from "do nothing" to providing complete automatic suppression system equipment. These options provide a spectrum of alternatives for operations to choose to minimize the occurrence and consequences of fire without seriously impacting the cost and schedule of the plant's limited life of the gloveboxes.

The analysis demonstrates that a fire associated with the gloveboxes may result in an expected dollar loss near $2,000,000 without automatic fire suppression systems. The installation of a fire suppression system in the gloveboxes at a cost of approximately $750,000, plus design costs, would only limit the expected damage of a fire to about a third of the cost of a fire occurring in the gloveboxes without the fire systems. The cost benefit analysis demonstrates that a fire occurring with implementation of Option 8 of the cost/risk analysis results in reducing the expected loss to half of that when the gloveboxes are provided with suppression systems at a significant cost savings to that of the cost of the fire suppression systems.

The request to not provide automatic suppression systems in these gloveboxes and to implement Option 8 of the cost/risk analysis is hereby approved as a permanent exemption and is contingent upon successful execution of the implementation plan of Option 8 included in the request.

You are requested to reference this exemption request approval as an author's note in the next update to the fire protection section of the PFP S/RID.

If any direction is provided to you by a Contracting Officer's Representative (COR) which your company believes exceeds the COR's authority, you are to immediately notify the Contracting Officer and request clarification prior to complying with the direction.

If you have any questions, please contact Paul J. Valcich, of the Transition Program Division, on (509) 373-9947.

Sincerely,

J. E. Mecca

J. E. Mecca, Deputy Assistant Manager
for Facility Transition

TPD:PJV

cc: F. R. Crawford, BWHC
D. L. McKinnis, BWHC
C. T. Sadanaga, BWHC
J. R. Bell, FDH
H. M. Bucci, FDH
L. J. Olguin, FDH

FLUOR DANIEL

Fluor Daniel Hanford, Inc.
P.O. Box 1000
Richland, WA 99352

July 16, 1998

FDH-9855795A R1

Ms. S. A. Sieracki, Contracting Officer
Procurement Services Division
U.S. Department of Energy A7-80
Richland Operations Office
Post Office Box 550
Richland, Washington 99352

Dear Ms. Sieracki:

CONTRACT DE-AC06-96RL13200 – SECTION H.14, LAWS, REGULATIONS, AND U.S. DEPARTMENT OF ENERGY DIRECTIVES – EXEMPTION REQUEST FOR THE REQUIREMENT FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT 94-01 GLOVEBOXES

References:

(1) Letter, J. E. Mecca, RL, to R. D. Hanson, FDH, "Contract No. DE-AC06-96RL13200-Exemption Request for the Requirement for Automatic Fire Suppression Systems in Existing Plutonium Finishing Plant 94-01 Gloveboxes, 98-TPD-113," 9855795 A, dated July 7, 1998.

(2) Letter, L. J. Olguin, FDH, to J. E. Mecca, RL, "Contract No. DE-AC06-96RL13200- Exemption Request for the Requirement for Automatic Fire Suppression Systems in Existing Plutonium Finishing Plant 94-01 Gloveboxes," FDH-9851833 R2, dated March 26, 1998.

Fluor Daniel Hanford, Inc., (FDH) acknowledges receipt of Reference 1 approving the Referenced 2 request for exemption. Pursuant to DOE Order 5480.7A, the request set forth in Reference 1 requires the approval of the Head of the Field organization (DOE O 5480.7A, 8.g.(4)). FDH requests the approval of Mr. Wagoner prior to implementing this exemption previously approved by the U.S. Department of Energy, Richland Operations Deputy Assistant Manager for Facility Transition.

RECEIVED
JUL 17 1998
DOE-RL/RLCC

FLUOR DANIEL

Ms. S. A. Sieracki
Page 2
July 16, 1998

FDH-9855795A R1

FDH is willing and anxious to proceed with this exemption. However, based on the direction provided in DOE Order 5480.7A, FDH believes that Mr. Wagoner's approval of this request is required prior to implementation. We regret any inconvenience this may cause. If Mr. Wagoner, as Head of the Field organization, has delegated approval authority to the Contracting Officer (CO) or a CO's Representative, please provide CO approval to accept less than Head of Field organization approval and specify the delegated authority.

Questions in regard to this request may be addressed to P. T. Jewell, of my staff, on 372-3355.

Very truly yours,

Jim L. Jacobsen, Director
Contracting

vb/llk

RL

J. E. Mecca R3-79

Contracting Officer
U.S. Department of Energy

Date

A 6002-108.1

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

SEP 0 3 1998

98-PRO-690

Mr. R. D. Hanson, Acting President
Fluor Daniel Hanford, Inc.
Richland, Washington 99352

Dear Mr. Hanson:

CONTRACT NO. DE-AC06-96RL13200 – SECTION H.14, LAWS, REGULATIONS, AND U.S. DEPARTMENT OF ENERGY DIRECTIVES – EXEMPTION REQUEST FOR THE REQUIREMENT FOR AUTOMATIC FIRE SUPPRESSION SYSTEMS IN EXISTING PLUTONIUM FINISHING PLANT 94-01 GLOVEBOXES

References: (1) Letter, FDH-9855795A R1, dated July 16, 1998, from J. L. Jacobsen, FDH, to S. A. Sieracki, RL, subject as above.

(2) Letter No. 98-TPD-113, dated July 7, 1998, from J. E. Mecca, RL, to R. D. Hanson, FDH, subject as above.

Reference (1) requests the approval by Mr. Wagoner as the Head of the Field Organization, prior to implementing the exemption approved by Reference (2). In Reference (1), FDH requests that RL specify where approval by less than the Head of the Field organization was authorized, because based on direction in DOE Order 5480.7A, FDH believes Mr. Wagoner's approval is required.

Approval by Mr. Wagoner is not required. RLID 5480.7A, Sections 6.1.a (5) and 6.1.b (3) defines the process for approval of exemption requests. The authority for approving this exemption request at the field level with QSH concurrence is described in DOE Occupational Safety and Health Standards Response Line Request number D98-01-020; a copy is attached for your information. Should you have any questions regarding the above, please contact me on (509) 376-7265 or Alan Hopko on (509) 376-2031.

Sincerely,

Marcia N. Roske
Contracting Officer

PRO:AEH

Attachment

Unclassified Facsimile Transmission

DOE Occupational Safety and Health (OSH) Standards Response Line

1-800-292-8061

TO: Craig Christenson

Fire Protection Engineer
DOE Richland Ops Office
Phone: (509) 376-5367
Fax: (509) 373-6100

FROM: DOE EH-5 Staff

Office of Worker Health & Safety
PHONE: (301) 903-9766
FAX: (301) 903-9976

SUBJECT: Authority Having Jurisdiction for fire protection

Request # D98-01-020

Number of Pages: 2

Your telephone request regarding Authority Having Jurisdiction for fire protection was received on 1/28/98. The results of our research are attached. We hope that this review will assist you in your safety and health program efforts

Your request has been assigned number D98-01-020. Please use this identifier if you correspond or have any questions regarding your inquiry.

If we have not fully addressed your questions, please make any changes and corrections to clarify your request and return the corrected copy with your initials via fax. The fax number for returning your copy is (301) 903-9976.

Thank you for your inquiry.

FAXED Time: 3/6/98 Date: mce

Reviewed by: Precedented Date

Department of Energy OSH Standards Interpretations Response Line

ID D98-01-020

Question 1) Is the DOE Authority Having Jurisdiction (AHJ) for fire protection still considered to be the "Heads of Field Organizations or designee" (except as directed by the Secretarial Officers)?

2) Is it the intent of the new Orders that the forwarding of exemption requests to DOE Headquarters for review and approval is no longer required; provided that the review and approval is conducted by the DOE fire protection engineer and a process is in place at the DOE field level for the AHJ to review and approve the request?

Regulatory Review 1) Yes. The intent of the DOE Orders concerning the fire protection AHJ is to have the authority reside within the DOE Field Office (or comparable DOE organization if no Field Office exists). The "Head of the Field Organization" is normally considered the AHJ unless that authority is delegated. At RL, as at other DOE Field Offices, AHJ authority has been delegated further down the management hierarchy. This is acceptable, provided that the AHJ is obligated to consult with the cognizant DOE fire protection engineer on fire safety issues prior to making a decision.

Finally, the Orders acknowledge that, under some circumstances, the Cognizant Secretarial Office may decide to retain AHJ authority. Under these circumstances, it is expected that a documented delineation of authority would be promulgated. Until such time as this was accomplished, the Head of the Field Organization would remain the fire protection AHJ.

2) Yes, except for requests for variances from OSHA requirements (See DOE Order 440.1, Section 5.a.(6)). When approval for variances from OSHA standards are solicited, the ultimate approving authority (AHJ) is the Assistant Secretary for Environment, Safety and Health (EH-1).

The Orders expect that a process be established for the review and approval of fire safety exemptions and equivalencies. Such a process usually originates with the fire protection staff of the Maintenance and Operating Contractor and terminates with the Head of Field Organization or designee (See response to Question 1.) Note that only variances from the explicit language of an Order would prompt approval under an "exemption." Most fire safety-related conditions could be couched in terms of nonconformance with provisions of DOE or Industry (NFPA) standards or guidelines and, therefore, could be resolved via the "equivalency" concept.

DISTRIBUTION SHEET

To	From	Page 1 of 1
U.S. Department of Energy, Richland Operations Office	PFP Facility Systems Engineering	Date 10/07/98
Project Title/Work Order HNF-SD-CP-FHA-004, Rev. 0 Fire Hazard Analysis for Plutonium Finishing Plant Project		EDT No. 700527 ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Babcock & Wilcox Hanford					
T. A. Brown	T5-15	X			
F. R. Crawford	T5-50	X			
M. R. Gibson	T5-55	X			
G. A. Glover	T4-20	X			
D. R. Groth	T4-15	X			
T. E. Huber	T5-50	X			
E. M. LaRock	T5-02	X			
D. L. McKinnis	T4-20	X			
R. D. Pickett	T4-20	X			
A. L. Ramble	T5-54	X			
R. D. Redekopp	T5-15	X			
L. L. Reed	T5-57	X			
P. E. Roege	T5-15	X			
C. T. Sadanaga	T5-11	X			
Department of Energy					
C. P. Christenson	A5-55	X			
J. E. Mecca	A5-11	X			
W. D. Seaborg	R3-79	X			
J. W. Todd	R3-78	X			
P. J. Valcich	R3-79	X			
DOE/RL Reading Room	H2-53	X			
Fluor Daniel Hanford					
J. R. Bell	H6-32	X			
J. D. Martin	N1-26	X			
L. J. Olguin	N1-26	X			
Lockheed Martin Services Inc.					
Central Files	B1-07	X			