sta 4 (3)

JUL 31 1996 ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 603190

2. To: (Receiving Organization) Solid Waste Management	3. From: (Originating Organization) Solid Waste Management	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Solid Waste Disposal	6. Cog. Engr.: KR Busching	7. Purchase Order No.: N/A
8. Originator Remarks: Attached is the TRUSAF FHA for review and approval.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 224-T/TRUSAF
11. Receiver Remarks: NONE		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: 7/31/96

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-WM-FHA-007	ALL	0	Fire Hazards Analysis of Transuranic Waste Storage and Assay Facility	SQ	1	1	1

16. KEY		
Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, O, D or N/A (see WHC-CD-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

(G)		(H)		17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)				(G)	(H)
Rea-son	Dis-p.	(J) Name	(K) Signature (M) MSIN	(L) Date	(J) Name	(K) Signature (M) MSIN	(L) Date	Rea-son	Dis-p.
1	1	Cog. Eng. KR Busching	<i>KR Busching</i>	7/30/96	KD Gibson		7-01	3	
1	1	Cog. Mgr. DB Powell	<i>DB Powell</i>	7/30/96	RR Ames		7-03	3	
1	1	QA: DL Vance	<i>DL Vance</i>	7/30/96	RR Durfee		7-04	3	
1	1	Safety: JR Keene	<i>JR Keene</i>	7-05	KM McDonald		7-03	3	
		Env. N/A			PJ Crane		7-03	3	
1	1	RL Mangum	<i>RL Mangum</i>	7/30/96					

18. KR Busching <i>KR Busching</i> Signature of EDT Date Originator	19. DB Powell <i>DB Powell</i> Authorized Representative Date for Receiving Organization	20. DB Powell <i>DB Powell</i> Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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(USE BLACK INK OR TYPE)

BLOCK	TITLE	
(1)*	EDT	<ul style="list-style-type: none"> Pre-assigned EDT number.
(2)	To: (Receiving Organization)	<ul style="list-style-type: none"> Enter the individual's name, title of the organization, or entity (e.g., Distribution) that the EDT is being transmitted to.
(3)	From: (Originating Organization)	<ul style="list-style-type: none"> Enter the title of the organization originating and transmitting the EDT.
(4)	Related EDT No.	<ul style="list-style-type: none"> Enter EDT numbers which relate to the data being transmitted.
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(6)*	Cognizant Engineer	<ul style="list-style-type: none"> Enter the name of the individual identified as being responsible for coordinating disposition of the EDT.
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(10)	System/Bldg./Facility	<ul style="list-style-type: none"> Enter appropriate system, building or facility number, if appropriate.
(11)	Receiver Remarks	<ul style="list-style-type: none"> Enter special or additional comments concerning transmittal.
(12)	Major Assm. Dwg. No.	<ul style="list-style-type: none"> Enter applicable drawing number of major assembly, if appropriate.
(13)	Permit/Permit Application No.	<ul style="list-style-type: none"> Enter applicable permit or permit application number, if appropriate.
(14)	Required Response Date	<ul style="list-style-type: none"> Enter the date a response is required from individuals identified in Block 17 (Signature/Distribution).
(15)*	Data Transmitted	
	(A)* Item Number	<ul style="list-style-type: none"> Enter sequential number, beginning with 1, of the information listed on EDT.
	(B)* Document/Drawing No.	<ul style="list-style-type: none"> Enter the unique identification number assigned to the document or drawing being transmitted.
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	(G) Reason for Transmittal	<ul style="list-style-type: none"> Enter the appropriate code to identify the purpose of the data transmittal (see Block 16).
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(17)	Signature/Distribution	
	(G) Reason	<ul style="list-style-type: none"> Enter the code of the reason for transmittal (Block 16).
	(H) Disposition	<ul style="list-style-type: none"> Enter the code for the disposition (Block 16).
	(J) Name	<ul style="list-style-type: none"> Enter the signature of the individual completing the Disposition 17 (H) and the Transmittal.
	(K)* Signature	<ul style="list-style-type: none"> Obtain appropriate signature(s).
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Fire Hazards Analysis of Transuranic Waste Storage and Assay Facility

KR Busching

WHC, Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: This document analyzes the fire hazards associated with operations at the Central Waste Complex. It provides the analysis and recommendations necessary to ensure compliance with applicable fire codes.

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**FIRE HAZARDS ANALYSIS
OF
TRANSURANIC WASTE STORAGE AND ASSAY FACILITY**

**WESTINGHOUSE HANFORD COMPANY
RICHLAND, WA**

**Prepared by:
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Revision: 0

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REVISION LOG SHEET

Revision Number	Date	Engineer	Reviewer	Description of Change
A	11/03/94	J.A. Gump T.F. Barry D.T. Brown	H.E. Goranson	Draft Fire Hazards Analysis
B	09/29/95	J.A. Gump T.F. Barry	J.R. Kern	Incorporated WHC comments
0	02/01/96	J.A. Gump T.F. Barry	R.H. Deschambeault	Incorporated WHC comments

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1.0 FACILITY DESCRIPTION AND LOCATION

The Hanford Site covers approximately 1,450 square km (560 square miles) of semi-arid land owned by the U.S. Government and managed by the Department of Energy (DOE) near Richland, Washington. The Transuranic Waste Storage and Assay Facility (Building 224-T) is located in the 200 West area of the DOE Hanford Site. The 224-T Building was originally constructed in the early 1940's as a chemical processing facility for purifying plutonium. Since the process is obsolete, the facility is no longer used for purifying plutonium. The facility was modified and used for storage of plutonium-bearing scrap until about 1985. The operating gallery and service areas have been stripped of all unnecessary equipment and partitions and are now used to provide approximately 1068.3 sq. m. (11,500 sq. ft.) of storage area for transuranic waste. In addition, the processing cells have been sealed from the operating gallery and service areas with exception of the south First Floor area. Ventilation exhaust for the Receiving area and Real-Time-Radiography (RTR) area on the First Floor located south of Column line 6 is provided through Cell "F". The cell doors are padlocked, and the cells have not been entered for at least a decade. It was indicated that cells only contain noncombustible equipment used in the plutonium purification process.

Reference area and site drawings in Appendix A.

2.0 PURPOSE OF STRUCTURE

Since May 1970, DOE has required that radioactive solid wastes be segregated by categorizing as either transuranic (TRU) which is placed in retrievable storage or non-TRU which is placed in non-retrievable disposal sites. The Transuranic Waste Storage Facility (TRUSAF) facility provides a location for interim storage of TRU waste. In 1985, the TRUSAF began storing transuranic, transuranic mixed, and low-level mixed waste for the U.S. Department of Defense and the U.S. Department of Energy. The administrative processing of waste in TRUSAF includes inspection of containers (external only) and associated documentation, an examination with a RTR system to confirm the absence of prohibited items (e.g. free liquids), and a neutron assay of the waste containers to confirm fissile gram content. Following this administrative processing, the containers are placed in the assigned storage modules. The containers are stored in rows or arrays following the pattern marked on the floors. A data package is placed with each container until final disposition. This package is used to record assay and RTR results.

The south end of the First Floor is used as a drum receiving and staging area. This area also contains an electronic scale for weighing the containers and a 1,016-kg (1-ton) crane for container¹ overpacking. The area just south of Column line 6 contains the RTR equipment, and the area just north of Column line 6 contains the assayer equipment. Only one container at a time is staged in each of the RTR and assayer ar-

eas. The north side of the First Floor is used for short-term storage before transfer of waste to other locations (i.e., upper floor storage, return to generators and/or generating units, Low-Level Burial Grounds). The TRUSAF Interim Safety Basis document indicates that the short-term storage area is divided into seven areas. Because of the irregularity in frequency, amount, and type of waste received, the first floor storage modules are flexible storage modules. Waste modules are adjusted as necessary to accommodate the size and waste incompatibilities of each shipment.

The Second and Third Floors are used for interim storage of TRU waste awaiting re-processing or shipment to an approved DOE disposal site.

Building reference drawings are in Appendix A.

3.0 TERMINOLOGY

- a. Automatic Fire Suppression - Sharply reducing the heat release rate of a fire and preventing its regrowth by means of direct and sufficient application of sprinkler system water spray through the fire plume to the burning fuel surface.
- b. Fire Control - Limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures and avoiding structural damage until the fuel can be eliminated or extinguishing effected.
- c. Partial Fire Control - Limiting the size of a fire by distribution of water so as to limit the increase in the heat release rate and pre-wet adjacent combustibles, while controlling the increase in ceiling gas temperatures and delaying structural damage.
- d. Ineffective Manual Fire Fighting Response - Manual fire fighting response time and fire fighting tactics which are not sufficient to prevent major or total building failure or significant releases of hazardous materials.
- e. Effective Manual Fire Fighting Response - Manual fire fighting response time and fire fighting tactics which are sufficient to prevent building failure or significant releases of hazardous materials.
- f. Uncontrolled Fire Incident - A fire that grows and propagates due to ineffective automatic, manual fire suppression operations, and storage configuration.

4.0 GOVERNING REQUIREMENTS

The following specific regulations, codes, and standards were utilized as reference or background material for the preparation of this fire hazards analysis.

Occupational Safety and Health Administration (OSHA)

29 CFR, 1910 - SUBPART E - MEANS OF EGRESS (September 12, 1980)

29 CFR, 1910 - SUBPART L - FIRE PROTECTION (September 12, 1980)

Department of Energy (DOE) Orders

DOE 5480.4 - ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH
PROTECTION STANDARDS (5/15/84)

DOE 5480.7A - FIRE PROTECTION (2/17/93)

National Fire Protection Association (NFPA)

NFPA 10 - PORTABLE FIRE EXTINGUISHERS (1994)

NFPA 13 - INSTALLATION OF SPRINKLER SYSTEMS (1994)

NFPA 24 - INSTALLATION OF PRIVATE FIRE SERVICE MAINS AND
THEIR APPURTENANCES (1992)

NFPA 25 - INSPECTION, TESTING, AND MAINTENANCE OF WATER-
BASED FIRE PROTECTION SYSTEMS (1992)

NFPA 72 - NATIONAL FIRE ALARM CODE (1993)

NFPA 80 - FIRE DOORS AND WINDOWS (1992)

NFPA 80A - PROTECTION OF BUILDINGS FROM EXPOSURE FIRES (1993)

NFPA 101 - LIFE SAFETY CODE (1994)

NFPA 231 - GENERAL STORAGE (1990)

NFPA 505 - POWERED INDUSTRIAL TRUCKS (1992)

UL Directories (1994)

FM Approval Guide (1994)

Uniform Building Code (1991)

Uniform Fire Code (1991)

5.0 REFERENCES

- a) *TRUSAF Interim Safety Basis*, WHC-SD-WM-ISB-004, Rev. 0, Dated September, 1995.
- b) *Summary of Research and Development Activities in Support of Waste Acceptance Criteria for WIPP*, SAND79-1305, Sandia Laboratories, dated June 1979.
- c) *Guide to Fire Protection in Caves, Canyons, and Hot Cells*, ARH-3020, HA Lee, Atlantic Richfield Hanford Company, dated July 1974.
- d) *Fire Testing of 55 Gallon Metal Waste Drums for Dry Waste Storage*, HK Hasegawa, KJ Staggs, SM Doughty, Lawrence Livermore National Laboratory, dated July 1993.
- e) *Loss Prevention Data Sheet 1-21, Fire Resistance of Building Assemblies*, Factory Mutual System, dated July 1977.
- f) *Fire Protection Handbook*, National Fire Protection Association, Seventeenth Edition.
- g) *Fire Protection Program Manual*, WHC-CM-4-41, Westinghouse Hanford Company, August 17, 1992.
- h) *The Westinghouse Hanford Company Building Emergency Plan for 224-T Transuranic Waste Storage and Assay Facility*, WHC-IP-0263-224T, Rev. 0, Dated 10/31/94.
- i) FAX regarding HEPA filter system to HSB PLC from Kent McDonald, dated 10/04/94.
- j) *Fire Protection Program Manual, Water Supplies*, WHC-CM-4-41, August 17, 1992.
- k) *Fire Alarm Receiving System Hanford Fire Department* write-up, Hanford Fire Department.
- l) Pyrotronics and GH Harlow manufacturer data sheets.
- m) *Building 224T Stairwell Doors*, 72500-85-500, Rockwell International, Internal letter dated September 4, 1985.

6.0 ANALYSIS BASES

1. Structural frame and floor slabs are capable of enduring a maximum 3-hour fire exposure. Assumption based on limited construction detail information on structural drawings provided by Westinghouse Hanford Company, and on fire resistance information provided in the NFPA Fire Protection Handbook for reinforced concrete.
2. Information provided in the draft TRUSAF Interim Safety Basis, dated September 1995 is accurate.
3. Information on drawings provided by Westinghouse Hanford Company representatives is accurate.
4. Information obtained during interviews and telephone conversations with Westinghouse Hanford Company site representatives is accurate.
5. Fire dampers in the supply air ducts at floor penetrations are at least 1½-hour listed assemblies. The fire rating of dampers was not known at the time of the survey. Based on the fire rating of doors provided to protect the vertical stairwell opening (1½ hr. fire rating), it was assumed that the vertical duct penetrations would be provided with equivalent protection.

7.0 ANALYSIS

7.1 Description of Construction

The structure consists of a reinforced concrete frame with reinforced concrete floors. There is insufficient detailed information available regarding the exact construction of these concrete structural components; however, it is assumed that sufficient protection (appears to be a minimum 3.8 cm [1½ in.] thick cover of concrete) has been provided for the steel reinforcing to endure a maximum 3-hour fire exposure (ref. Drawings W-72315, W-72316, and W-72317; NFPA Fire Protection Handbook, Seventeenth Edition, Section 6, Chapter 5; and Factory Mutual System, Loss Prevention Data Sheet 1-21, *Fire Resistance of Building Assemblies*, Dated July 1977). Building construction meets Uniform Building Code fire-resistive requirements for Type II, 1-hour.

The exterior wall consists of poured reinforced concrete (20.3 cm [8 in.] thick) anchored to the concrete frame with 25.4-cm (10-in.) bolts (ref. Drawing H-2-36399). The interior room on the First Floor enclosing the ventilation supply and electrical switchgear (Mechanical Equipment room) is constructed of 20.3 cm (8-in.) concrete block with standard block reinforcing and voids filled with

concrete. This wall should provide a minimum 1-hour fire barrier (ref. Drawings H-2-36215 and H-2-36228 and Factory Mutual System, Loss Prevention Data Sheet 1-21, *Fire Resistance of Building Assemblies*, Dated July 1977) assuming the pedestrian doors are capable of providing protection equivalent to a minimum $\frac{3}{4}$ -hour fire rated door assembly. At the time of the walkdown, duct penetrations through the Mechanical Equipment room wall were not provided with fire dampers, which is appropriate for a 1-hour fire barrier. The two pedestrian doors are constructed of hollow metal with wired glazing less than 8,362 sq. cm. (1,296 sq. in.) but are not labeled fire rated assemblies. There are no requirements for the Mechanical Equipment Room to be within a fire rated enclosure.

The stair towers and elevator shaft are constructed of reinforced concrete. Concrete block walls, similar to the concrete block wall described above for the Mechanical Equipment room, are provided for Stairwell "A" at the Second Floor and Third Floor landings and for Stairwell "B" at the Second Floor landing to separate the stairwells from the floor areas. The elevator shaft is provided with an Underwriters Laboratories, Inc. (UL) listed door at the opening to each floor. The two stair towers are separated from each floor by hollow-core, steel doors. The only doors with a label attached are to Stairwell "B" from the Third Floor vestibule and the small vacant Third Floor room off the Stairwell "B" vestibule. The remainder of the doors to the stairwells and the door between the Third Floor vestibule and the storage area are non-labeled assemblies, with a minimum 18 gauge sheet facing and welded joints as indicated by Drawing H-2-36228. These non-labeled doors are also thicker ($2\frac{1}{2}$ -inches) than the labelled doors ($1\frac{3}{4}$ -inches), and provide protection equivalent to a $1\frac{1}{2}$ -hour rated fire door. All doors in both stairwells are provided with labeled fire exit hardware.

Stairwell doors were reviewed by a fire protection engineer from the Industrial Hygiene and Safety organization in 1985. The review determined that the doors are "equivalent to a listed or approved assembly" (reference n). There has been no change in occupancy or combustible loading to invalidate that review.

The vestibules at the bottom of each stairwell and the north airlock are separated from the First Floor area by a concrete block wall similar to the one provided for the Mechanical Equipment room. The door separating the First Floor storage area from the south vestibule and the north air lock are the same type as provided for the Mechanical Equipment room. The door between the First Floor air lock and the north vestibule is a non-labelled hollow metal door $1\frac{3}{4}$ -inches thick. This door is also constructed with a minimum 18 gauge sheet facing and welded joints as indicated by Drawing H-2-36228. This door

provides protection equivalent to a 1½-hour fire rated assembly. These doors are also provided with labeled fire exit hardware.

The Second Floor area south of Column line 6 has been separated from the First Floor area by an 20.3-cm (8-in.) pumice concrete block wall (ref. Drawings H-2-36215 and H-2-36228). The wall is anchored to the structure with 1.6-cm (5/8-in.) by 20.3-cm (8-in.) bolts located at 121.9 cm (48 in.) on center and 1.6-cm (5/8-in.) reinforcing is also provided at 121.9-cm (48-in.) on center. Voids in the blocks are filled with concrete and standard block reinforcing is provided at alternate courses. This wall should be capable of providing a 4-hour fire barrier based on Factory Mutual System, Loss Prevention Data Sheet 1-21, *Fire Resistance of Building Assemblies*, Dated July 1977, Table 2.

An exhaust hood near Column C-7 on the First Floor has been enclosed with plywood walls. The enclosed hood area is not protected by the automatic sprinkler system. This arrangement results in a large unprotected, combustible, concealed space which is not permitted by NFPA 13, Section 4-5.1. The wall enclosing this hood should be constructed with steel studs and gypsum wall board to eliminate combustibles in the concealed hood space or sprinkler protection should be extended to the concealed space.

Window openings within the 0.6-m (2-ft.) thick, reinforced concrete wall between the Second Floor storage area and the old process cells have been sealed with 0.6-m (2-ft.) thick, poured concrete anchored to the exterior reinforced concrete wall as indicated by Drawing H-2-36228. Pipe penetrations between the Second Floor and Third Floor storage areas and the old process cells have been covered with 18-gage sheet metal enclosures (pipe block-out) bolted to the reinforced concrete wall in six locations as indicated by Drawings H-2-36222 and H-2-36223. Drawings H-2-36215 and H-2-36228 also indicate a sliding shutter for openings between the Third Floor storage area and the old process cells. The pipe block-out enclosure and the sliding shutters were not observed or visible on the Third Floor during the walkdown. It appears that these openings may have been sealed with concrete. Site personnel stated that the cells still contain some process equipment but that combustible materials were removed from the cells before they were locked to restrict entry. Entry to the cell area is restricted and cells have not been opened since they were permanently locked to restrict entry.

Supply air duct penetrations through the Second Floor and Third Floor slabs are protected by fire dampers. Six 0.6-m by 0.3-m (24-in. by 12-in.) supply air duct penetrations are provided through the Second Floor slab and three 0.6-m by 0.3-m (24-in. by 12-in.) supply air duct penetrations are provided through the Third Floor slab (ref. Drawings H-2-36221 and H-2-36222).

Information was not available during the walkdown regarding the make and model of the fire dampers. The horizontal dampers between floors are single blade type, and it is assumed that the fire dampers are 1½-hour labeled fire rated assemblies. Two multi-blade vertical dampers are provided on the First Floor, but are not located in a fire barrier due to interior wall changes. The fire dampers are provided with a fusible link releasing device (ref. Drawings H-2-36218 and H-2-72858, Sh. 1 and 2). Westinghouse Hanford Company should confirm that dampers capable of providing a minimum 1½ hr. fire resistive barrier are provided in ventilation duct floor penetrations.

Other interior fire barrier wall and floor penetrations consist of a 0.3-m by 0.3-m (1-ft. by 1-ft.) opening through the Second and Third Floor slabs for the sprinkler riser (ref. Drawing H-2-36215). There are other smaller pipe and conduit penetrations through the floor which are also sealed with an unknown material. It is unknown if these penetration seals are listed fire rated assemblies. In addition, open pipe and conduit penetrations were observed extending through the fire barrier separating the First Floor vestibules from the stairwells. Penetration seals through fire barriers should be investigated to ensure the penetration is properly protected to maintain the integrity of the fire barrier. Penetration seals that cannot be verified as providing an adequate fire barrier should be replaced with a listed assembly. Open penetrations in fire barriers should also be sealed with a listed configuration.

Exhaust duct penetrations through the exterior building barriers are as follows:

- First Floor - 0.8 m by 0.5 m (30 in. by 18 in.) (north storage area), two- 0.6 m by 0.2 m (22 in. by 10 in.) (Mechanical Equipment room), and 0.9 m by 0.2 m (35 in. by 10 in.) (RTR) through the west wall and a 0.6 m by 0.6 m (24 in. by 24 in.) duct opening through the roof of Cell F up to a HEPA filter box.
- Second Floor - 0.7 m by 0.4 m (26 in. by 14 in.) riser through the roof.
- Third Floor - 0.8 m by 0.4 m (32 in. x 14 in.) through the south wall.

Potential failure of exhaust ducting on the exterior side of the structure during a fire may provide a pathway for contaminated combustion products to escape to the outside. Drums should be stored as far as practical from wall areas where ventilation exhaust openings penetrate exterior structural barriers. If the exhaust ducting is subject to direct flame impingement temperatures, it may fail within 10 to 20 minutes.

Additional exterior building barrier penetrations consist of a 1.5-m by 1.5-m (5-ft. by 5-ft.) sheet metal hatch in the roof of the first floor receiving area (ref. Drawings H-2-36221, H-2-36222, and H-2-36223). Exterior doors on the First Floor include a 1.8-m by 2.4-m (6-ft. by 8-ft.) pedestrian opening on the south side with double hollow metal doors. The doors have wired glazing less than 8,362 sq. cm. (1,296 sq. in.) but are not labeled fire rated assemblies. There are two 1.1-m by 2-m (3-ft. 4-in. by 6-ft. 6-in.) pedestrian openings (hollow metal but not labeled fire rated assemblies), one 2.1-m by 2.4-m (7-ft. by 8-ft.) elevator opening (hollow metal but not a labeled fire rated assembly), and an 2.4-m (8-ft.) roll-up door opening on the west side. The roll-up door is a labeled fire rated assembly. Exterior door openings from the process cell areas on the east side consists of six 1-m by 0.9-m (3-ft. 4-in. by 6-ft. 6-in.) pedestrian openings (doors do not appear to be labeled fire rated assemblies). An exterior door opening on the Third Floor consists of one 0.9-m by 2.6-m (3-ft. 1-in. by 7-ft. 1-in.) pedestrian door (hollow metal but not a labeled fire rated assembly). Consideration should be given to upgrading the double pedestrian doors located on the south side of the First Floor to help improve the integrity of the exterior building enclosure in limiting releases of fire combustion products outside the building.

Ventilation ducting on the First Floor north of Column line 6 consists of asbestos transite supported by 5.1-cm by 10.2-cm (2-in. by 4-in.) wood framing. Wood framing is hung from the reinforced concrete beams. Ducting on the south side of Column line 6 and on the Second and Third Floors consists of 10- and 18-gage galvanized steel. Flex connections constructed of glass cloth coated with neoprene are provided on both sides of duct wall and ceiling/floor penetrations (ref. Drawing H-2-36222). Flex connections are not visible from the exterior side of the structure.

Ventilation exhausts from the building join at a common plenum upstream of the four roof mounted filter banks. The filter banks are located in 10-gage galvanized sheet metal enclosures. The prefilter and HEPA filter frames for each filter bank (total of four filter banks) consist of two grids separated by approximately 0.91 m (3 ft.). Each grid is capable of receiving nine 0.6-m by 0.6-m (24-in. by 24-in.) pre-filters or HEPA filters (ref. Drawings H-2-36222 and H-2-36223). The filter banks discharge into a common plenum which is exhausted by parallel fans K1-8-1 and K1-8-2. The exhaust air from the process cells vents through one stage of HEPA filters in a two by two grid (located above Cell "F" before joining the common exhaust plenum upstream of final filtration. HEPA filters consist of stainless steel framed filters meeting UL-586 and pre-filters consist of fiberglass with a cardboard frame. A study documented in *Guide to Fire Protection in Caves, Canyons, and Hot Cells*, H.A. Lee, dated July 1974 (Atlantic Richland Hanford Company) indicates that ignition of soot collected on the filters is still possible.

Outside air is provided by supply fan K1-7-1 at a rate of approximately 944 cubic meters per min. (CMM) (33,335 CFM), when supply fan is operating, and air is exhausted through the HEPA filters by paralleled fans K1-8-1 and K1-8-2 at a rate of approximately 462 CMM (16,318 CFM) per fan (total 924 CMM [32,636 CFM]). Approximately 22.6 CMM (800 CFM) of air can be exhausted to the environment unfiltered through stairwells, elevator shaft, and vestibules not connected to the building exhaust system (ref. Drawing H-2-36220). The building is maintained at a pressure of minus 0.13 cm (0.05 in.) of water gauge with respect to atmosphere by a pressure transmitter. A negative pressure is not maintained on the stairwells, elevator shaft, and vestibules since these areas are not connected to the building exhaust system. The building ventilation system is capable of providing up to 9 air changes per hour. The minimum requirements for the facility are to maintain a constant negative pressure with respect to the atmosphere and maintain a recommended ventilation rate of 4 to 8 air changes per hour.

Loss of the building's negative pressure will result in the cut off of supply fan K1-7-1 and exhaust fan K1-8-2. Failure of supply fan K1-7-1 results in the cut off of exhaust fan K1-8-2 and failure of exhaust fan K1-8-2 results in the cut off of supply fan K1-7-1. Exhaust fan K1-8-1 will continue to operate. Failure of exhaust fan K1-8-1 results in the cut off of supply fan K1-7-1 but exhaust fan K1-8-2 will continue to operate or be started. Air flow from fans is monitored by pressure sensors in order to respond to fan failures as indicated above. Exhaust fan K1-8-1 must be running (panel controls must indicate operation mode for exhaust fan K1-8-1) before exhaust fan K1-8-2 and supply fan K1-7-1 can operate (Ref. Drawings H-2-36217 and H-2-36220, sh. 1 and 2). The Pyrotronics fire alarm panel supplementary relay panel is connected to the Fan Control Panel to shut down exhaust fan K1-8-2 upon alarm condition. Supply fan K1-7-1 is shut down upon shut down of exhaust fan K1-8-2. There are no redundant power supply or signal cables provided for the ventilation system. Signal cables from the Pyrotronics fire alarm panel to the fan control panel and power cables for the roof mounted exhaust fans extend through the storage areas. Cables are not provided with special protection such as fireproofing. However, all areas where cables are located are provided with sprinkler protection. The Uniform Fire Code (UFC) requires manual ventilation shut down capabilities outside the room adjacent to the access door into the room or in a location approved by the fire chief (ref. UFC, Section 80.301, m, 4). Manual ventilation fan shutdown controls are provided on the southwest wall of the First Floor, Mechanical Equipment room.

Fire dampers consist of vertically mounted multiblade type units and horizontally mounted single blade type units. Dampers are held open by a chain connected to a fusible link. Dampers close by gravity upon activation of fusible link. There was no information available during the survey regarding

the temperature rating of the fusible damper links (ref. Drawings H-2-336218, H-2-36219, H-2-72858, and H-2-36222).

Normal electrical power is supplied by a 2,400-V, three-phase line, from the 242-W Substation. It is reduced to 480 V at the 224-T Building, E8-5-26 Substation. Backup power is supplied at 2,400 V by line E-8-L-16. It is reduced to 120/240 V by a transformer located between Buildings 224-T and 222-T. The continuous air monitor (CAM), emergency lighting, Pyrotronics fire alarm panel, and GH Harlow radio fire alarm transmitter (Box #2720) are provided with emergency battery power backup. (ref. *TRUSAF Interim Safety Basis* document, Drawings H-2-36394, H-2-93854, and H-2-97692).

Back-up power is not required by the TRUSAF Safety Analysis, and no detailed reliability studies were available for review.

Potable water supply is provided by a 20.3-cm (8-in.) underground main which dead-ends shortly after the T-1 fire hydrant tee connection to the supply line. A 15.2-cm (6-in.) tee connection from the 20.3-cm (8-in.) main supplies water to the T-3 fire hydrant and to the Building 224-T sprinkler system. Potable water for the restroom and inlet water wash (swamp cooler) is provided by a separate 10.2-cm (4-in.) line from the 20.3-cm (8-in.) main (ref. *TRUSAF Interim Safety Basis* and Drawing H-2-36536).

7.2 Essential Safety Class Systems

There are no essential safety class systems, as discussed in DOE Order 5480.7A, identified in the TRUSAF Interim Safety Basis document.

7.3 Fire Protection Features

a. Automatic Suppression System

Automatic fire suppression is provided by a dry pipe automatic sprinkler system. The sprinkler system piping is sized in accordance with NFPA 13-1994 ordinary hazard pipe schedule. Grinnell Duraspeed sprinkler heads are provided in the majority of the facility. Water supply is provided by an underground 15.2-cm (6-in.) ductile iron pipe fed from an 20.3-cm (8-in.) dead-end main. The 15.2-cm (6-in.) supply line feeds the 3-T fire hydrant and the Building 224-T sprinkler system. Double check valves (15.2 cm [6 in.]) are provided in the supply line to the sprinkler system. A post indicator valve (PIV) is located upstream of the double check valve assembly but downstream of the 3-T fire hydrant.

Tamper switches and valve seals are provided for the two gate valves at the double check valve assembly and the PIV (ref. Drawings H-2-36214 and H-2-36536). Electronic valve supervision is provided to the site fire department through the Seatronics Supervisory Alarm System (located in the Pyrotronics fire alarm panel) and the GH Harlow Co. radio fire alarm box (Hanford Box #2720). Site personnel indicated that the supervisory system is not supervised or fail safe. According to the maintenance list provided by the Hanford Fire Department, the supervisory system was out of service for approximately one year in 1991 to correct design deficiencies. The extended period of time required to repair the supervisory system was caused by a delay in obtaining parts (ref. Drawings H-236219, H-2-97494, and H-2-97692), but the system now operates properly. Replacement of the supervisory system should be considered if the system is going to be unavailable for extended periods of time due to unavailable parts or frequency of failures.

A water flow pressure switch and a low air pressure switch are provided at the dry pipe valve (ref. Drawing H-2-36227). Low air pressure supervision is provided to the site fire department through the Seatronics Supervisory Alarm System and the GH Harlow Co. radio fire alarm box (Hanford Box #2720). Water flow alarm is provided to the site fire department through the Pyrotronics fire alarm panel (Zone 1) and the GH Harlow Co. radio fire alarm box (Hanford Box #2720).

The sprinkler system was analyzed using the hydraulic model Sedan. The most remote demand area was identified as the Third Floor. Sprinkler operation area was evaluated over 285.8 sq. m (3077 sq. ft.) with a 30 percent increase in area to 371.6 sq. m (4000 sq. ft.) for the dry pipe valve as required by NFPA 13-1994, Section 5-2.3.2.3. The sprinkler system was determined to be capable of providing a density of 5.3 LPM/sq. m (0.13 gpm/sq. ft.) with a 1,892 LPM (500 gpm) hose demand. The sprinkler system was analyzed using design information provided by the Hanford Fire Department (static 115 psi, residual 45 psi, flow 1807 gpm).

NFPA 13-1994, Figure 5-2.3 requires a sprinkler design density of approximately 4.89 LPM/sq. m (0.12 gpm/sq. ft.) for a 285.8 sq. m (3,077 sq. ft.) sprinkler design area (increased to 371.6 sq. m (4,000 sq. ft.) for a dry pipe system) for an Ordinary Hazard Group 1 sprinkler system. NFPA 231-1990 recommends using NFPA 13, Ordinary Hazard Group 3 (equivalent to Ordinary Hazard Group 2 in NFPA 13-1994) sprinkler design requirements for Group B plastics and free-flowing group A plastics in storage. Since the material is stored in metal drums, Ordinary Hazard Group 1 sprinkler design requirements are considered adequate

protection. NFPA 231 does not address a commodity classification for materials stored in noncombustible containers, but the fire hazard is clearly less than that expected for a Class IV commodity with exposed combustible plastics.

Based on the hydraulic analysis, the sprinkler system hydraulic design meets NFPA requirements for Ordinary Hazard Group 1, and is considered adequate to provide quick automatic fire control. Under current storage conditions, the plywood separating the two high drum tiers in storage arrays wider than 1.2 m (4 ft.) may shield the lower drums from the overhead water spray so manual fire suppression may be needed to complete extinguishment. Where non-fire retardant plywood is used to separate layers, a fire could propagate through the array along the underside of the plywood. However, if this situation occurred, sprinkler protection would still confine fire propagation (which would consist mainly of the plywood separator burning on the undersides, representing a low heat release exposure) to the single storage array of fire origin. The existing sprinkler system is adequate to meet the objectives of DOE 5480.7A requirements for a highly protected risk, and NFPA 13-1994 requirements for those areas where the arrays are limited to a maximum 1.2 m (4 ft.) in width and arrays are separated by minimum 0.9 m (3 ft.) wide aisles.

The most remote 371.6 sq. m. (4,000 sq. ft.) area with a 1,892 LPM (500 gpm) hose stream requires 326,661 liters (86,304 gallons) total water demand based on a 60 minute duration. The 200 West area has two clearwells each with a storage capacity of 757,000 liters (200,000 gallons) of potable water. In addition, there is a 757,000-liter (200,000-gallon) raised tank on the potable distribution system. The pumping capacities from the clearwells to the potable water distribution piping consist of three 3,785-LPM (1,000-gpm) electric pumps, one 2,271-LPM (600-gpm) electric pump, one 3,785-LPM (1,000-gpm) steam pump, and two 2,271-LPM (600-gpm) steam pumps (ref. Fire Protection Program Manual, *Water Supplies*, WHC-CM-4-41, August 17, 1992). The three steam pumps provide standby capacity and automatically start when the water pressure in the potable supply main drops below 59,763 kgs/sq. m (85 psi.) Based on the hydraulic analysis, the existing water supply for the TRUSAF appears to be adequate to meet the objectives of DOE 5480.7A, requirements for a highly protected risk, and NFPA 13-1994 requirements. Analysis of the water supply facilities is based on document review and interviews with WHC representatives and did not include a detailed physical inspection of the water supply equipment.

b. Hydrant

Fire hydrant 3-T is located approximately 15.2 m (50 ft.) southwest of Building 224-T within the TRUSAF fenced area. Fire hydrant 1-T is located approximately 39.6 m (130 ft.) west and is fed from the same dead-end, 26.3-m (8-in.) main as hydrant 3-T. Hydrant 4-T is located approximately 30.5 m (100 ft.) west of Building 221-T and is fed from a dead-end 25.4-m (10-in.) main. The location and number of fire hydrants within the area is adequate to meet the objectives of DOE 5480.7A requirements for a highly protected risk, and NFPA 24-1994.

c. Manual Fire Fighting

Portable, 4,536 grams (10-pound), multi-purpose dry chemical fire extinguishers are provided throughout the facility. Fire extinguishers are adequately located and of sufficient number and type to meet the objectives of DOE 5480.7A requirements for a highly protected risk, and NFPA 10-1994.

The Westinghouse Hanford Company Building Emergency Plan for 224-T Transuranic Waste Storage and Assay Facility, WHC-IP-0263-224T, Dated 10/31/94, provides the following instructions for responding to a fire incident. "In the event of a fire, the discoverer activates a fire alarm and calls 911. Trained personnel may use portable fire extinguishers for small fires. Personnel are expected to use their best judgment about whether to fight a fire or to evacuate. Under no circumstances will personnel remain to fight a fire if unusual hazards exist." It was indicated that all operations personnel have received hands-on fire extinguisher with fire extinguisher retraining consisting of video tape reviews.

d. Fire Alarm System

Automatic fire detection is provided by a Pyrotronics Pyr-A-Larm early warning fire detection and alarm system. The Pyr-A-Larm FIU-6 unit provides supervision for all relay coils. The detection circuit is supervised to detect open or short circuits, or loss of power or undervoltage. The alarm circuit is supervised to detect open or short circuits and ground faults. The unit is capable of operating with a ground fault on the positive or negative side of the detection circuit. A ground fault on both sides of the detection circuit will result in a short circuit (alarm condition). The Pyrotronics ZIU-6 unit provides supervision for all relay coils to detect open circuits or loss of power. Four zones are provided for detection circuits (Zone 1-First Floor, Zone 2-Second Floor, Zone 3-Third Floor, Zone 4-Duct Detector). Detectors consist of Pyrotronics DIS-5B and DIA-6-AST6 (duct detector) ionization type detectors. The sprinkler system water flow switch is connected to Zone 1. The Class B

detection circuits are supervised to detect open and short circuits, loss of power, or undervoltage. The system is not capable of detecting ground faults but will operate with one ground fault on the detection circuit. A ground fault on both the positive and negative sides of the detection circuit will result in a short circuit (alarm condition).

Exhaust fan K1-8-2 shutdown is provided through a Supplementary Relay Panel (SRP-210). A bypass switch is provided as part of the Gong Timer Panel at the Supplementary Relay Panel to bypass exhaust fan K1-8-2 shutdown. The Supplementary Relay Panel is not supervised. Therefore, there is no way to monitor exhaust fan signal circuits.

Listed maximum detector spacing of 9.1 m (30 ft.) is exceeded in some areas. Detectors are more than 0.7 times the listed spacing from some areas on the south side of the Second Floor. In addition, detectors are not provided in each beam pocket on the First Floor near the assayer. Maximum detector coverage recommended by manufacturer is limited to 83.6 sq. m. (900 sq. ft.) (ref. NFPA 72, Sections 5-3.5.5.1.1 and A-5-3.5.7.4).

The GH Harlow Co., GHR02 Radio Fire Alarm boxes are designed to supervise the signal contacts for ground fault and short circuit. The system is capable of providing an alarm with one ground fault. The Base Station Model GHRD02 monitors the radio frequency to ensure a clear communications link between the transmitter and receiver. The receiver reports trouble if frequencies are not clear. The transmitter also sends a test signal once every 24 hours. If the transmitter does not receive a test signal from a specific transmitter box, an error message summary is created and sent by the receiver to the site fire department every 24 hours (at 9:00 AM the summary sheet is automatically printed and appears on the computer screen at the Station 2 Control Center). The transmitter and receiver are also capable of supervising for low battery power and loss of main power. Two trancivers are provided for redundancy (one in the Gable Mountain Microwave Shack and one at the 300 area fire station). The signals are transmitted to the site microwave system by both trancivers with redundant signals transmitted over dedicated telephone lines to the four site fire departments. As a third backup, Stations 1, 2, and 3 have antennae on the buildings that pick up the signal directly from the radio transmitter boxes. Each of the four site fire department stations has a Radio Fire Alarm Receiver (RFAR) computer which can decode signals into a box number, a zone, and a specific message. The RFAR computer passes the signal information to the computer-aided dispatch (CAD) system for response action (ring house bells, raise the doors, turn on lights, and activate the traffic light at all four stations). If the CAD

system should fail, the RFAR system can be used in a stand-alone mode as a fire receiving system.

The CAD system consists of Compaq 386 computers running OS2 as an operating system. Using OS2 allows the computers to run multiple screen sessions, tasks, and threads (multi-task). The CAD system's primary function is dispatching equipment to emergencies. At the time of dispatch, specific information as to which apparatus to send, what hazards may be found in the building, what exposures may be affected by a fire, and a graphic floor plan of the fire zone are sent to the stations and to the responding vehicles. Fire department personnel at Station 1 indicated that the on-board computers in response vehicles are not reliable. Typically the fire department control center dispatcher relays response information by radio.

The CAD and RFAR systems at Station 2 are set up in a redundant fashion, with two separate systems.

Electrical power backup is provided by dedicated battery banks at the Fire Alarm Panel, the Radio Master Fire Alarm Box (Box #2720), and RFAR receivers. Each CAD and RFAR system at Station 2 is powered through a separate uninterruptable power supply (UPS). A propane-powered generator provides backup AC power supply, as well as the 4 hours of battery supply through the UPSs for the RFAR and CAD computers at Station 2 (Ref. Drawing H-2-72858 and H-2-97494, *Fire Alarm Receiving System Hanford Fire Department* write-up, Pyrotronics and GH Harlow manufacturer data sheets, and Telephone Conversation Summary, Name Mack Knight. Recorded by: D.T. Brown, 9-16-94).

The Pyrotronics fire alarm panel is outdated technology and no longer meets the NFPA 72 requirements for new fire alarm panels. Smoke detector coverage is not provided in the First Floor area south of Column line 6, detectors are not provided in all the beam pockets in the First Floor assayer area, and detectors on the south side of the Second Floor are spaced greater than 6.4 m (21 ft.) from walls. The fire alarm panel is also not capable of detecting ground faults and the Supplementary Relay Panel is not supervised. Although new parts are not available for this system, site personnel indicated that an inventory of replacement parts is available from the removal of systems at other facilities at the Hanford Site. Based on the maintenance list provided by the Hanford Fire Department, the Pyrotronics fire alarm panel appears to have a low failure rate.

Replacement of the Pyrotronics fire alarm panel should be considered if the system may be unavailable for extended periods of time due to unavailable parts or if increased failures are witnessed during testing.

If the Pyrotronics system is not replaced, consideration should be given to reconnecting the sprinkler system water flow alarm directly to the Radio Fire Alarm System. Presently, the water flow alarm is connected through Zone 1 of the Pyrotronics panel.

7.4 Description of Fire Hazards

Building 224-T contains several 208-liter (55-gallon) metal drums of transuranic waste. The drums are provided with HEPA filter vents in the lid or a scored metal tab at the drum lid seal to vent pressure buildup within the drums (hydrogen generated by radiolytic decomposition of hydrogenous materials). Drum storage on the south side of the First Floor is waiting to be inspected. Inspected drums are temporarily stored on the north side until transferred to other locations. The Second and Third Floors are used for the interim storage of transuranic waste drums.

Combustible contents in the 208-liter (55-gallon) drums at Building 224-T consists of wood, paper, rubber, plastic/polyurethane, and cloth/rags/nylon. It was indicated that small quantities of lab pack liquids in absorbent (i.e., absorbent provided would absorb twice the liquid quantity) may be present in some drums. From a fire heat release and potential burning duration, plastics represent the upper bound fire exposure. Therefore, in Appendix B, the hazards and risk from an initiating drum failure and plastics ignition were modeled.

The *TRUSAF Interim Safety Basis* document indicates in Table A-1 that the maximum inventory of plutonium in a single 208-liter (55-gallon) drum at Building 224-T is less than 200 grams.

The primary contributor to fire initiation in Building 224-T would be human error. Human error can occur in both drum handling and packaging operations. The initiating event modeled in Appendix B is based on drum failure with ignition of contents. The primary contributing factors are identified as a forklift-drum collision, an abnormal reaction inside the drum, or a combustible material fire exposure to storage drums inside building. Fault tree and event tree support is provided in Appendix B.

Ignition controls are provided in Building 224-T by prohibiting smoking, limiting personnel access, and using electric powered fork lifts. The Hanford Site also has procedures to control hot work and portable heaters and to pro-

vide fire watches in facilities where fire protection systems are out of service (ref. Fire Protection Program Manual, WHC-CM-4-41).

Since it was indicated that there are no combustible materials within the process cells, a fire is not anticipated within these cell areas. Since there are no combustible materials in the process cells, a fire on the TRUSAF drum storage side of the structure is not expected to effect the process cells.

7.5 Life Safety Considerations

The facility is considered a high-hazard, Storage Occupancy as defined under NFPA 101 and a Group H, Division 7 Occupancy as defined under the Uniform Building Code. (High hazard requirements apply due to the extremely toxic nature of expected plutonium laden combustion products.) Means of egress from the First Floor is provided through the storage area to two remotely located vestibules near the stairwells and double pedestrian doors from the south receiving area. Means of egress from the Second Floor and Third Floors areas is provided by two remotely located stairwells which discharge to the First Floor vestibules. Travel from any point within the storage area to an exit is less than the maximum 30.5 m (100 ft.) of travel accepted by NFPA 101. There is a maximum 19.5 m (64 ft.) common path of travel from the north storage area on the Third Floor; however, NFPA 101, Section 29-2.5.5 does not permit common paths of travel for high hazard storage areas.

Raised door sills are provided for selected door openings on all floors. The sills are raised 5.1 cm (2 in.) with a 34.3 cm (13.5-inch) width which is acceptable (ref. NFPA 101, Section 5-2.1.3.3 and Drawings H-2-36215 and H-2-36228). The door swing from Stairwell "B" to the First Floor vestibule obstructs more than half the means of egress through the vestibule (ref NFPA 101, Section 5-2.1.4.3). A plywood telephone terminal board is located at the Third Floor landing of Stairwell "B". Penetrations into an exit enclosure are prohibited except for electrical conduit, piping, and ducting serving the stairwell and required exit doors. In addition, stairwells should not be used for any purpose that could interfere with egress (ref. NFPA 101 Sections 5-1.3.1 and 5-2.2.6.5).

Sufficient self-illuminous exit signs appeared to be adequately located at the time of the survey to direct occupants to the nearest exit. Battery powered emergency lighting is provided throughout the facility; however, the existing lighting arrangement may not provide sufficient lighting in the First Floor RTR area to comply with NFPA 101, Section 29-2.9 and 30-7.2.2.

The door swing from Stairwell "B" to the First Floor vestibule should be corrected such that not more than half of the exit width is obstructed during its

swing and the door does not project more than 17.8 cm (7 in.) into the required width of the means of egress when fully opened. An additional battery powered emergency light unit should also be considered for the First Floor RTR room. The plywood telephone terminal box should be removed from Stairwell "B" to limit combustible materials (plywood and cable insulation) within the stairwell. Based on the limited amount of time that occupants spend within the storage arrays, the intent of NFPA 101 appears to be met even with the common paths of travel created by the storage aisles.

The objectives of 5480.7A and the intent of NFPA 101 for means of egress from the structure appear to be met if the door swing from Stairwell "B" into the exit width of the First Floor vestibule is corrected, the plywood telephone terminal board and telephone cables are removed from Stairwell "B", and an additional emergency lighting unit is provided for the First Floor RTR area.

7.6 Critical Process Equipment

Critical process equipment consist of the RTR equipment and assayer equipment on the First Floor and exhaust filters (prefilters and HEPA filters) on the south Second Floor roof. Replacement filter boxes may have to be specially constructed. Replacement time is expected to be approximately 1 to 2 years. The RTR equipment and assayer equipment are also specialty items and may take 1 to 2 years for replacement. Due to the nature of the operations at Building 224-T, an interruption in operations due to a fire is not expected to affect vital DOE programs. It appears from a operations interruption standpoint that the facility meets the objectives of DOE 5480.7A.

7.7 High Value Property

Real-Time Radiograph equipment -	\$1,000,000.
Assayer equipment-	\$1,250,000.
Replacement facility:	
Structure -	\$972,400. (Based on a metal building similar to the Central Waste Complex Structures at \$50/sq. ft.)
HEPA filters-	\$500,000.

Building 224T was originally constructed for a different purpose. The RL Property System *Building Fire Replacement Cost* report for June 1994 lists a building replacement cost of \$2,489,216. However, fire loss estimates are based on a facility specifically designed for the current purpose. The value of \$972,400 represents the Value-in-Continued-Use appraisal for Building 224T.

The largest costs from a fire at Building 224-T is expected to be from decontamination and cleanup of the interior of the building due to the release of plutonium from storage drums during a fire.

7.8 Damage Potential

Fire hazard severity and probabilities were modeled for MCFL and MFL fire incident scenarios in Appendix B.

MCFL evaluation assumes the automatic operation of the sprinkler system. Fire modeling results estimated sprinkler activation in 3 to 4 minutes following ignition. Potential release of PU species outside the building for an MCFL incident, as estimated in Section 5.0 of Appendix B, represents a small exposure potential.

MCFL damage potential would be limited to the immediate area of fire origin and damage restoration costs would be primarily associated with internal building cleanup and decontamination near the area of fire origin. Outside cleanup and decontamination costs would be very minimal.

MCFL damage restoration costs are estimated to be in the range of \$50,000 with 80% of this cost related to internal building cleanup and decontamination expenses, and 20% related to outside building cleanup.

MFL evaluation assumes the automatic sprinkler system fails and the responding fire department is effective in controlling the fire. In Appendix B, the Fire Department fire control time is estimated in the 24-minute range.

MFL damage potential would be limited to the storage array of fire origin and damage restoration costs would be primarily associated with internal building cleanup and decontamination within the floor area of fire origin. For the MFL incident, the potential release of PU species outside the building, as estimated in Section 5.0 of Appendix B, represents a small exposure potential and cleanup costs should be minor.

MFL damage restoration costs are estimated to be in the range of \$100,000 with 80% of the cost related to internal building cleanup and decontamination expenses, and 20% related to outside building cleanup.

7.9 Fire Department Response

a. Method of Alarms and Communications

The primary method for the Hanford Fire Department to receive an alarm from Building 224-T is through the GH Harlow Company, Inc. radio fire alarm transmitter and receivers as described above in the *Fire Protection Features* section. Manual pull stations within Building 224-T, smoke detectors, the water flow alarm, and the fire department call button at the radio fire alarm transmitter (Box 2720) are transmitted to the fire department through Box 2720. Alarms may also be transmitted by dialing 911 on telephones connected to the Hanford Site telephone network.

Hanford Fire Department personnel are provided with 16-channel portable radios for communication with the Fire Department Central Control Center or other fire department personnel. The Hanford Fire Department also has radio channels to communicate with mutual aid fire departments. Computers and printers are provided on first line response vehicles for transmitting facility pre-fire plan information from the CAD system; however, the vehicle on-board computer system is unreliable.

It appears that fire department notification methods and the fire department communications system are adequate to meet the objectives of DOE 5480.7A, if pre-fire plans are made available to response personnel at the scene.

b. Staffing, Training, and Equipment

A Deputy Chief and Battalion Chief are on duty during day-shift weekdays. A Battalion Chief is on call during off-shift hours. Each of the four stations is continuously staffed by 3 to 4 fire fighters and a captain. Two medically trained personnel [emergency medical technician (EMT) and a paramedic] are also continuously on duty. Additional staffing during day-shift weekdays consists of approximately 28 fire fighters in the inspection and testing group. During off-shift hours, a minimum of 20 fire fighters are available from the four site fire stations (Maximum of 24 fire fighters).

The Hanford Site Fire Department also has mutual agreements with surrounding communities.

Fire fighters are qualified to minimum fire fighter level 1, and officers are trained to officer level 1 and instructor level 1. All fire fighters are trained as radiation workers.

The Hanford Fire Department maintains a total of 35 vehicles, representing diverse capabilities. Some of this emergency equipment was speci-

cally designed to control situations unique to the Hanford Site. The vehicles are located as shown below.

Table 7.9'

Emergency Equipment by Station

<u>Station 1</u>	<u>Station 2</u>	<u>Station 3</u>	<u>Station 4</u>
Engine 91	Engine 92	Engine 93	Engine 94
Engine 912	Engine 922	Engine 932	Medic 94
Pumper/tanker 91	Pumper/tanker 92	Pumper/tanker 93	Pumper/tanker 94
Tender 91	Hazmat 92	Rescue 93	Cascade 94
Mass Casualty 91	Aid 922	Pumper/tanker 932	Chemical 94
Grass 91	Grass 92	Grass 93	Grass 94
Chief 91	Attack 92	Aid 932	
	Pumper/tanker 922		

One aerial ladder pumper is located in each of the four fire stations, with ladder sizes ranging from 15.2 to 22.7 meters (50 to 75 feet). They are equipped with 5,677 to 7,570-LPM (1,500 or 2,000-gpm) pumps, with the capability of discharging 3,785 LPM (1,000 gpm) from the aerial ladder nozzle. Operation of the ladder nozzle can be controlled from atop the ladder or remotely. The pumper carries 10.2-cm (4-in.) Snap-Tite hose for water supply and the aerial ladder for rescue, protection of adjoining buildings, or extinguishment of fires.

Each station is also equipped with a pumper truck with a 2,271-liter (600-gallon) water tank and a 5,677-LPM (1,500-gpm) pump. These trucks are also turbo-charged diesel powered, with automatic transmissions. They are equipped as fire pumpers as per NFPA 1901.

Six modular ambulances are located on site, with one assigned as first response in each fire station. The remaining two ambulances are used as spares when the front line units are in for repair or otherwise out of service. These ambulances are equipped with radio communications with the local hospital emergency room. All ambulances are licensed by Washington State Emergency Services and carry medical supplies and equipment to allow attendants to provide advanced life support.

A diesel powered water tanker with a 1,703 LPM (450 gpm) pump capable of carrying 18,925 liters (5,000 gallons) of water is housed at the 100 station. This unit is primarily used to supply brush tankers during range fire activities.

Four 4-wheel-drive command vehicles are in service. Each is equipped with multi-channel radios and cellular phones to aid in communicating with on-site emergency organizations and mutual aid fire departments. Each vehicle carries firefighting gear and specialized equipment to allow

establishment and operation of a field command post, including personnel accountability equipment.

Four all-wheel-drive grass trucks are equipped with portable fire pumps and 757-liter (200-gallon) water tanks. These units provide quick attack capability for extinguishing small spot fires. They also have AFFF foam on board using an induction system. Each station is assigned one grass truck.

A 4X4 triple combination fast attack truck, ATT-92, is equipped with 1,135 liters (300 gallons) of premix AFFF foam, 1,135 liters (300 gallons) of AFFF concentrate, and 204 kg (450 pounds) of dry chemical. This unit can discharge AFFF foam and dry chemical at the same time through a dual barrel turret mounted on the roof. All agents can also be discharged through handlines. This truck has a single stage 1,325 LPM (350 gpm) pump that, when used in conjunction with the 1,135 liters (300 gallons) of AFFF pure concentrate foam, can produce 37,850 liters (10,000 gallons) of workable firefighting foam. This unit is utilized for light aircraft, electrical, and flammable liquid fires.

CHEM-94 is used for pyrophoric metal fires, such as sodium and lithium. It is equipped with a 226 kg (500-pound) container of carbon microspheres and a 454 kg (1,000 pound) spherical inverting container of NAX dry chemical. There is an electrical hose reel with 76.2 m (250 ft.) of 2.5-cm (1-in.) hose and nozzle for each agent. Three 8.5-m³ (300-ft³) nitrogen cylinders are used for discharging the NAX dry chemical. One 300-cubic-foot Argon cylinder is used for discharging the carbon microspheres.

Six 6X6 brush tankers are used for rangeland firefighting and in areas with limited water supplies. These units are equipped with diesel auxiliary engines and 1,892 LPM (500-gpm) Hale pumps. They carry 5,677 liters (1,500 gallons) of water and have one remote-control and one manual nozzle. Three of these trucks are stationed on each end of the Hanford Site.

A hazardous materials response vehicle is located in Station 2. This vehicle is equipped with many types of diking, plugging, and patching material. HM-91 is equipped for cleanup and overpacking. Protective clothing ranges from coveralls to fully encapsulated suits. Many information resources are available in the vehicle in the air-conditioned resource module.

One cascade truck, equipped for remote bottle filling from electric or diesel-driven motors, is kept in Station 94. This truck was designed on-site.

A heavy rescue squad truck is stationed at the 300 fire station. This vehicle carries equipment for cave-in, confined space, building collapse, and high angle rescues. A similarly-equipped trailer is located at Station 92.

A mass casualty trailer is maintained at Station 91 for use across the site. This unit has large quantities of medical supplies on board, designed for an accident with multiple victims.

Hanford Fire Department staffing, training, and equipment is adequate to meet the objectives of DOE 5480.7A.

c. Response Times and Access

An average response time of seven minutes from time of alarm with an additional three minutes to lay hose lines was provided by the Hanford Site Fire Department for Building 224-T. Fire Department response personnel carry master keys for most facilities and have access to forcible entry equipment. Fire Department response vehicles have access to all four sides of Building 224-T.

Hanford Fire Department response time and facility access is adequate to meet the objectives of DOE 5480.7A.

d. Fire Department Building Inspections

General building fire inspections are scheduled to be conducted by operations personnel. Procedures are in place which indicate that operations personnel have been trained to and certified to perform the operations identified in the procedure. Personnel are responsible for monthly visual inspections of fire extinguishers, a daily facility tour to identify off-normal conditions, monthly housekeeping inspection, and monthly visual inspection of PIV and fire system pressures (water supply and supervisory pressures). The Westinghouse Safety Organization monitors the general building fire surveillance activities conducted by operations personnel.

The Hanford Fire Department, Fire Systems Testing and Maintenance Division is responsible for testing and maintenance of fire detection and suppression systems. Test procedures are documented as Facility Maintenance Support Services, Site-Wide Test Procedures. Hanford Fire Department test and maintenance activities consist of an annual battery maintenance, a 60-day RFAR test, a 6-month smoke detector inspection, a 2-

month alarm bell test, and a 2-month flow test or winter low air pressure supply test. Impairments and deficiencies are track in a handwritten log (Deficiency Log Book - Book 1) maintained by the Hanford Fire Department. Impairments and deficiencies are also logged and tracked on a data base. An Internal Memo, *Impaired Fire Suppression Systems and General Information* is submitted to the building administrator or manager on a monthly basis. The building administrator or manager is requested to provide status updates of impairments and deficiencies.

Westinghouse Hanford Company inspection, test, and maintenance activities meet the objectives of DOE 5480.7A requirements for a highly protected risk, and NFPA 25.

7.10 Recovery Potential

Recovery from an MFL scenario may require moderate cleanup and decontamination efforts within the floor area of fire origin and near the vicinity of Building 224-T. Recovery from a MFL type fire may take approximately three to six months for exterior outside cleanup and potentially six months to nine months to complete internal building cleanup.

Recovery from an MCFL scenario may require minor contamination and cleanup efforts, primarily in the immediate area of fire origin. Recovery from an MCFL fire incident may take approximately one to two months for exterior outside cleanup and potentially one to three months to complete internal building cleanup.

Since operations conducted at Building 224-T will not affect vital DOE programs, the objectives of DOE 5480.7A appear to be met from an operation recovery standpoint.

7.11 Potential for a Toxic, Biological, and/or Radiation Incident Due to a Fire

A fire at Building 224-T is expected to have minor environmental impact. The risk of unfiltered plutonium within the fire's combustion products escaping outside the building for a MCFL and a MFL at Building 224-T is quantified in Appendix B and is considered a low exposure.

The receiving area on the south side of the First Floor appears to be outside the 5.1-cm (2-in.) high curbed containment area (ref. Drawing H-2-36215). Fire suppression water may flow under the exterior door openings. It appears that the remaining storage areas are within a 5.1-cm (2-in.) high curbed area. This curb should be capable of containing liquid runoff for approximately 10 minutes of sprinkler system operation over the minimum design area. The

UFC, Section 80.301 requires containment to be provided for the worst case spill from the single largest container plus the volume of fire-protection water from the system over the minimum design area for a period of 20 minutes. Additional containment capacity is needed to meet UFC, Section 80.301 requirements.

The TRUSAF Interim Safety Basis document indicates that a criticality is not a credible event.

7.12 Emergency Planning

The facility emergency plan is documented in *224-T Transuranic Storage and Assay Facility Building Emergency Plan*, WHC-IP-0263-224T, Westinghouse Hanford Company.

Fire Department Facility Pre-fire Plans are also available but are not carried on response vehicles. Response information is relayed to the responding vehicles from the Fire Department Central Station by radio. On-board computers and printers are provided for first line response vehicles; however, fire department personnel indicated that the system was not reliable. Response vehicles are supposed to receive pre-fire plan information through the on-board computer system from the CAD system described above in the Fire Protection Features section. A pre-fire plan is also available at the facility near the Pyrotronics fire alarm panel. The pre-fire plan provided by the Hanford Fire Department is dated March 1990. Since operations at Building 224-T have not changed, the pre-fire plan is still current. Consideration is being given to carrying the pre-fire plans on first response vehicles (ref. Telephone Conversation, J.A. Gump and Bob Messer, dated 10/27/94 and Facility Pre-Fire Plan, Building 224-T, dated March 1990).

Emergency planning appears to be sufficient to meet the objectives of DOE 5480.7A and the requirements for a highly protected risk based on pre-fire plans being made available to emergency response personnel.

7.13 Security and Safeguards

Access to the 200-West area is controlled by guard gates at the Yakima, Rattlesnake, and Wye barricades. The doors to the Building 224-T drum storage area are located within a fenced area. The fence is approximately 3.1 m. (10 ft.) high with three strands of barbed wire at the top. The vehicle gates on the south and north sides of the facility are maintained locked except when the facility is manned. The exterior doors to the facility are maintained locked when operations personnel are not present and have fire exit or panic hardware

for exiting. The process cell doors are located outside the fenced area and are padlocked.

The current methods for securing the facility do not adversely affect egress from the structure, or restrict fire department access. The current method for securing the facility appears to meet the objectives of DOE 5480.7A.

7.14 Natural Hazards

Natural phenomena are addressed in the *TRUSAF Interim Safety Basis* document. Due to the design of the facility to resist seismic and tornado occurrences and the limited height of drum storage, a fire resulting from a natural phenomenon was not considered a credible incident (ref. *TRUSAF Interim Safety Basis*). The natural hazard from a range fire was also reviewed. Due to the massive concrete construction of the building, the protection of exterior openings by metal doors which are assumed to be capable of preventing a range fire from entering the drum storage side of the structure, limited vegetation near Building 224-T, and small growth vegetation within the vicinity of the facility, a drum fire resulting from a range fire was also not considered credible.

The facility is adequately constructed to limit fire risks for natural hazards. The objectives of DOE 5480.7A and the requirement for a highly protected risk appear to be met for natural hazards.

7.15 Exposure Fire Potential

a. Exposing Structure

Building 221-T is a noncombustible, reinforced concrete structure (canyon building that was once used for processing radioactive material). There are no openings within the wall of Building 221-T facing Building 224-T. Building 221-T is located approximately 36.6 m (120 ft.) northwest of Building 224-T. Building 221-T is approximately 18.3 m (60 ft.) high, 22.9 m (75 ft.) wide, and 266.7 m (875 ft.) long. Building 221-T is currently being used to decontaminate large items which are brought into the building on railroad cars.

Building 222-T is a one story noncombustible, reinforced concrete structure. There are no openings within the wall of Building 222-T facing Building 224-T. Building 222-T is located approximately 24.4 m (80 ft.) northeast of Building 224-T. Building 222-T is approximately 4.6 m (15 ft.) high, 12.2 m (40 ft.) wide, and 42.7 m (140 ft.) long. Building 222-T is currently being used for office space.

Trailer MO-289 is located approximately 9.1 m (30 ft.) northwest of Building 224-T. MO-289 is a combustible structure which is used as an administrative and records keeping area. NFPA 80A, Table 2-4 recommends a 7.6 m (25 ft.) separation for this one story trailer. Results from NFPA 80A, Table 2-3 indicates a 5.4 m (17.6 ft.) building to building separation. Therefore, the existing separation for this non-sprinklered trailer is adequate.

There is a negligible exposure hazard to Building 224-T from Buildings 221-T and 222-T and Trailer MO-289 based on NFPA 80A. Building 224-T is adequately separated from surrounding exposures to meet the objectives of DOE 5480.7A, the requirements for a highly protected risk, and NFPA 80A requirements.

b. Exposed Structure

Building 224-T is a noncombustible, reinforced concrete structure. The structure is approximately 18.9 m (62 ft.) wide, 60.1 m (197 ft.) long, and 12.2 m (40 ft.) high. Openings in exterior walls are identified above in the *Description of Construction* section.

There is no exposure hazard to Buildings 221-T and 222-T and Trailer MO-289 from Building 224-T based on NFPA 80A. Buildings 221-T and 222-T and Trailer MO-289 appear to be adequately separated from Building 224-T to meet the objectives of DOE 5480.7A, the requirements for a highly protected risk, and NFPA 80A requirements.

7.16 National Security Consequences

Operations which can affect national security are not conducted at Building 224-T.

8.0 CONCLUSION

Based on the probability modeling conducted in Appendix B, MCFL and MFL incidents were estimated to be extremely unlikely events.

For both MCFL and MFL incidents, the consequential quantities of plutonium species which could potentially be released outside the building envelope were estimated to be fairly low. Risk estimations are presented in Section 5.0 of Appendix B.

9.0 RECOMMENDATIONS AND SUGGESTED IMPROVEMENTS

Recommendations relate to improvements associated with meeting UBC, UFC and NFPA requirements. Suggested improvements relate to good fire protection engineering practices which should be considered to improve the overall fire safety level of the facility.

Recommendations

- 96-1 Replace the plywood walls enclosing the hood on the First Floor at Column C-7 with walls constructed of steel studs and gypsum board to eliminate combustible concealed spaces or install sprinkler protection in this space (NFPA 13) (*Reference Appendix C for Recommendation resolutions*).
- 96-2 Seal conduit and pipe penetrations through fire barriers with listed through-penetration firestop systems (NFPA 101) (*Reference Appendix C for Recommendation resolutions*).
- 96-3 Provide sufficient containment for fire-protection water runoff to comply with UFC, Section 80.301. UFC, Section 80.301 requires containment to be provided for the worst case spill from the single largest container plus the volume of fire-protection water from the system over the minimum design area for a period of 20 minutes (*Reference Appendix C for Recommendation resolutions*).
- 96-4 Correct the door swing from Stairwell B to the first floor vestibule such that not more than half of the exit width is obstructed during its swing and the door projects not more than 7 in. into the required width of the means of egress when fully opened (NFPA 101) (*Reference Appendix C for Recommendation resolutions*).
- 96-5 Provide an additional battery powered emergency light unit for the first floor RTR room (NFPA 101) (*Reference Appendix C for Recommendation resolutions*).
- 96-6 Remove the plywood telephone terminal box from Stairwell B to limit combustible materials (plywood and cable insulation) within the stairwell (NFPA 101) (*Reference Appendix C for Recommendation resolutions*).

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APPENDIX A	
Site Layout Drawings	
Drawing Number	Revision
FHA-TRUSAF-A	0
FHA-TRUSAF-S	0
FHA-TRUSAF-1	0
FHA-TRUSAF-2	0
FHA-TRUSAF-3	0
FHA-TRUSAF-1B	0
FHA-TRUSAF-2B	0
FHA-TRUSAF-3B	0

2ND FLOOR PLAN

FIRE HAZARD ANALYSIS TRUSAF	HANFORD RESERVE TRUSAF BLDG. 224-T	
	FHA-TRUSAF-2	REV-0
	02/01/96

LEGEND

- EMERGENCY LIGHT
W/BATTERY POWER SUPPLY
- MANUAL PULL STATION
- ABC DRY CHEMICAL
EXTINGUISHER (10 LB.)
- DRY PIPE VALVE
- FIRE DEPT. CONNECTION
- FIRE ALARM BELL
- FIRE ALARM PANEL
- MASTER FIRE ALARM BOX
- HEPA FILTER FAN
ELECTRICAL CONDUIT
- VENTILATION DUCT

3RD FLOOR PLAN

FIRE HAZARD ANALYSIS TRUSAF	HANFORD RESERVE TRUSAF BLDG. 224-T		
	FHA-TRUSAF-3	REV-0	02/01/96

NOTES: 1/2" PLYWOOD USED BETWEEN DRUM STORAGE LEVELS
DRUMS ARE NOT BANDED TOGETHER
AISLES BETWEEN PILES—MINIMUM 36" WIDE

2ND FLOOR PLAN DRUM STORAGE

NOTE: STORAGE ARRAYS ARE BASED ON
AN AUGUST 1994 WALKDOWN
AND ARE SUBJECT TO CHANGE

FIRE HAZARD ANALYSIS TRUSAF	HANFORD RESERVE TRUSAF BLDG. 224-T		
	FHA-TRUSAF-2B	REV-0	02/01/96

3RD FLOOR PLAN
DRUM STORAGE

NOTES: 1/2" PLYWOOD USED BETWEEN DRUM STORAGE LEVELS
DRUMS ARE NOT BANDED TOGETHER
AISLES BETWEEN PILES-MINIMUM 36" WIDE

NOTE: STORAGE ARRAYS ARE BASED ON
AN AUGUST 1994 MEASUREMENT
AND ARE SUBJECT TO CHANGE

FIRE HAZARD ANALYSIS TRUSAF	HANFORD RESERVE TRUSAF BLDG. 224-T	
	FHA-TRUSAF-3B	REV-0 02/01/96

APPENDIX B

TRUSAF BUILDING FIRE RISK ASSESSMENT

APPENDIX B
TRUSAF BUILDING
FIRE RISK ASSESSMENT

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1.0 METHODOLOGY

HSB Professional Loss Control applied quantitative risk assessment for supporting the TRUSAF Building Fire Hazard Analysis (FHA). Risk assessment steps included:

- Definition of Risk Assessment Focus
- Hazard Identification & Risk Screening
- Fire Severity Modeling
- Event Tree Probability Modeling
- Risk Estimation

Risk Assessment Focus

The primary focus of the FHA risk assessment support information was to provide quantification of:

- Radioactive species within fire combustion products which potentially could be released outside the TRUSAF solid waste storage building during a fire.
- The probability of occurrence for the following defined exposure levels:
 - Maximum Credible Fire Loss (MCFL)
 - Maximum Foreseeable Loss (MFL)
 - Maximum Possible Fire Loss (MPFL)

Hazard Identification & Risk Screening

Building walk-down surveys, design and procedures reviews, evaluation of storage inventory data sheets and reviews of previous hazard and safety reports were conducted to evaluate fire-related exposures and existing protection levels.

The material properties and fire hazards of the contents stored inside a representative sampling of storage drums based on review of inventory data records were evaluated. The material inventory, % composition, heats of combustion, and potential mass burning rates were quantified in order to establish a credible upper boundary heat release rate profile for input into the fire severity modeling.

The contributing factors which could lead to an accidental drum failure, ignition of the drum's contents, and sustained burning were identified. In section 2.0 of this appendix, Fault Tree Analysis (FTA) was used to assess and screen selected accident events and to estimate the potential frequency of an initiating drum fire.

Fire Severity Modeling

The 1995 fire tests performed to evaluate potential fire propagation related to palletized storage of solid waste in drums [1] was used to support the development of fire stages and to estimate fire heat release rates.

FPEtools, version 3.2, a computerized fire model developed by the National Institute of Standards and Technology (NIST) [2] was utilized to estimate fire temperatures inside the building and to support engineering judgements concerning the potential mass release rates of radioactive species outside of the TRUSAF building during a fire.

Event Tree Probability Modeling

Event Tree Analysis (ETA) was applied in the estimation of the probabilities of occurrence for the MCFL, MFL, and MPFL fire exposure levels. Where needed, fault trees were developed to support certain event probabilities such as fire detection and sprinkler system suppression success.

Risk Estimation

The annualized probability of MCFL, MFL, and MPFL fire exposure levels versus the potential mass of PU species which potentially could be released outside the TRUSAF building during a fire was estimated and is presented in section 5.0 of this Appendix.

Acronyms and Abbreviations

TRUSAF	Transuranic Waste Storage and Assay Facility
TRAS:	A separate document, TRUSAF Fire Hazard Analysis and Risk Assessment Support Information, provides additional data and modeling documentation. The acronym TRAS (TRUSAF Risk Assessment Support) will be used when referring to this document.
POC:	Products of Combustion from the Fire.
EV:	Equivalent Vent.
PU/PE	Plutonium and/or plutonium equivalent materials (i.e., various radioactive isotopes).

2.0 HAZARD IDENTIFICATION & RISK SCREENING

Fire Hazard Identification

Fire hazard identification focus was placed on reviewing and ranking drum storage inventories in terms of heat release rate potential. The goal was to establish a credible heat release profile for an initiating drum fire exposure potential.

The TRUSAF Building storage inventory data base was sorted according to types of materials. 168 drums were identified as containing 50-100% fill of plastic/polyurethane type materials.

	Number of drums with 50% or greater fill by volume.
Plastic / Polyurethane	168
Rubber	37
Paper / Cardboard	10
Cloth / Rags / Nylon	6

Solid Waste Storage Record data sheets were requested for selected drums containing plastics and rubber materials for use in estimating the % compositions and drum loading. Selected inventory data is located in the TRAS document.

Based on engineering examination and some preliminary fire modeling concerning an initiating fire scenario, the storage of mixed plastic materials, at or above a 50% by volume drum fill, represented an upper boundary fire heat release rate exposure in the solid waste drum storage areas.

Risk Screening

Fault trees were constructed to identify contributing drum fire accident factors and to allow frequency estimation. Contributing drum fire accident events included:

- Fire Caused by Drum Handling Accident Involving a Forklift – Drum Collision
- Drum Fire Caused by Abnormal Reaction Inside Drum
- Combustible Material Fire Exposure to Storage Drums Inside Building

Concerning a delivery truck accident – drum collision:

It is possible that a delivery truck collision accident could initially fail more than one drum. However, as indicated in Fault Tree IN-D, the annualized frequency of this type of accident exposure was estimated at 2.0×10^{-8} accidents/year which was considered a non-credible event that did not warrant additional multi-drum fire modeling efforts. Also drum fire accidents inside the building caused by natural events such as earthquake or windstorm were judged as non-credible events.

The estimated "aggregate" accident event frequency which could lead to the initial failure of one drum and contents ignition was calculated at 1.05×10^{-4} , which is considered a credible event. The initiating accident fault trees are provided in this section.

INITIATING DRUM FIRE EXPOSURE
ESTIMATED FREQUENCY PER YEAR

0.000105

Fault I.D.	Probability Selection Basis	Assumptions	Remarks
1.1	Refer to: FAULT TREE IN - A		
1.2	Refer to: FAULT TREE IN - B		
1.3	Refer to: FAULT TREE IN - C		
1.4	Refer to: FAULT TREE IN - D		

FORKLIFT / DRUM COLLISION FIRE

FAULT TREE IN - A

Fault ID	Probability Selection Basis	Assumptions	Remarks
1.1	Based on Interim Safety Basis Document For TRUSAF Building, August 1994		Annualized probability of a forklift accident
1.2	Based on Interim Safety Basis Document For TRUSAF Building, August 1994	Predicting Error (Human Error) where small amount of flammable gas is released into storage drum.	May be small possibility of hydrogen vapors inside drum. Test data not available to assess probabilities.
1.3	Based on Interim Safety Basis Document For TRUSAF Building, August 1994		
1.4	Based on engineering judgement		
1.5	Based on engineering judgement		

DRUM FIRE CAUSED BY ABNORMAL REACTION INSIDE DRUM

Fault ID	Probability Selection Basis	Assumptions	Remarks
1.1	Based on Hazard Identification and Accident Scenario Development for CVC, Niesker 1994.	Spontaneous combustion inside drums; 2001 based on a Human Error of 0.01 and a reduction of one order of magnitude in the presence of incompatibles in a form/quantity to react.	
1.2	Based on Interim Safety Basis Document For TRUSOF Building, August 1994		
1.3	Engineering Judgement	Assumed reaction caused heat and pressure of drum contents to sustain ignition	
1.4	Engineering Judgement		

COMBUSTIBLE MATERIAL FIRE EXPOSURE
TO STORAGE DRUMS INSIDE BUILDING

FAULT TREE IN - C

Fault
L.D.

Probability Selection Basis

1.1 Based on: Reference:

National Fire Protection Research Foundation; Phase 1 Technical Report

for fires - general warehouse storage

1.2 Based on engineering judgement

1.3 Based on Sandia Laboratories Test, June 1979, SAND79-1305
(1 out of 12 drums failed from exposure fire)

Test was conducted with DOT 17C drums. According to TRUSAF Interim Safety Basis document, 17C drums are approved containers for newly generated wastes.

TRUCK COLLISION INTO BUILDING CREATING FIRE EXPOSURE TO DRUMS

2E-08
2224034

FAULT TREE IN - D

2E-08
Fire Resulting
from Delivery Truck
Collision with
Storage Drums

AND

0.0006
Vehicle Accident
Occurs Near
Building

0.05
1.2
Unattended Vehicle
Crashes Through
Exterior Door

0.5
1.3
Vehicle Fuel Release
Exposes Storage
Drums

0.0018
1.4
Vehicle Fuels
Ignited

Fault
Tree

Probability Selection Basis

1.1 Reference: ARCHE Manual - Appendix F
page F-1, .0001 accidents/mile

1.2 Based on 259 ft. which is linear distance
between south and west walls versus 13 ft.
which is linear distance of doors opening directly
to first floor storage
13 ft./259 ft. = 5% Or 0.05

1.3 Estimated probability of fuel release following
crash estimated at 50% based on
ARCHE Manual - Chapter 11, page 11-4.

1.4 Ignition estimate is based on reference
"Severities of Transportation Accidents",
SLA-74-0001, R.K. Clark, J.T. Foley,
J.W. Hartman, D.W. Larson, July 1976,
which indicates fire occurring in approx. 1.6%
of all truck accidents - Chapter 2.

Remarks

ARCHE Manual exact reference: "Handbook of Chemical
Analysis Procedures", published by Federal Emergency
Management Agency, U.S. Department of Transportation,
U.S. Environmental Protection Agency, 1980.

Assumptions

One mile around facility
has 50 deliveries per
year.

Reduced estimate one order of
magnitude (2018) based on agreement with
TRUSAF Interim Safety Basis
document, based on slower
(non-highway) driving speeds.

3.0 FIRE SEVERITY MODELING

Fire Severity Modeling Objectives

Fire severity modeling objectives included:

- Quantification of the fire propagation phases and associated heat release rates for storage of solid waste in drums, which are stored two drums high with plywood separations.
- Utilization of the FPE tools fire model to estimate fire exposure versus time. Primary fire exposure variables of concern included:
 - Smoke Layer temperatures inside the building.
 - Fire Plume ceiling jet temperatures directly over the storage.
 - Detector and sprinkler system actuation times.
 - Mass Loss rate(s) profiles.

3.1 Fire Propagation Phases and Heat Release Rates

Primary fire propagation phases include:

- Phase 1 — Initiating Fire from failure of a solid waste storage drum and ignition of plastic drum contents which burns in a pool fire configuration at the floor level.
- Phase 2 — Fire Propagation through the drum storage pile via plywood separator flame spread and storage drum fuel contribution.
- Phase 3 — Fuel Depletion stage related to transition from flaming combustion to smoldering combustion (i.e., near fuel burnout) as the exposed portion of the plywood separators within the drum storage pile are consumed.

Phase 1 — Initiating Fire

The following table presents the heat release rate profile for the selected initiating fire scenario. Scenario involves the failure of a storage drum, 50% plastic fill, resulting in a floor level pool configuration fire. Peak heat release was estimated at 1,561 kw (assuming a 1 sq. meter plastic pool area) with an approximate 15-18 minute burning duration.

Phase 1 - Initiating Fire - Estimated Heat Release Rate Profile

USAF Storage Drum Contents

90 1

10	(a)	Number of Turns	(b)	Material	(c)	Material by Process	(d)	Weight	(e)	Estimated Total Heat Energy Released (TW)	(f)	Time to Purge (seconds)
1	(a)	Storage (T)	(b)	Polymethylene	(c)	Polymethylene	(d)	15.00%	(e)	50.00%	(f)	15.00%
2	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
3	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
4	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
5	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
6	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
7	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
8	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
9	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
10	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
11	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
12	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
13	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
14	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
15	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
16	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
17	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
18	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
19	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
20	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
21	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
22	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
23	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
24	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
25	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
26	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
27	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
28	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
29	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
30	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
31	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
32	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
33	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
34	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
35	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
36	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
37	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
38	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
39	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
40	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
41	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
42	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
43	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
44	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
45	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
46	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
47	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
48	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
49	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
50	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
51	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
52	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
53	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
54	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
55	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
56	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
57	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
58	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
59	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
60	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
61	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
62	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
63	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
64	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
65	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
66	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
67	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
68	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
69	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
70	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
71	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
72	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
73	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
74	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
75	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
76	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
77	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
78	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
79	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
80	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
81	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
82	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
83	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
84	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
85	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
86	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
87	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
88	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
89	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
90	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
91	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
92	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
93	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
94	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
95	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
96	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
97	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
98	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
99	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%
100	(a)	Storage (T)	(b)	General Plastic	(c)	General Plastic	(d)	15.00%	(e)	50.00%	(f)	15.00%

Phase 2 — Fire Propagation

The Phase 1 initiating fire, previously described, grows to 1,561 kw in approximately 7 minutes. It is assumed that the initiating fire occurs within the aisle space between two storage piles. The assumed standard pile arrangement consists of a total of thirty-two (32) 55-gal. drums. Drums are stored two wide, eight deep, two high and separated by 1/2" plywood. A minimum 3 ft. aisle is provided between piles. As the initiating fire grows, plywood drum separators within the drum storage piles ignite and slowly propagate the fire. In addition, heat is contributed by the combustion of drum contents projected from the drums or from internal drum smoldering created by the exposing fire and failed drum seals and lids. At approximately 30 minutes it is estimated that a reduced steady-state heat release continues from the combined combustion of the plywood drum separators and escaping combustible drum contents. This steady-state heat release rate was estimated at 50% of the peak heat release from the initiating fire, or 781 kw (1,561 kw x 50%).

Plywood Drum Separators - Heat Contribution

Results from recent solid waste fire tests (Reference 1) approximated fire spread through a 16 ft. long palletized storage pile (four adjacent pallet stacks) in approximately 60-70 minutes. From review of the fire test video [1] it took between 15-30 minutes from pallet flaming combustion and spread to smoldering, combustion (near burnout) per drum storage stack. The steady state heat release rate contributed by the wood pallets burning was approximated at 2,100 kw for this test configuration.

The palletized drum storage test configuration consisted of three wood pallets per stack (i.e., three-high drum storage). During the test, fire spread through the storage pile via the wood pallets which provide an approximate 4" combustible pathway (i.e., horizontal flue space) between drum storage levels.

TRUSAF storage consists of one plywood separator (i.e., one piece of plywood separating two-high drum storage) per each four drums. The plywood is solid 1/2" thick, laying horizontally flat between drums, thus providing a limited exposed surface area and limited flame spread potential.

Based on the obvious heat release and flame spread difference between the wood pallets and plywood separators, the potential heat release rate contributed by the plywood separators would be much less, probably in the range of 10-20%, based on the relative difference in exposed surface area available for burning.

Reference^[4] indicates a peak heat release rate per unit area of plywood in the range of 150-200 kw/m², as depicted in the following graphs:

Five-minute average heat release of six materials tested in OSU apparatus.

Experimental Data on Wood Materials

Five-minute average heat release rate of five materials in the OSU and Cone Calorimeters.

The surface area exposed (i.e., not covered by drum storage) per 4' x 4' plywood separator is approximately 22%:

Plywood separator, surface area: $4' \times 4' = 16 \text{ sq. ft.}$
 Area occupied by 4 drums on the plywood $= 12.56 \text{ sq. ft.}$

If we assume four plywood separators exposed to flame spread:

$$4 \text{ plywood separators} \times 1.49 \text{ m}^2/\text{separator} \times 22\% \text{ exposed area} \times 200 \text{ kW/m}^2$$

$$= 262 \text{ kW} - \text{heat release rate potential}$$

(Note: approximately 12% of wood pallets)

Drum Content Heat Contribution

Results from palletized solid waste fire test data [1] indicated a total weight loss of approximately 528 lbs of drum content material. The weight loss was estimated by weighing each of the 144 drums used in the fire test prior to the test and following the test, after the drums cooled down. Based on this test data an average mass loss rate of drum contents can be estimated:

<u>Weight Loss</u>	
528 lbs	(weight loss from ignition to drum cool down)
<u>X 80% *</u>	
422.4 lbs	
<u>Mass Burning Rate</u>	
422.4 lbs/70 minutes	= 6 lbs/min = .045 kg/s

- * Assumed 80% of combustible content mass loss during fire propagation through wood pallets which took approximately 60-70 minutes.

Convective Heat Release

The potential convective heat release rate (Qc) contributed by drum contents can be estimated as:

$$Q_c = .7 \times \text{Mass Burning Rate} \times \text{Heat of Combustion}$$

Assumed Convective Heat Release Fraction — .7 [3]

Assumed Heat of Combustion for polyethylene plastic

$$Q_c = .7 \times .045 \text{ kg/s} \times 41,825 \text{ kJ/kg} = 1,317.49 \text{ kW}$$

During fire tests [1], 18 drums had lid seal failures from the fire exposure; three of these drums had lid top failure. Although drum lid failures occurred along with wood pallet burning, pile stability was maintained during the fire test.

In the palletized solid waste drum storage tests^[1], 18 drums out of 96 exposed had some level of lid failure. With the reduced flame spread and heat release potential of the plywood separators (i.e., plywood separator heat release potential is approx. 10-20% that of the wood pallets), a conservative engineering judgement was applied in estimating the drum storage exposure in TRUSAF at 50% lower than CWC palletized solid waste storage arrangement. Since two TRUSAF solid waste storage piles generally consist of 64 drums, the estimated drums which may be exposed to some level of lid failure is:

$$\frac{18 \text{ drums}}{96 \text{ drums}} \times 50\% \times 64 \text{ drums exposed} = 6 \text{ drums subject to lid failure - TRUSAF}$$

The estimated heat release potentially contributed by exposed TRUSAF drums is approximately 1/3 (six drums TRUSAF exposed/18 drums CWC exposed) or:

$$1/3 \times 1,318 \text{ kW} = 435 \text{ kW}$$

The combined heat release rate contributed by plywood separators and drum contents is estimated as:

$$\begin{array}{rcl} 435 \text{ kW} & + & 262 \text{ kW} \\ \text{drum contents} & & \text{plywood separators} \end{array} = 697 \text{ kW}$$

In this evaluation, the heat release rate following the peak heat release from the initiating fire was reduced 50% or to 781 kW (1561 kW x 50%) to account for the plywood separator - drum content heat release rate contribution.

Phase 3 - Fire Depletion

Based on reference [1], the following figure indicates a flame spread range on a horizontal wood surface at .5 - 1.1 mm/s.

Figure 5-17 shows flame spread and fuel surface temperature data for horizontal flame spread on wood. Since wood is not capable of spreading flame horizontally without preheating, the wood was exposed to radiant heat to the high initial surface temperature of 235°C. For three different radial positions, temperature histories are shown in the figure. The wood heats slowly due to flame radiation and is quite rapidly heated when the flame arrives at the measuring location. The ignition temperature of the wood is shown in the figure. The dotted line shows the flame spread rate as a function of time, and the star data points are the estimates using the flame spread model. As the radius of the fire increases, the flame radiation increases, and the flame spread rate increases. In this experiment, the flame spread rate ranged from 0.5 to 1.1 mm/s.

Figure 5-17
Surface Temperatures and Flame Spread Rate on a Horizontal Wood Surface
(Amey, A. "Pyrolysis, Ignition and Flame Spread on Horizontal Surfaces of Wood," Cambridge, MA: Harvard University, May 1981, p. 3-49)

Applying the upper flame spread rate 1.1 mm/s or .215 ft./min. and the 16 ft. pile length:

16 ft./216 ft./min. = 74 minutes for fire to spread along the length of exposed aisle-side plywood separators

Assuming sustained flame spread of the plywood separators at seven minutes (when initiating fire reaches peak), then at 67 minutes (74 minutes - 7 minutes) the fire could progress down the storage pile via the exposed edge of the plywood separator facing the aisle. Following this point, minor flame spread and plywood and drum contents smoldering may continue to occur with fuel burnout or near burnout prior to 180 minutes (3 hours) and with no drum storage instability expected.

Heat Release Rate Profile

The following graph represents the composite Fire Phase 1 → Fire Phase 2 → Fire Phase 3 estimated heat release profile for a solid waste drum storage fire inside the TRUSAF Building.

3.2 FPETools Fire Modeling Output

The FPETOOLS computerized fire model developed by the National Institute of Standards and Technology (NIST) [2] was used to assist in the fire severity modeling. The input data, computer printouts and spreadsheet data are located in the TRAS document.

The following graphs in this section provide a summary of the selected fire modeling output:

- Representative Solid Waste Drum Storage Fire Potential in Third Floor, Second Floor, and North First Floor Areas
 - Scenario A1 – Fire with supply air fan OFF
 - Scenario A2 – Fire with supply air fan ON

Note: Both scenarios assume HEPA filter exhaust fans running.

The graphs which are presented in this section include:

- Smoke Layer Temperature
- Mass Burning Rate – Total from Composite Fuel Burning
- Mass Loss Rate – Solid Waste Burning
- Mass Release Rate – PU Species Outside of Building

Building Temperatures

The graphs depicting smoke layer temperatures are averaged temperatures of the hot smoke layer inside the building over the fire duration time. Smoke layer temperatures are lower with supply air fans on (ventilation rate approximated at 8 air changes per hour). In none of the scenarios modeled did the smoke layer temperatures exceed 1100°F which could create a situation of building ventilation equipment failures and major failures of storage drums (i.e., exposure to drums outside the immediate area of fire origin; beyond two storage piles).

In order to provide an estimate of potential ceiling jet plume temperature, which is the temperature directly above the fire source, a fictitious ceiling detector with an operating temperature of 1400°F and located within the ceiling jet region was added into the FPEtools Modeling. This data (labeled Scenario B1 and B2) is located with the FPEtools computer output. In Scenario A1 (supply air ventilation off) the ceiling jet temperature exceeded 1100°F for approximately five minutes. This situation would not be expected to cause any structural or floor level barrier failures.

Mass Loss Rate of Solid Wastes

Mass Loss Rates of the solid waste from drums were estimated as 100% of the total mass burning rate during the first 15 minutes. This is based on the initiating fire scenario involving plastic contents being released from a failed drum and burning as a pool fire on the floor. Following the initiating fire, fuel contribution and burning rate is a combination of wood pallets burning, combustion of drum contents being projected outside of failed drum lids, and internal drum combustion (i.e., smoldering drum contents being released through failed drum seals or lids). The potential mass loss rate of solids following 15 minutes was conservatively estimated at 50% of the total mass burning rate.

Potential PU Species Mass Release Rate

The maximum idealized mass loss of PU species from the solid waste combustion surface can be first estimated by multiplying the solid waste mass loss rate by the fraction of the mass of PU contaminant in the storage drum. Assuming 150 grams PU/drum and a drum loading of 26kg Solid Waste, then:

$$\begin{array}{lcl} \text{Mass Loss Rate} & = & \text{Mass Loss Rate} \\ \text{PU Species} & & \text{Solid Waste} \end{array} \quad \times \quad \frac{150\text{g}}{26,000\text{g}}$$

$$[A] \text{ Mass Loss Rate} = \text{Mass Loss Rate} \quad \times \quad .00577$$
$$\text{PU Species} = \text{Solid Waste}$$

To more realistically quantify the mass of PU species which may be dispersed outside the drum from internal drum combustion, entrained into the fire plume, and released outside of the building envelope, estimates have to be developed for:

- % of PU species vented out an internally smoldering drum and connectively transported into the fires hot gas layer.
- % of PU species vented out the building. Since dispersion inside the building will be PU contaminant attached to carbon molecules there will be a fair amount of soot and PU specie deposition within the building envelope. In addition, the TRUSAF Building is equipped with a HEPA filtering system.

The following table provides a breakdown of estimates used to evaluate potential fire induced PU species release fractions outside the TRUSAF building.

FIRE SCENARIO	[B]	[C]
	PU SPECIES FRACTION VENTED FROM DRUMS (LEAKAGE FACTOR)	PU FRACTION VENTED OUTSIDE BUILDING (VENTING FACTOR)
Scenario A1-Supply Air Fan OFF	.5	.05
Scenario A2 - Supply Air Fan ON	.5	.10

Remarks:

[B] Based on engineering judgement following review of test results, specifically drum lid seal failures, Reference [1].

[C] Based on conservative engineering judgement involving evaluation of building size and ventilation factors and following review of building temperature profiles estimated in the FPETools fire modeling.

With the supply air fans off, a lot of the contaminated species and soot particulator would tend to fall out or be scrubbed out near the area of fire origin. Conservatively, a 95% HEPA filtering efficiency is assumed for the smaller particulate transported to the filter (.05 vented through system). For the supply air fans on, minor HEPA filter plugging may occur with minor species being dispersed out other floor level leakage paths.

The graphs depicting Mass Release Rates of PU species outside of buildings were estimated by:

$$\begin{array}{l}
 \text{Mass Loss Rate} \\
 \text{PU Species} \\
 \text{Outside Building}
 \end{array}
 =
 \begin{array}{l}
 \text{Idealized} \\
 \text{Mass Loss Rate} \\
 \text{PU Species} \\
 \text{[A]}
 \end{array}
 \times
 \begin{array}{l}
 \text{PU Species} \\
 \text{vented} \\
 \text{from Drums} \\
 \text{[B]}
 \end{array}
 \times
 \begin{array}{l}
 \text{PU Species} \\
 \text{vented} \\
 \text{Outside Building} \\
 \text{[C]}
 \end{array}$$

Selected Fire Modeling Output

Representative Solid Waste Drum Storage Fire - TRUSAF Building

Scenario A1 — Fire With Supply Air Fan OFF

Smoke Layer Temperature

Mass Loss Rate

Mass Burning Rate

Mass Release Rate

Selected Fire Modeling Output
Representative Solid Waste Drum Storage Fire - TRUSAF Building

Scenario A2 — Fire With Supply Air Fan ON

4.0 EVENT TREE PROBABILITY MODELING

The following event tree analysis (ETA) was conducted to estimate the sequence and probabilities of fire propagation events and to define those pathways which could lead to defined exposure levels for:

- ETA-1 Representative Solid Waste Drum Storage Fire - TRUSAF

The defined pathway fire exposure levels of interest in this risk assessment include:

- Maximum Credible Fire Loss Probability (MCFL)
- Maximum Foreseeable Loss (MFL)
- Maximum Possible Fire Loss Probability (MPFL)

The following table provides a listing of event occurrence versus exposure level definition. MCFL and MPFL meet the FHA loss exposure analysis definitions in DOE Order 5480.7A. MFL is used by some industrial sectors for evaluating improvements in passive fire protection measures, improved reliability in active protection features and improved emergency response. MFL is normally evaluated after assuming the primary active fire protection system is out of service (which in many cases is the automatic sprinkler system) and then evaluates backup protection systems and/or the responding fire department effectiveness in controlling the fire.

EVENTS	MCFL	MFL	MPFL
[A] Initiating Fire Occurs	Yes	Yes	Yes
[B] Employee Suppresses Fire	No	No	No
[C] Fire Detection Successful	Yes	Yes	Yes/No (1)
[D] Supply Air Fan Shutdown	Yes/No (2)	Yes/No (3)	Yes/No (4)
[E] Fire Propagates to Plywood Drum Separators	Yes	Yes	Yes
[F] Sprinkler Suppression Successful	Yes	No	No
[G] Fire Dept. Suppression Successful		Yes	No
[H] Fire Propagates Involving Additional Drum Piles			Yes
[I] Building maintains Structural Integrity			Yes (5)

Remarks:

(1) There are multiple fire detection means in the TRUSAF Building:

- Smoke Detection / Alarms
- Sprinkler System Water Flow Alarm
- Manual Fire Alarms activated by Employees

However, detection of the fire will not modify the severity if automatic sprinkler suppression and manual Fire Department suppression fail.

(2) (3) (4) Effect of supply air was evaluated by fire modeling two scenarios; one with the supply air OFF and one with supply air ON.

(5) Building maintains structural integrity based on fire modeling.

Represents TRUSAF Building - Drum Storage of Solid Waste

Event Tree Analysis - TRUSAF

ETA FREQUENCY / PROBABILITY INPUT TABLE

Event Tree Analysis: Based on existing design, procedures

EVENT TREE ITEM		FREQUENCY / PROBABILITY	Selection Method
Initiating Fire Occurs Which Exposes Drums Inside Building	A1	1.05E-04	Fault Tree - Risk Screen Section For Initiating Drum Fire
Employee Suppresses Fire	B1	0.05	Engineering judgement based on evaluation of employee availability, employee training, emergency response procedure (WHC-IP-0263-224T).
Fire Detection System Successful	C1	0.9902	Refer to Fault Tree C1
Ventilation Supply Air Fan Shutdown	D1 D2	0.8722 0	Refer to Fault Tree D1
Fire Propagates to Plywood Drum Separators	E1 E2 E3	0.9 0.9 0.9	Based on Engineering Judgement following review of Fire Tests (Reference 1)
Automatic Sprinkler Suppression Successful	F1 F2 F3 F4 F5 F6	0.9676 0.9676 0.9676 0.9676 0.9676 0.9676	Refer to Fault Tree F1
Manual Fire Dept. Suppression Successful	G1 G2 G3 G4 G5 G6	0.95 0.99 0.95 0.99 0.01 0.01	Based on interview with Battalion Chief, who indicated response within 7 minutes from time of alarm and lay hose to fire area within 3 minutes after arrival. Assigned .99 probability to situation where fire does not propagate to plywood separators. If Fire Dept. is not notified by normal means, assigned very low likelihood of successful suppression based on notification by person(s) remotely located from this building.
Fire Propagates Involving Two Entire Storage Piles	H1 H2 H3 H4 H5 H6	0.01 0.01 0.01 0.01 0.01 0.01	Based on Engineering Judgement following review of Fire Tests (Reference 1) and fire modeling.
Barriers Limit Fire to Compartment of Fire Origin	I1 I2 I3 I4 I5 I6	@ 3 Hours 1 1 1 1 1 1	Based on fire modeling, flame spread propagation between floor levels (each floor level is considered a separate compartment) would not occur for the representative fire scenario modeled in this risk assessment.

1.1	Engineering judgment	
1.2	Center for Chemical Process Safety, Guidelines for Quantitative Risk Analysis, Section 3.2.2, 4.0 human error probability is related to proficiency a critical action under conditions of moderately high stress.	
1.3	IEEE Std 500 - 1984, Section 3.2, Figure 3, to estimate detection failure of the Alcatel Infrared Alarm Zone System. Used mean failure rate for all failure mode data, 0.017 relay failure/year. Mean failure rate for 0.017 relay failure/year, 3 relays = 0.05	
2.1	Based on review and evaluation of maintenance and testing records, annual smoke detection system downtime is approx. 25 hours.	
2.2	Based on Electric Power Research Institute report EPRI NP-144, Project 1843-2, Detection Failure Probability - Directors (88 pages) 3 failures / 1000 detector years = 0.003 failures/year 0.003 detection failure probability * 0.05 Alcatel Panel failure probability (from item 1.3 above) = 0.07	
2.3	Based on Fire Modeling, smoke detection system will respond in approx. 90 seconds.	
3.1	Based on review and evaluation of maintenance and testing records, annual speaker system downtime is approx. 87 hours.	
3.2	Based on Electric Power Research Institute report EPRI NP-144, Project 1843-2, Speaker Just the Bits to Operate - 01 probability 0.035 speaker/Alarm failure probability * 0.05 Alcatel Panel failure probability (from item 1.3 above) = 0.05	
3.3	Based on Fire Modeling, speaker system will respond in approx. 383 seconds. Assumed a 01 probability that a shutoff pumpdown could cause a delayed activation of the speaker system.	

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There is redundant systems for determining the radio fire alarm system readiness to the fire Dept. This system is fully approved, is reliably supported, and tested frequently.

TRUSAF - Fault Tree D1

Fault

I.D.

Probability Selection Basis

Assumptions / Remarks

1 From Fault Tree C1

2 IEEE Std. 500 - 1984, Section 3.2 Relays. To estimate potential failure of the Autocall Interface Alarm Zone Panel, used mean failure rate for all failure mode data ; .017 relay failures/year
.017 relay failures/yr. x 4 relays = .068

3 For estimating human error potential:
NUREG/CR-1278; Handbook of Human Reliability Analysis - 1980.
Failure to carry out plant policy- procedures, no check on operator, .05 probability.

Assumed 4 relays in series to estimate signal relay transmission:
Detection Device - Autocall Panel - Supply Fan Interlock
Note: Interlock / Shutdown system is not tested on periodic schedule.

By-Pass switch prevents shutdown of the supply air fan during maintenance and testing activities.

Automatic Sprinkler
Suppression
IS NOT
Successful

F.I.D.	Probability Selection Basis
1	From review of plant maintenance records, annual downtime for maintenance/operation is 57 days
2.1	EPR1 Report No. 144, Project 1845-2
2.2	Engineering judgement based on review of maintenance and firing procedures
2.3	Source (over 200 years) from NUREG ICJ-1278 Failure potential: $0.05 \times 0.83 \times 0.004$
3.1	Based on fire modeling, spooler system will activate at system failure, and will be able to maintain a fire in the event of a shutoff fire which may cause a delayed spooler situation
3.2.1	Based on spooler system hydraulic analysis, assigned 0.6 probability.
3.2.2	Engineering judgement based on the modeling of spooler situation time and hydraulic analysis of spooler system entry.
3.3	Engineering judgement based on evaluation of combined growth in pump-out water supply system.

5.0 RISK ESTIMATION

The following risk profiles combine the results of the fire severity modeling with the probability estimations of MCFL, MFL, and MPFL events developed in section 4.0 of this Appendix.

The risk profiles present the estimated fire induced PU release potential outside of CWC buildings in terms of annualized probability and release size. Risk Profiles were developed for:

- Risk Profile A1 – Representative of Fire Scenario A1 - Fire with Supply Air Fan OFF
- Risk Profile A2 – Representative of Fire Scenario A2 - Fire with Supply Air Fan ON

RISK PROFILE A1

Scenario A1 - Fire with Supply Air Fans OFF

MCFL Maximum Credible Fire Loss

Sprinkler Activation Time	3.23 Minutes
Smoke layer Temp. @ 3.23 minutes	169 F
Average Release Rate of PU Species outside the Building over 0 - 10 minute time interval	4E-06 kg/s
Accumulative release of PU @ 3.23 minutes Outside the Building	0.7826 Grams PU
Annualized Probability of MCFL Event	7.5E-05 events/year
MCFL scenario assumes sprinkler systems operate. Sprinkler activation time was estimated using FPETool	

MFL Maximum Foreseeable Loss

Fire Department Fire Control Time	24 Minutes
Smoke layer Temp. @ 24 minutes	232 F
Average Release Rate of PU Species outside the Building over 0 - 24 minute time interval	3.9E-06 kg/s
Accumulative release of PU @ 24 minutes Outside the Building	5.5966 Grams PU
Annualized Probability of MFL Event	2.4E-06 events/year
MFL scenario assumes sprinkler system does not operate however fire control is achieved by Fire Department within approximately 24 minutes from the start of the fire.	

MPFL Maximum Possible Fire Loss

Fire Duration Limit	180 Minutes
Smoke layer Temp. @ 180 minutes	79 F
Average Release Rate of PU Species outside the Building over 0 - 180 minute time interval	1.3E-06 kg/s
Accumulative release of PU @ 180 minutes Outside the Building	13.5714 Grams PU
Annualized Probability of MPFL Event	1.3E-09 events/year
MPFL assumes sprinkler systems do not operate and Fire Department does not respond	

SCENARIO A1 DATA TABLE

Probability	PU, Grams
7.5E-05	0.7826
2.387E-06	5.5966
1.256E-09	13.5714

RISK PROFILE A2**Scenario A2 - Fire with Supply Air Fans ON****MCFL**
Maximum Credible Fire Loss

Sprinkler Activation Time	3.42 Minutes
Smoke layer Temp. @ 3.42 minutes	149 F
Average Release Rate of PU Species outside the Building over 0 - 10 minute time interval.	8.1E-06 kg/s
Accumulative release of PU @ 3.42 minutes Outside the Building	1.6574 Grams PU
Annualized Probability of MCFL Event	1.1E-05 events/year
MCFL scenario assumes sprinkler systems operate. Sprinkler activation time was estimated using FPETool	

MFL
Maximum Foreseeable Loss

Fire Department Fire Control Time	24 Minutes
Smoke layer Temp. @ 24 minutes	238 F
Average Release Rate of PU Species outside the Building over 0 - 24 minute time interval.	7.8E-06 kg/s
Accumulative release of PU @ 24 minutes Outside the Building	11.1973 Grams PU
Annualized Probability of MFL Event	3.5E-07 events/year
MFL scenario assumes sprinkler system does not operate however fire control is achieved by Fire Department within approximately 24 minutes from the start of the fire.	

MPFL
Maximum Possible Fire Loss

Fire Duration Limit	180 Minutes
Smoke layer Temp. @ 180 minutes	108 F
Average Release Rate of PU Species outside the Building over 0 - 180 minute time interval.	2.5E-06 kg/s
Accumulative release of PU @ 180 minutes Outside the Building	27.173 Grams PU
Annualized Probability of MPFL Event	4.7E-10 events/year
MPFL assumes sprinkler systems do not operate and Fire Department does not respond.	

SCENARIO A1
DATA TABLE

Probability	PU, Grams
1.1E-05	1.6574
3.497E-07	11.1973
4.658E-10	27.173

6.0 REFERENCES

1. *Solid Waste Drum Array Fire Performance*, WHC-SD-WM-TRP 246, Rev. O, issued 11/95.
2. Deal, Scot, *Technical Reference Guide for FPEtool Version 3.2*, National Institute of Standards and Technology report NISTIR 5486, August 1994.
3. *A Review of Airborne Release Fractions For Contaminated Waste In Large Scale Liquid Pool Fires*, Final Report, May 1995, by J.G. Quintiere, University of Maryland and G.D. Kaiser, SAIC, Report for U.S. Department of Energy, Rocky Flats Environmental Technology Site.
4. V. Babrauskas and S.J. Grayson, *Heat Release in Fires*, Chapter 11, Wood Materials, part (b) Experimental Data on Wood Materials by Hao C. Tran; Elsevier Applied Science, New York, NY, 1992.
5. Fire Dynamics Course Guide, National Fire Academy Open Learning Fire Service Program, Unit 5: Ignition and Flame Spread, published by Federal Emergency Management Agency, April, 1994.

APPENDIX C

SWM RECOMMENDATION RESOLUTIONS

- 96-1 Replace the plywood walls enclosing the hood on the First Floor at Column C-7 with walls constructed of steel studs and gypsum board to eliminate combustible concealed spaces or install sprinkler protection in this space (NFPA 13).

SWM Corrective Actions: TRUSAF is scheduled to be vacated by the end of FY 1997. Costs associated with removing the existing enclosure which surrounds a radiologically contaminated fume hood or performing any work which would penetrate the plywood barrier would far exceed the benefit gained from the work performed.

- 96-2 Seal conduit and pipe penetrations through fire barriers with listed through-penetration firestop systems (NFPA 101).

SWM Corrective Actions: Known penetrations have been sealed and a maintenance program has been initiated to seal additional penetrations as they are identified.

- 96-3: Provide sufficient containment for fire-protection water runoff to comply with UFC, Section 80.301. UFC, Section 80.301 requires containment to be provided for the worst case spill from the single largest container plus the volume of fire-protection water from the system over the minimum design area for a period of 20 minutes.

SWM Corrective Actions: As TRUSAF is scheduled to be vacated by the end of FY 1997, the design and construction costs associated with performing this work would exceed the benefit gained from it.

- 96-4 Correct the door swing from Stairwell B to the first floor vestibule such that not more than half of the exit width is obstructed during its swing and the door projects not more than 7 in. into the required width of the means of egress when fully opened (NFPA 101)

SWM Corrective Actions: SWM Facility Engineering has decided to remove the door and seek an equivalency for the walls of the vestibule to qualify them as rated fire barriers. This work has been completed.

- 96-5 Provide an additional battery powered emergency light unit for the first floor RTR room (NFPA 101).

SWM Corrective Actions: This item has been completed.

- 96-6 Remove the plywood telephone terminal box from Stairwell B to limit combustible materials (plywood and cable insulation) within the stairwell (NFPA 101).

SWM Corrective Actions: This item has been completed.