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Plant Safety Document

Section 4.8

Unirradiated Fuel Storage Facility

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IDAHO NUCLEAR TECHNOLOGY AND ENGINEERING CENTER

PLANT SAFETY DOCUMENT

Section 4.8

SAFETY ANALYSIS FOR HANDLING AND STORAGE OF FUELS IN THE UNIRRADIATED FUEL STORAGE FACILITY (UFSF), CPP-651

December 2002

REVISION LOG

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1. SUMMARY

The Unirradiated Fuels Storage Facility (UFSF), designated CPP-651, is a two-compartment inner-vault building approximately 42 feet wide by 45 feet long, surrounded by a reinforced concrete shell. The facility originally consisted of the two inner vaults. In 1984 the original facility was enclosed within an outer reinforced concrete shell to provide upgraded security and safeguards protection for the stored fuel. The original facility (the vaults) was designed to withstand the DBE, and the outer roof was analyzed and found to be capable of withstanding the DBE.[1] The outer shell also provides a 20-ft-wide interior receiving area on the west end for use in receiving and preparing material shipments. The north, east, and south walls of the outer shell have gravel berms from ground level to roof, with nonstructural concrete slabs covering the berms. A chain link fence on the north, east and south sides, and the reinforced concrete wall on the west side surround the facility.

Access to the building is through a set of five hydraulically operated double doors. These doors are ganged so that either half may be opened for personnel passage or both halves for material or equipment passage.

The inner vault building is divided into two separate areas, the North Vault and the South Vault. Each Vault is accessible from the Receiving Area only. The two vaults are separated by a 12-in.-thick concrete wall.

The North Vault storage area is 25 ft long and 19 ft wide. Access is from the Receiving Area through a combination-locked sliding door followed by key-locked, hinged, double doors. Material in approved shipping or storage packages may be stored in the North Vault if no other materials are in storage there. The South Vault storage area is an L-shaped area that includes the remainder of the 42- by 45-ft internal vault area. Access is from the Receiving Area through a combination-locked sliding door followed by key-locked, hinged, double doors. The South Vault is divided into 6 storage areas, each approximately 10 ft by 12 ft. Reinforced concrete walls 1 ft thick divide adjacent compartments. Each compartment is secured against access by a chain-link security fence with a locked access gate.

An aisle runs the length of the South Vault for access to the individual storage compartments. This aisle is called Area 100 and is designated as a criticality control area (CCA) for loading and unloading shipping or storage packages, repackaging, and inventory of fissile material. No fuel storage is permitted in Area 100.

The South Vault is used to store a wide variety of fissile materials. Each type of material is handled and stored under specifically approved criteria. The materials are stored in specially designed racks, cabinets, boxes, or drums.

Fuel in approved storage configurations in the facility is critically safe under all degrees of moderation and full water reflection.

The UFSF is a storage facility, not a processing facility. Fuel handling operations are conducted according to detailed procedures which ensure compliance with Technical Standards. Because of the configuration of the facility and nature of the operation, the principal safety concern is prevention of a criticality during both fuel handling and storage. Criticality safety evaluations (CSEs) have been prepared to cover all handling and storage operations in the facility, and the controls derived from the CSEs are implemented by technical standards. Criticality control is accomplished principally by mass limits, but in a few cases, nuclear poisons are used in storage conditions and moderator control is utilized during fuel handling.

Three principal storage modes are used in the UFSF. Some fuel elements, bundles, and packaged materials are stored in specially designed racks or cabinets which provide geometrical constraints and/or nuclear poison. Other materials are stored in approved packages, principally DOT or DOE-approved shipping packages. Some materials are stored in cans in specially designed racks which provide geometry control but do not require nuclear poison.

Fire safety is a particularly important concern because of the high value of material stored in the facility, the potential for release of airborne contamination, and the fact that the building has only one entrance/exit. The principal defenses against fire are the building construction of concrete and metal, a very strict limitation on flammable materials permitted in the facility, and Halon and dry-pipe water fire suppression systems, where appropriate. Ignition sources are few and of relatively low energy. Hydrocarbon-fueled vehicles are not permitted inside the facility.

Radiation safety is normally not of major concern because the material stored is unirradiated or low activity and the opening of containers of powdered, granular or liquid material in the facility is forbidden. If an accident occurred in which a container were dropped and ruptured, the concern would be the potential for inhalation of alpha-emitting material. All fuel handling requires working to detailed procedures with monitoring by OHP personnel. Alpha continuous air monitors (CAMS) are in operation during all fuel handling operations, along with any portable radiation instrumentation deemed necessary by OHP personnel. Criticality Alarm Systems (CASs) are in place and functional at all times.

No radiological waste, other than ordinary contamination control material, is generated in the UFSF during normal operations. A small amount of contamination control material is used during any operation in the UFSF. If contamination is released during an operation, the cleanup materials are disposed of as compactable solid waste. Other than these, the only waste to be disposed of is an occasional amount of packaging material. No gaseous or liquid wastes are generated.

Because of the large amount of unirradiated fissile material stored in the UFSF, security features are dominant factors in the design of the facility. Special safety considerations are required to provide adequate personnel protection while retaining the necessary security integrity. Some of these considerations are engineered safety features, and others are administrative procedures.

The UFSF is determined to have a moderate safety hazard classification because of the possibility of an accidental nuclear criticality.

1.1 Reference

1. WINCO, "Assessment of CPP-651 Safeguards Modifications for Personnel Safety," WIN-160.

2. FACILITY DESIGN

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FIGURE

2. FACILITY DESIGN

2.1 Building Description

The Unirradiated Fuels Storage Facility (UFSF), designated CPP-651, is a two-compartment inner-vault building approximately 42 ft wide by 45 ft long, surrounded by a reinforced concrete shell. Figure 2-1 shows the general layout of the facility. The purpose of the UFSF is to provide secure storage of a variety of unirradiated fuel materials for subsequent processing or shipment to other facilities for use.

The facility originally consisted of the two inner vaults used for storage of unirradiated nuclear fuel materials. In 1984, the original facility was enclosed within an outer reinforced concrete shell to provide upgraded security and safeguards protection for the stored fuel. The outer shell also provides a 20-ft-wide interior receiving area on the west end for use in receiving and preparing material shipments. The north, east, and south walls of the outer shell have gravel berms from ground level to roof, with nonstructural concrete slabs covering the berms. A chain-link fence on the north, east and south sides, and the reinforced concrete wall on the west side surround the facility.

Access to the building is through a set of five hydraulically operated chevron double doors. These doors are ganged so that either half may be opened for personnel passage or both halves for material or equipment passage.

The inner vault building is divided into two separate areas, the North Vault and the South Vault. Each vault is accessible only from the Receiving Area through its own lockable access door. The two vaults are separated by a 12-in.-thick concrete wall.

The North Vault storage area is 25 ft long and 19 ft wide. Access is from the Receiving Area through a combination-locked sliding door followed by key-locked, hinged, double doors. Material in approved shipping or storage packages may be stored by transport index in the North Vault. The South Vault storage area is an L-shaped area that includes the remainder of the 42- by 45-ft internal vault area. Access is from the Receiving Area through a combination-locked sliding door followed by key-locked, hinged, double doors. A second door, previously used for emergency exit, was welded closed in the 1984 security upgrade. The South Vault is divided into 6 storage areas, each approximately 10 by 12 ft. Reinforced concrete walls one foot thick divide adjacent compartments. Each compartment is secured against access by a chain-link security fence containing a locked access gate.

An aisle, 8 ft wide for half its length, and 7 ft wide for its remainder, runs the length of the South Vault for access to the individual storage areas. This aisle is called Area 100 and is designated as a criticality control area (CCA) for loading and unloading shipping containers, repackaging, and inventory of fissile material. No fuel storage is permitted in Area 100. Storage Areas 101 through 106 are individual CCAs.

The South Vault is used for storage of a wide variety of fissile materials. Each type of material is handled and stored under specifically approved criteria. In general, the types of materials stored include Fluorinel, PWR, Rocky Flats scrap, ANL scrap, LANL scrap, ICPP product and product samples, uranium solutions, and miscellaneous fissile materials stored in drums. These materials are stored in specifically designed racks, cabinets, boxes, or drums.

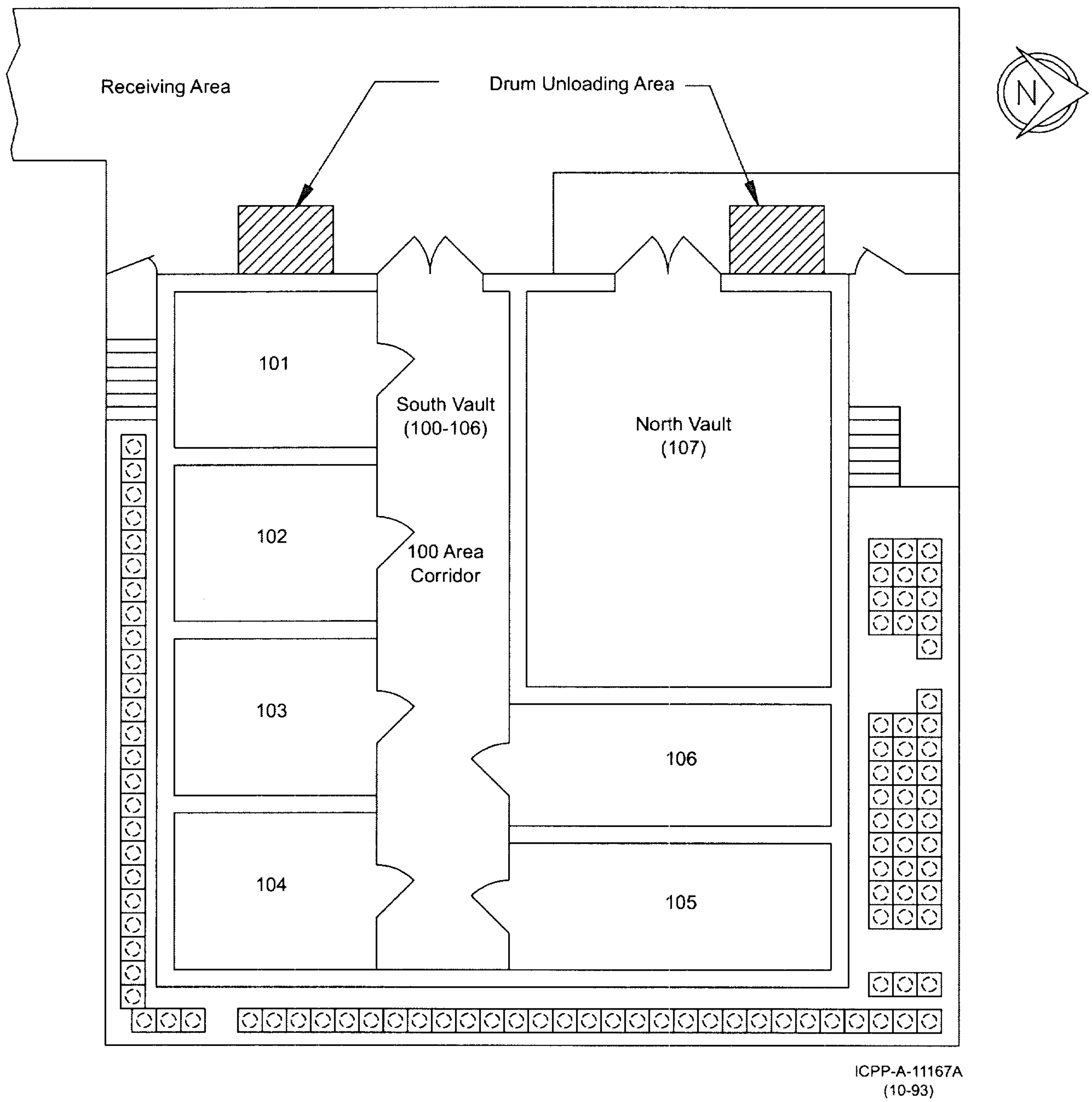

Figure 2-1. Plot plan of the Unirradiated Fuel Storage Facility criticality control areas (CPP-651).

The drums are stored by keeping the total DOT transport index ≤ 50 in any one CCA. The transport index is the number 50 divided by the number of similar packages which may be safely transported together, as determined by procedures described in USNRC 10 CFR 71. The transport index is very conservative as applied to storage.

Ventilation in the UFSF is provided by a variable-speed exhaust blower in the Receiving Area and a filtered pressurizing system in the North Vault. The North Vault system is intended to supply clean air at a slightly positive pressure. This system operates continuously. The Receiving Area system is used intermittently, at the operator's discretion. The South Vault has no separate ventilation system.

Fuel in approved storage configurations in the facility is critically safe under all degrees of moderation and full water reflection.

3. PROCESS SYSTEM

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3. PROCESS SYSTEM

3.1 Process Theory

The UFSF is not a processing facility, but the fuel handling operations performed may be viewed as processes. These operations, although simple, must be performed in strict adherence with approved safety requirements to prevent criticality, damage to materials, contamination release, personnel injury, and loss of accountability of the special nuclear materials. The large variety of fuel handling operations performed in the UFSF will be described in principle here, with details supplied in Section 3.2.

3.1.1 Storage and Handling Philosophy

The philosophy employed for fuel storage in the UFSF is summarized briefly as follows: (a) fuels in storage shall be critically safe for all degrees of moderation and full water reflection, and (b) controls used to implement this philosophy and for fuel handling operations shall be based on triple contingency criteria. Triple contingency means that sufficient safety factors are incorporated, in the design or administratively, that after at least three unlikely, independent, and concurrent changes occur, the k_{eff} shall still be less than 1.0.

Fuel handling in the UFSF is necessary for inspection, storage, accountability, transfers into and out of the facility, and, in some instances, the repackaging of stored fuels. Criticality control is maintained by establishing fuel handling limits for each type of fuel approved for storage. The fuel handling limits control the mass of fuel allowed outside of approved storage to that amount that would be critically safe with moderator control but without configuration control.

3.1.2 Criticality Safety Evaluations

CSEs are required for both the storage and handling of all fuels proposed for storage in the UFSF. The CSE for the proposed storage configuration must show that the stored fuel is critically safe for all degrees of moderation and full water reflection. The CSE for handling each fuel must assure that the fuels, when out of approved storage, will be critically safe, using mass and moderator controls. Supporting CSEs by an independent criticality specialist must concur with the conclusions of the primary CSE.

Fuels similar to, and enveloped by other fuels previously approved for storage and handling in the UFSF do not require a new CSE, since the previous evaluations assure their safety. CSEs are not required for storage in approved shipping or storage packages if the storage is by transport index, with transport index less than 50 in each CCA. Transport index is assigned in accordance with DOT regulations for the particular package. Fuels requiring removal from an approved shipping package require a CSE if the fuels are not covered by existing approvals.

3.1.3 Approvals

Fuel storage in the UFSF requires approval by ICPP management and concurrence by DOE-ID. Approvals are based on CSEs and reviews of safety analysis of the proposed fuel storage.

3.1.4 Operating Procedures

Chemical Plant Operating Procedures (CPOPs) are required for storing and handling fuels in the UFSF. The CPOPs assure that fuels are being handled and stored in accordance with the criticality safety limits and other safety requirements, as specified by approved safety documents. Management approval of CPOPs is required before they may be used.

3.1.5 Control

An accurate record of all fuels stored in the UFSF is maintained showing fuel identification, storage location, type of material, and quantity of fissile material. This record is in addition to accountability records, and both sets of records serve as independent checks. Before any fuel is moved into, out of, or between storage locations, the source and destination locations are predetermined. These locations are verified as operations progress, and final positions, after verification, are entered in the master record. This serves to help prevent inadvertent placement of fuel into an incorrect storage position or CCA. Incorrect placement of fuel can cause unsafe interactions between fuels or cause excessive fuel loadings.

A log is maintained on the door of each CCA showing either total grams of U-235 or transport index, as appropriate, stored in that CCA. The log is updated at the conclusion of each fuel handling operation affecting that CCA.

3.1.6 Surveillance

Each time fuel is transferred into or out of the UFSF or moved into or out of an approved storage location, the identity of the fuel and compliance with storage limits, location, configuration, fuel handling limits, and requirements for fuels outside of approved storage are double-verified by qualified fuel handlers, the custodian, or alternate custodian. Implementation of these requirements reduces the risk of excessive loading and fuel interaction by requiring visual and documentary checks of compliance with fuel handling and storage criteria.

3.1.7 Criticality Control Areas

Each compartmented CCA within the UFSF has only one access door which is accessible only from the common aisle. Each CCA is kept locked except when it is being used. By physically isolating each area, interaction between different fuels is eliminated or kept within specifically analyzed and approved bounds, and the probability of storage errors is reduced. Inadvertent interaction between fuels being handled and fuels in storage is prevented by eliminating transfer paths across different CCAs.

3.1.8 Moderator

Fuel in approved storage configuration does not require moderator control, since all stored fuels have been evaluated to be safely subcritical at any degree of moderation. Moderator control is required at any time fuel is out of storage in the South Vault. Permitted quantities of moderator materials are specified by technical standards, where applicable. There is no source of water in the South Vault. The North Vault and the Receiving Area have dry-pipe fire systems. If a fire should occur in the Receiving Area during a fuel handling operation, flooding of the South Vault cannot occur, since the doorstep to the South Vault is higher than the floor at the facility chevron doors, so water will run outside first. If a fire should occur when the building is not occupied, all fuel would be in storage and would be critically safe at any degree of moderation.

3.2 Process Description

The types of fuel materials handled and stored in the UFSF are described in this section. The operations performed vary with the types of fuel and are described in subsequent paragraphs.

3.2.1 Fuel Description

The fuel categories currently stored in the UFSF are shown in Table 3-1. Approved storage areas and handling criteria for each fuel type are shown in Table 3-2.

3.2.1.1 Approved Shipping Packages. Approved shipping packages contain various types of fissile materials, including clad fuel elements, pieces, fines, etc. The packages are stored in CCAs specifically approved for them under transport index less than 50 limits. The transport index is assigned in accordance with government regulations covering the specific package, usually DOT. The transport index must be assigned based on criticality safety. Shipping packages are stored on the floor or in special racks designed for storage efficiency and accessibility.

Shipping packages intended for storage are usually opened only for inventory and accountability purposes. Occasionally, materials are transferred from shipping packages to other forms of storage, such as racks, or to other shipping packages. All such handling and storage operations are governed by approved procedures controlled by appropriate CSEs and safety documentation. These operations are performed only in Area 100, which is CCA-approved for fuel handling. Fuel storage is not permitted in Area 100.

3.2.1.2 Fluorinel. Fluorinel fuels are highly enriched fuel elements, pieces, and fines, which vary from gram-size samples to complete elements. The Fluorinel fuels are stored in specially designed racks as described in Section 3.3.1.1. Fluorinel fuel packages are occasionally removed from storage and divided, and parts are sent to other ICPP locations for process experimental work. The remaining parts are replaced in storage and may be combined with other partial packages for storage efficiency. Some small pieces are placed in capped metal pipes for storage. In all cases, storage configurations and fuel handling restrictions are controlled by approved safety limits.

3.2.1.3 PWR Core 2, Seed 1 (Mockup). PWR Core 2, Seed 1 type fuel elements are a mockup known as Core A. The fuel elements are $U0_2$-$Zr0_2$ ceramic, clad with Zircalloy. The elements are stored in SPERT shipping boxes described in Section 3.3.2.1.

3.2.1.4 PWR Core 2, Seed 2. PWR Core 2, Seed 2 is a subassembly 265.43 cm long, of which 246.38 cm contains fuel. The cross section is 8.89 cm square. The subassembly contains 4,841 g U-235 and 5,240 g total uranium. The subassembly is stored in a metal box, as described in Section 3.3.2.2.

3.2.1.5 Denitrator Product Sample Bottles. Product sample bottles are stored in an enclosed metal cabinet as described in Section 3.3.1.4. The sample bottle is a nominal 15 ml glass bottle with a plastic cap. The glass bottle is contained within a polyethylene outer container. Both the bottle and the outer container are sealed with vinyl tape. The $U0_3$ sample is approximately 83 wt% uranium, and the enrichment ranges from 50% to 97% U-235.

Table 3-1. Fuel categories approved for storage in the Unirradiated Fuel Storage Facility.

Fuel Category/Type Designation	Fuel Composition
1. Approved Shipping Package	Various (Generic U Fuel)
2. Fluorinel	Zr-U
3. PWR Core 2 Seed 1 (Mockup)	Zr-($U0_2$ - $Zr0_2$)
4. PWR Core 2 Seed 2	Zr - ($U0_2$ - $Zr0_2$)
5. Denitrator Product Samples	$U0_3$
6. LANL Material	Misc. Graphite-U Matrix
7. ANL Material	Various U-metal, U-alloys, oxide, and Vycor glass as described in SAR for Area 104, Ref. 2
8. Rocky Flats	U_30_8, as described in SAR for Area 104, Ref. 2
9. Denitrator Product	$U0_3$, in shipping or storage packages

Table 3-2. Storage and handling criteria for approved materials in the Unirradiated Fuel Storage Facility.

Fuel Category/Type	Approved Storage	Handling Criteria, Out of Storage
1. Approved Shipping Package	CCAs 101, 103, 105, 106, and 107; on floor or in drum storage racks	Material removed from drums not to exceed 9.5 kg U-235, or 11.6 kg denitrator product; ≤1.0 kg moderator
2. Fluorinel	A or B racks in CCA 102 or in approved shipping packages ≤500 g U-235 per ft in bundles; less than 0.36 void fraction in bundles or in watertight container; cross-section dimensions 4.0 by 4.50 in. max; bundles not wrapped in material impervious to water unless in watertight container.	Less than contents of one storage position Less than 21 pipes ≤1.0 kg moderator No open container larger than 5.0 L
3. PWR Core 2 Seed 1 (mockup)	CCA 104, in SPERT shipping boxes on floor	≤9.5 kg U-235, ≤1.0 kg moderator
4. PWR Core 2 Seed 2	CCA 104, in special metal box	≤9.5 kg U-235, ≤1.0 kg moderator
5. Denitrator Product Samples	CCA 104 cabinet, less than 16 sample bottles per storage compartment	Less than 9 sample bottles (volume nominal 15 ml), <70 g U-235 per bottle
6. LANL Material	LANL scrap racks in CCA 102, with ≤4.3 kg U-235 per bottle or can, or approved shipping container	Less than 6 cans or bottles
7. ANL Material	Can storage racks in CCA 104, with ≤4.8 kg U-235 per storage can, or approved shipping container	Less than 6 storage cans (outer cans)
8. Rocky Flats Material	Can storage racks in CCA 104, with ≤4.8 kg U-235 per storage can, or approved shipping packages	Less than 6 storage cans (outer cans)
9. Denitrator Product	Approved shipping or storage packages	≤11.6 kg U-235, ≤1.0 kg moderator
10. Uranium Solution	Approved shipping packages	Contents of 1 drum

Sealed product sample bottles are brought into the UFSF in lots of not more than 19 bottles and containing not more than 350 g U-235, whichever is more limiting. The bottles are never opened in the facility. They are accurately weighed under the direction of Safeguards personnel, who verify the accuracy of the transfer documentation. The bottles are then immediately placed into storage. No additional lot is brought into Area 100 until the previous lot is in storage.

The storage compartments, made of cadmium sheet, in the cabinet are sized so that no more than 16 bottles will physically fit in each compartment.

3.2.1.6 LANL Material. LANL scrap material consists of assorted oxides and carbides of uranium mixed with graphite. It is received packaged in 1- or 2-L sealed plastic bottles. Each bottle may contain not more than 4.3 kg U-235. One or two of these bottles are received in each approved shipping container (drum). The plastic bottles are removed from the drum one at a time and placed inside a metal can specifically sized to hold only one of the plastic bottles. A slip-fit lid is placed on the metal can and the can is labeled and stored in a designated position in the LANL scrap racks described in Section 3.3.1.2. The racks and cans are sized so only 12 cans will fit in each rack compartment.

Storage and handling of LANL material are as described in "Safety Analysis Report - CPP-651 Rover Storage Racks (For LANL Fuel Scraps),"[1] Addendum B to PSD 4.8. The storage racks were fabricated and installed under a project entitled Rover Storage Racks, but are now called LANL scrap racks.

3.2.1.7 Rocky Flats. Rocky Flats material is uranium oxide, U_30_8. It is received and may be stored in approved shipping packages (drums) under the transport index less than 50 limit. The preferred storage method is to remove the doubly contained cans from the drum, place them into storage metal cans, and store them in the can storage racks in Area 104 described in Section 3.3.1.3. This process is as described in "SAR for Area 104 of Unirradiated Fuel Storage Facility (CPP-651)."[2]

3.2.1.8 Denitrator Product. Denitrator product is received in the UFSF in approved shipping or storage packages (drums). It is stored in the drums under transport index less than 50 limits for short terms while awaiting shipment. The polyethylene product bottles are occasionally removed from the drums for inventory purposes, but they are never opened in the UFSF.

3.3 Equipment Description

3.3.1 Fuel Storage Racks

Storage racks for critically safe storage of unirradiated fuels are provided in the fuel storage facility. Other racks are provided for storage of DOT- or DOE-approved containers (drums) by DOT transport index less than 50 limits. The racks are attached to the storage facility floor and/or walls for positive positioning and to withstand the effects of a design basis earthquake (DBE) without damage.

3.3.1.1 Fluorinel (A and B Racks). Fluorinel fuel is stored in poisoned racks ("A" and "B"), which are permanently installed in Area 102 of the South Vault (Figure 3-1). The "A" rack, constructed of angle iron, is 3 ft wide, 3 ft deep, and approximately 8 ft high. It contains 60 storage slots, each 4 in. wide, 4.5 in. high, and 36 in. deep. The "B" rack is of the same construction as the "A" rack, but differs in size and configuration. The "B" rack contains three different sized storage slots: 42 slots - 5 by 7 by 60 in. long; 18 slots - 5 by 7 by 72 in. long; and 4 slots - 12 by 14 by 84 in. long. Both types of racks have cadmium sheet inserts above, below, and on both sides of each storage position. Both are provided with a door and a hasp to permit locking for security, accountability, and storage configuration control. A drawer approximately 6 in. deep is provided in the bottom of the rack for storing miscellaneous material. The drawer is within the locked doors, and, for storage purposes, is considered as one storage slot.

3.3.1.2 LANL Material Racks. LANL is stored in storage racks (Figure 3-2) mounted on the walls above the Fluorinel racks in Area 102 of the South Vault (Figure 3-3). These racks are modular and of all-stainless-steel construction. The racks are designed to survive the DBE seismic event while maintaining the storage configuration integrity. They are accessible from a working platform mounted above the Fluorinel Racks in Area 102, or from a moveable working platform.

The racks are designed to contain cylindrical metal cans two deep by six wide on each shelf. Each modular unit has five such shelves, each shelf having an individually secured half-height, bottom-hinged door. The shelves are designed to contain the cans in upright position and to prevent the can lids from coming off while in storage. LANL material is received in plastic bottles and stored one bottle inside each metal can. Only one plastic bottle will physically fit in each metal can.

3.3.1.3 Can Storage Racks. These racks are identical to the LANL Racks. They are located on the west wall of Area 104 in the South Vault (Figure 3-4). They are intended for storing ANL, Rocky Flats, and other materials which may be approved in the future.

3.3.1.4 Product Sample Storage Cabinet. The Product Sample Cabinet is an enclosed metal cabinet with locking front doors, located in Area 104 of the South Vault as shown in Figure 3-5. The cabinet is 36 in. wide, 16.75 in. deep, and 75 in. high. It contains five horizontal storage shelves. Each shelf contains a compartmented tray, which is fabricated of 1/16-in.-thick cadmium sheet on the bottom and sides of each compartment, with a carbon-steel sheet cover. The cadmium provides neutron isolation between adjacent compartments and between trays. The cabinet is bolted to the south wall of Area 104. A seismic analysis performed for a fully loaded cabinet has determined that the cabinet shelves, storage trays, and anchoring bolts will withstand the DBE without compromising the integrity of the individual components or contents thereof.[3]

It is anticipated that, at some future date, the sample bottles stored in this cabinet will be transferred to the Can Storage Rack and the cabinet will be removed.

3.3.1.5 Drum Storage Racks. Drum Storage Racks are located in Areas 105 and 106. They are intended for efficient storage and handling of the drums. Because the drums are DOT- or DOE-qualified packages stored by transport index less than 50 rules, the configuration of these racks is not required to be maintained for criticality safety. The drum storage racks are fabricated of carbon-steel structural materials and have designed-in flexibility for storing different size drums. The racks are bolted to the wall to withstand DBE seismic requirements.

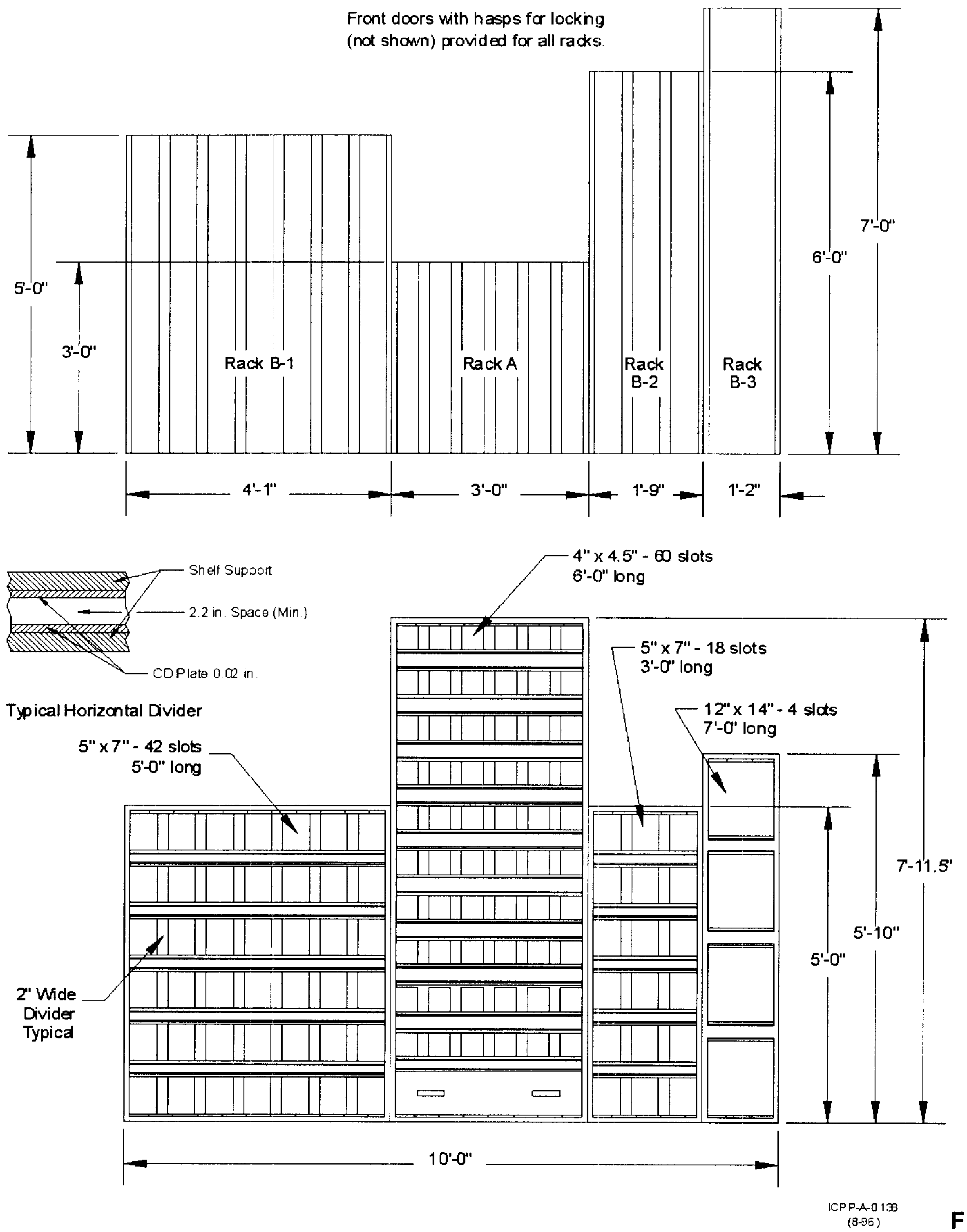

Figure 3-1. Fluorinel "A" and "B" storage racks.

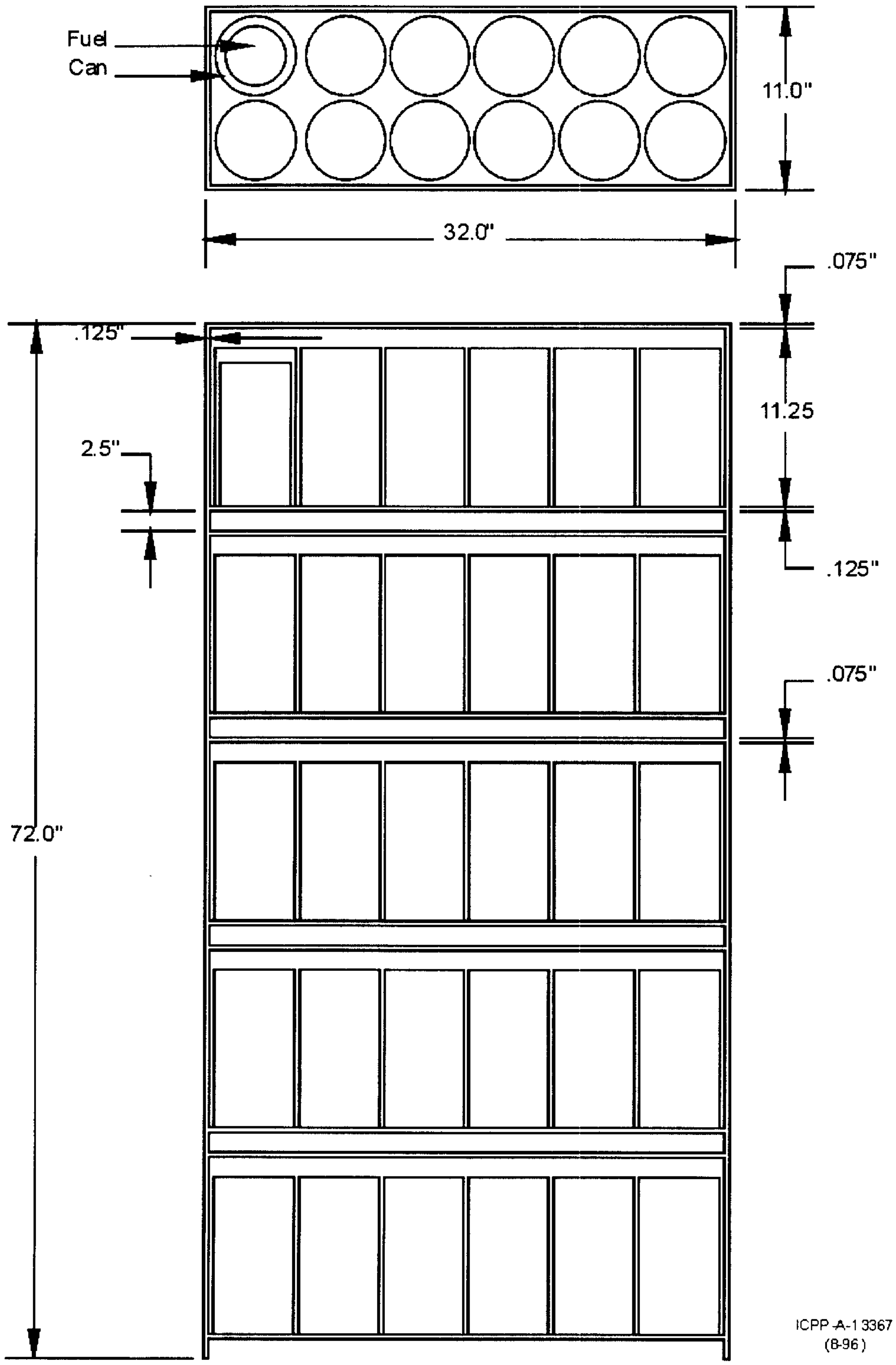

Figure 3-2. Sketch of a LANL fuel storage rack.

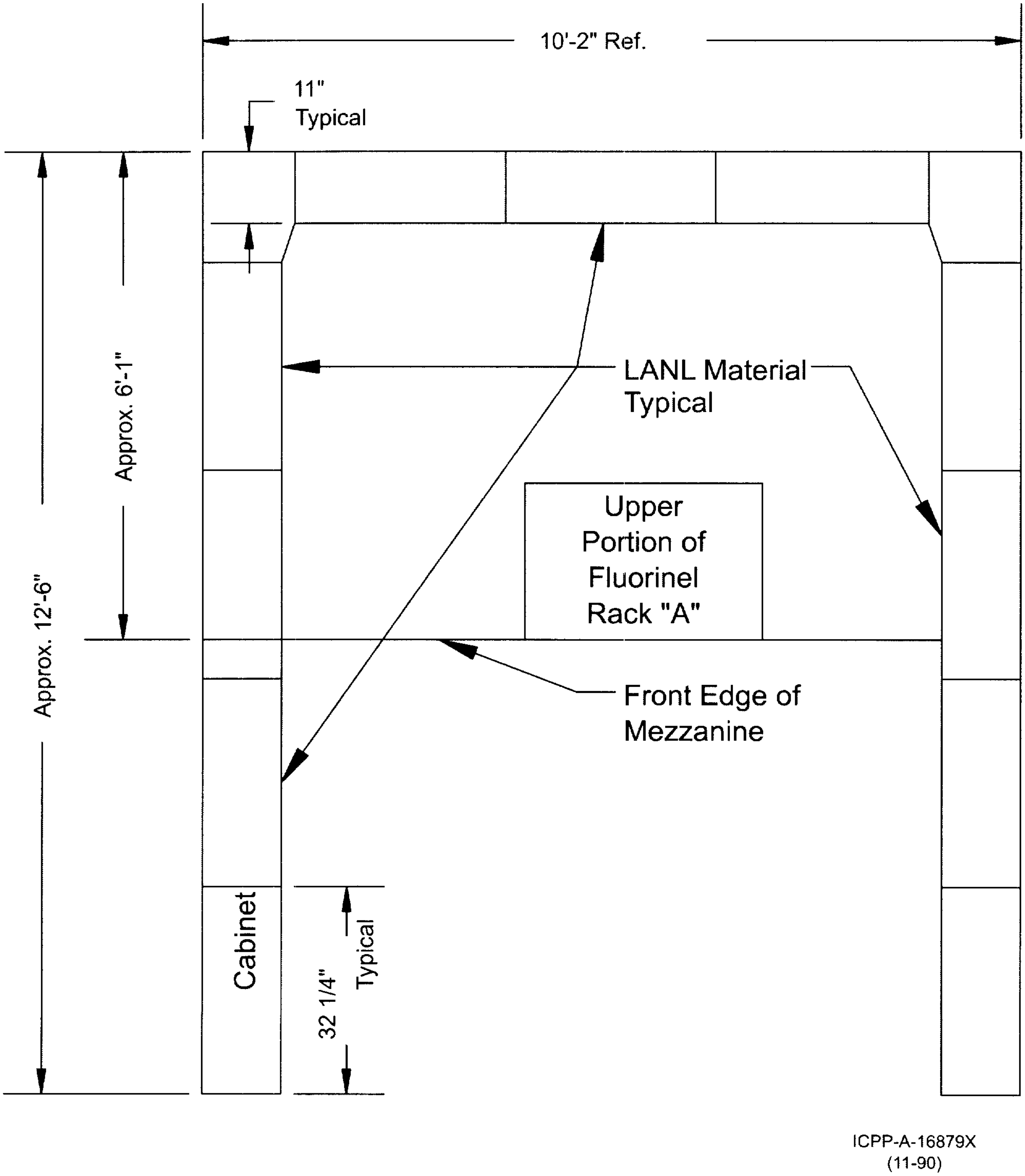

Figure 3-3. Layout of the LANL fuel storage room (Room)102.

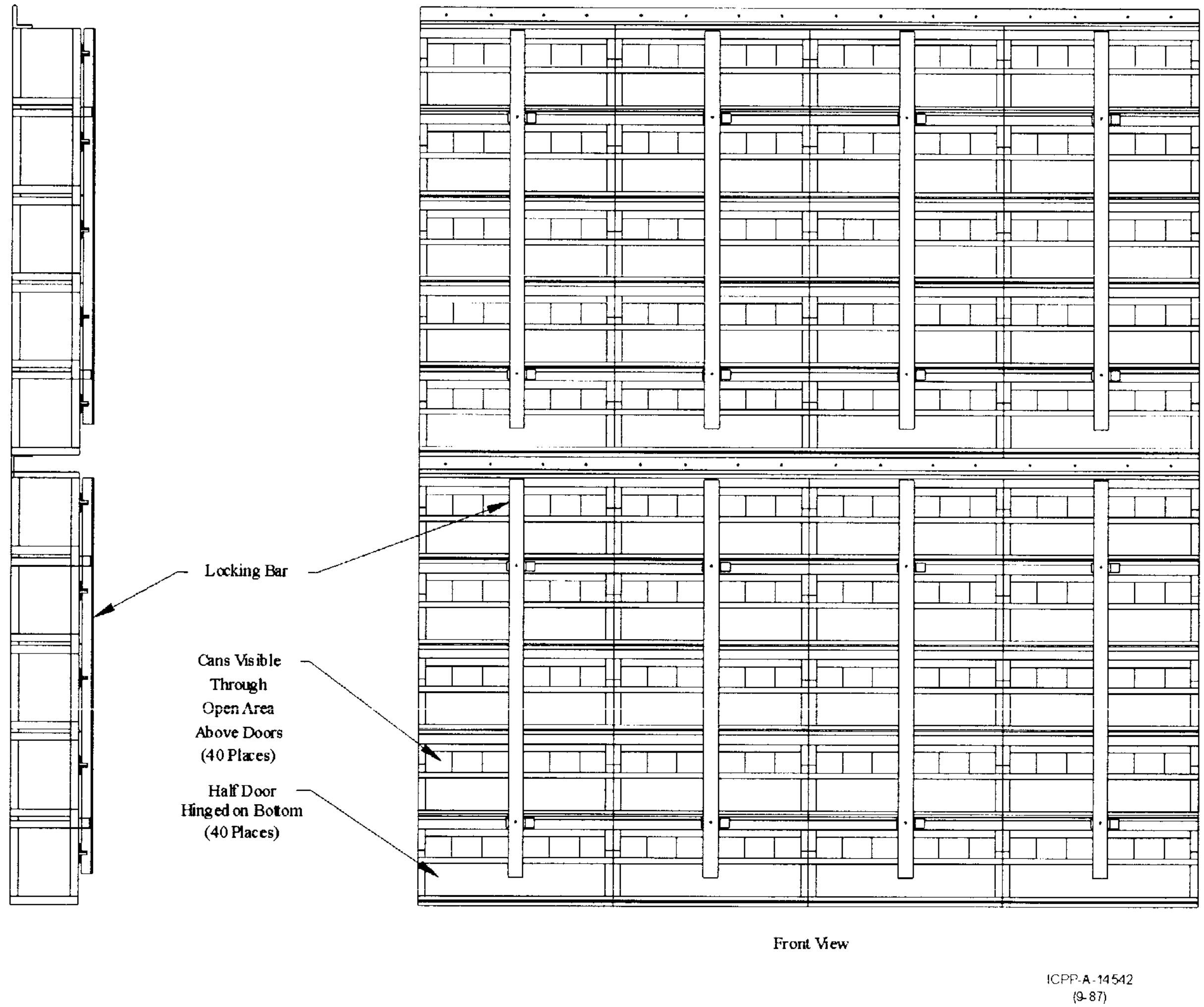

Figure 3-4. Front and end views of Area 104 storage racks.

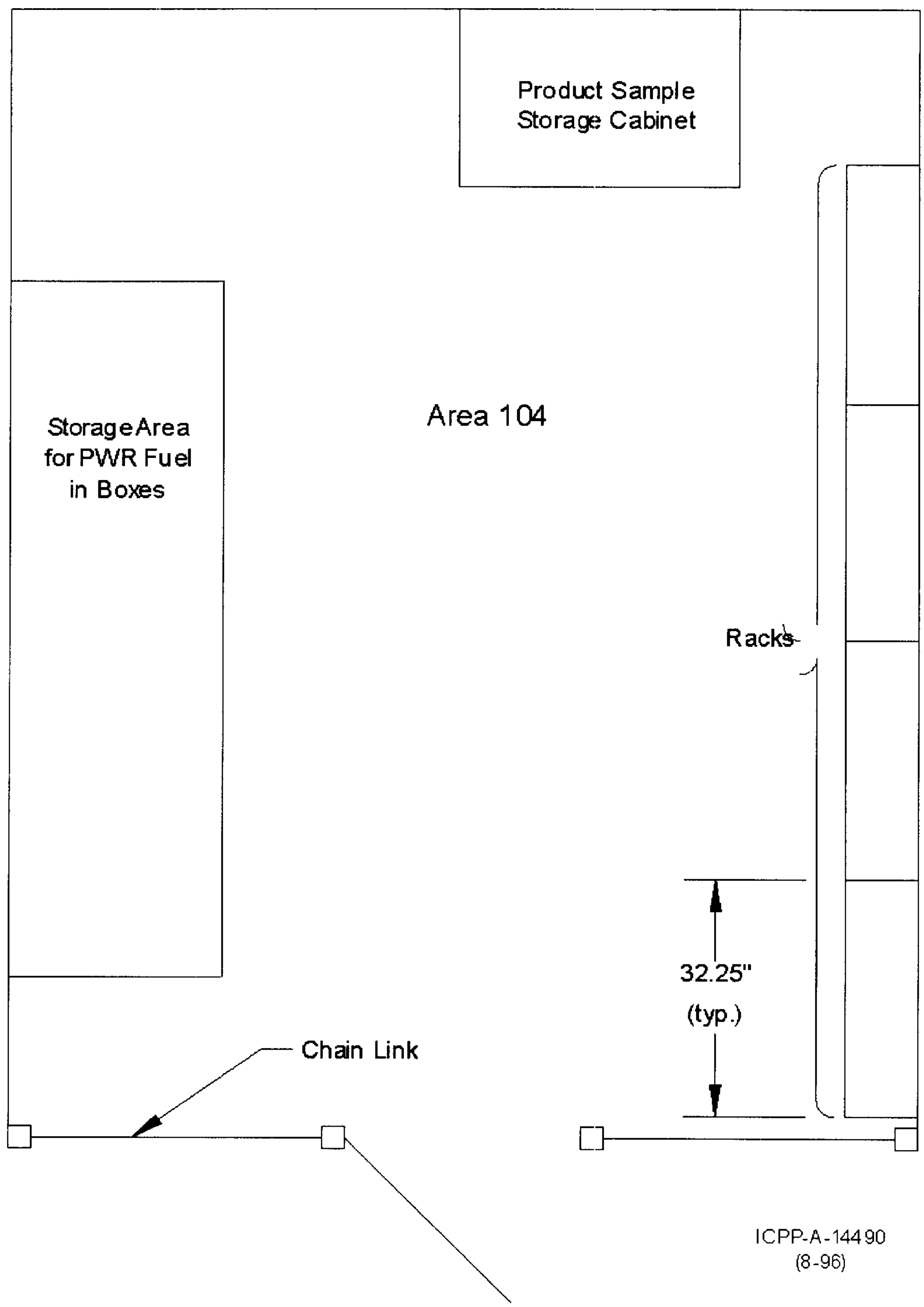

Figure 3-5. Layout of Fuel Storage Area 104.

3.3.2 Fuel Storage Containers

3.3.2.1 PWR Core 2 Seed 1 (Mockup). PWR Core 2 Seed 1 fuel is stored in five SPERT fuel shipping boxes. Storage of the material in these boxes has been evaluated and approved.

3.3.2.2 PWR Core 2 Seed 2 (Subassembly). The PWR Core 2 Seed 2 Subassembly is stored in a steel box. Overall dimensions are 9-1/2 in. square and 10 ft long. Storage in this box has been evaluated and approved.

3.3.3 Utilities

The utilities for the UFSF are supplied by existing CPP utility systems.

3.3.3.1 Electrical. The UFSF is provided with normal, standby, and emergency power. Should normal power be lost, switching to standby or emergency power is automatic. Normal electrical power is obtained from the ICPP electrical distribution system and supplies lights, space heaters, instruments, and alarm systems. Standby power for the alarm systems (fire, radiation, evacuation, and security) is obtained from ICPP standby generator GEN-PH-601.

The Criticality Alarm System (CSA) has its own battery operated uninterruptible power supply (UPS) system. If there is a normal power failure, the CAS is supplied by UPS power. The CAS can run off UPS power for at least 2 hours before UPS battery degradation and subsequent system performance degradation.

3.3.3.2 Water. There is no supply of water in the UFSF. If water is required, it can be obtained from CPP-637, the high bay laboratory, or CPP-653 (VMF). The quantity of water permitted in the UFSF is subject to moderator control limits. The floor drain originally installed in the North Vault is sealed closed to prevent inadvertent backup of water and potentially corrosive gases into the facility. A French drain in the Receiving Area is a closed drain for the same reason.

3.3.3.3 Ventilation. There is no ventilation system in the South Vault. In the North Vault, a pressurized air system prevents particulates from reaching the fuel. The filtered air for this pressurization system is supplied by a dedicated duct from the outside. The ventilation in the Receiving Area consists of an exhaust blower system which is capable of exchanging the air in the building 6 times per hour. A variable speed exhaust blower is located at the north end of the Receiving Area. Air supply is through inlets at the south end of the Receiving Area near the entrance doors and around the main doors since they do not form a seal.

3.3.4 Instrumentation and Controls

Instrumentation installed in the UFSF includes that required for security, fire, radiation detection, special nuclear material accountability, and contamination control.

3.3.4.1 Security. Instrumentation required for Security purposes in the UFSF is sensitive information and is outside of the scope of this document. The safety aspects of the security features of the UFSF are analyzed in WIN-160, "Assessment of CPP-651 Safeguards Modifications For Personnel Safety," Addendum C to PSD 4.8.[4]

3.3.4.2 Fire Detection. Fire detection instrumentation consists of ionization and particulate detection systems in the North and South Vaults. The detectors serve both to alarm and to activate the

Halon fire suppression systems in the Vaults. Alarms are given locally and at the Central Facilities Area (CFA) fire station. The dry-pipe water systems are activated by heat sensors. Water-flow alarms are also given locally and at the CFA fire station.

3.3.4.3 Radiation. The UFSF is equipped with a CAS to alert personnel of a criticality by activating facility warblers and the INTEC plant evacuation alarm. The CAS in CPP-651 includes: three clusters with three detectors per cluster, a Data Acquisition System (DAS-7), three warblers, an uninterruptible power supply (UPS), and associated cables and conduit. The CAS uses neutron detectors because the presence of a significant quantity of neutrons in CPP-651 is indicative of a criticality. The system works on a 2-out-of-3 alarm logic. This logic requires that 2 detectors in a cluster indicate a criticality before the evacuation alarm and warblers activate. The system is also activated if one or more detectors fail and one is in the high alarm state. The CAS is described in detail in Plant Safety Document WIN-107, Section 3.5A.

There are two detector clusters in the South Vault (R-YDC-701, R-YDC-702) and one in the receiving area (R-YDC-703). CAS coverage must be provided before any fuel handling operation can begin. This means at least two of the three detectors in the cluster covering the area and DAS-7 must be operable.

Once fuel is properly stored and fuel handling operations are complete the CAS is not required to be in operation. The approved storage configurations are critically safe with all degrees of moderation, as stated in Sections 2.1 and 3.1.2. If sufficient fuel were erroneously stored in unapproved configurations, which could result only from multiple failures of at least two contingencies, flooding could result in a possible criticality. However, flooding of the facility from external sources is not credible, as shown in Sections 3.1.8 and 6.3.4. Flooding from internal sources is extremely unlikely. The only source of water within the facility is a dry pipe fire suppression system. This system is located only in the north vault, the annulus, and the receiving area. In those areas, storage is only in approved shipping or storage packages, which are critically safe with any type of flooding, as provided by transport index determination for the packages. The floors in the south and north vaults are higher than the floor in the receiving area.

The only fuel storage in the facility not using shipping or storage packages is in engineered racks in the south vault. In the unlikely event that water from the fire suppression system should enter the UFSF, it is not likely that it could rise high enough to enter the south vault and flood the racks before it would run out under the chevron doors to the outside, since the doors do not seal or provide a tight fit. If water were released by the system, a water flow alarm would be initiated, the facility doors would be opened within approximately 10 minutes, and the water would be shut off. If a fire occurred in the south vault, a halon fire suppression system (an engineered safety feature) is provided. The probability of occurrence of a fire in the facility is less than E-02 because of the concrete and steel construction of the building, special restrictions, and the low fire loading limits. In the event of a fire, failure of the halon system, with a probability of less than 5 E-03, would be necessary before water might be introduced by a fire hose. Even if a fire occurred and the halon system failed, the additional failures of two administrative controls, having probabilities of failure of E-4 and E-1, respectively, per demand, with less than 10 demands per year, would have to occur before a criticality would be possible. The probability of occurrence of a criticality when fuel is in storage is therefore less than E-06, and CAS operation is not required when fuel is in storage.

The storage racks and cabinets, as well as the building, are designed to withstand a DBE seismic event without loss of safe storage configuration as discussed in Sections 1.0, and 3.3.1 of this document, and Section 4 of Reference 2. A loss of safe storage configuration by a large fire is shown in Section 6.3.3 to be incredible.

If there is a commercial power failure, the CAS is supplied by its own internal UPS power. The CAS can run off UPS power for at least 2 hours before UPS battery degradation and subsequent system performance degradation. If power to the CAS is not restored within two hours, all fuel handling operations must terminate or alternate alarm coverage must be provided.

The UFSF building is equipped with two roof warblers that identify the location of the alarm. In addition, the DAS is equipped with a local warbler. The detectors are also connected to the plantwide evacuation alarm system which activates in the event of a criticality.

The CAS in CPP-651, as analyzed in References 5 and 6, meets the requirements of DOE Order 5480.5, "Imposition of Proposed Nuclear Safety Requirements,"[7] DOE-ID Order 5480.5A, "Safety of Nuclear Facilities,"[8] and the detection requirements of ANSI/ANS-8.3-1986 "Criticality Accident Alarm Systems."[9]

Two alpha CAMs are provided, one for each storage vault, to detect and measure airborne alpha contamination. There are three DOE-supplied nuclear accident dosimeters (NAD), two in the South Vault and one in the North Vault. These are canister-type units and are mounted to provide ready recovery in the event of an accident. Health physics personnel bring portable radiation measuring devices, as appropriate, when required for specific operations.

3.3.4.4 Material Safeguards and Accountability. Three instruments are used in the UFSF to verify and maintain inventory records of the quantities of nuclear fuel materials in storage. An accurate balance is used to weigh materials shipped in or out of the facility and to periodically verify inventory records. A stabilized assay meter (SAM) is used to verify that fissile material is present in a package. The SAM is a gamma analyzer that detects and analyzes gamma radiation from spontaneous fissions in the nuclear material. An active well coincidence counter is used to measure the quantity of fissionable material in a container. It uses an Am-Li neutron source to cause fission in the material and counts coincidental neutron emissions indicative of fissioning. Material quantity is obtained by comparing measurements with standards. The instruments are portable. When they are used in the UFSF, they are used in Area 100 of the South Vault.

3.4 Interconnections

There are no interconnections in the UFSF, in the true sense of the word. All operations in which fuels are moved to or from storage or between storage positions are manual operations in which specific physical steps must be intentionally taken. Each CCA is a discrete, physically isolated area, isolated by reinforced concrete walls and welded chain-link floor-to-ceiling walls with locked gates. Within each CCA, all fuels stored are kept in physically restrained condition. The arrangement of the CCAs in the facility is such that no transfer path from one storage location to another passes through another storage CCA. Transfers between storage CCAs do pass through Area 100 CCA, but no fuel storage is permitted in Area 100, and only the fuel being transferred is allowed to be out of storage.

3.5 References

1. WINCO, "Safety Analysis Report CPP-651 Rover Storage Racks (for LANL Fuel Scraps)."

2. WINCO, "SAR for Area 104 of Unirradiated Fuel Storage Facility (CPP-651)," WIN-234.

3. E. D. Uldrich letter EDU-8-85, to P. Fineman, "Supplemental Seismic Analysis of CPP-651 Product Bottle Sample Storage Cabinet," December 5, 1985.

4. WINCO, "Assessment of CPP-651 Safeguards Modifications for Personnel Safety," WIN-160.

5. B. M. Palmer, CSS-10-92, "Criticality Alarm System Detector Placement Analysis for CPP-651," August 1992.

6. B. M. Palmer, BMP-05-92, "CAS Coverage in CPP-651," October 15, 1992.

7. DOE Order 5480.5, "Imposition of Proposed Nuclear Safety Requirements," U.S. Department of Energy.

8. DOE-ID Order 5480.5A, "Safety of Nuclear Facilities," U.S. Department of Energy Idaho Operations Office, September 2, 1990.

9. ANS-8.3-1986, "Criticality Alarm Systems," American National Standards Institute.

4. WASTE MANAGEMENT

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4. WASTE MANAGEMENT

4.1 Radiological Wastes

No radiological waste other than ordinary contamination control material is generated in the UFSF during normal operations. If the potential for contamination release is present in an operation, ordinary contamination control material such as blotter paper, rags, and plastic bags are used for containment. These materials are surveyed by health physics personnel at the completion of the operation and if found to be contaminated, they are disposed of as compactible solid waste.

The potential for contamination release is minimal, since bundles or containers of granular, powdered, or liquid materials may not be opened in the UFSF. The principal potential source of contamination release is damaged or corroded containers within shipping or storage packages. Inner containers removed from shipping or storage packages are surveyed by health physics personnel before any further handling. Fuel handlers wear appropriate protective clothing for all such operations.

4.2 Nonradiological Wastes

Small amounts of blotter paper, rags, and plastic bags are used in maintaining cleanliness and contamination control. These materials are surveyed by health physics personnel before disposal. If not contaminated, these are disposed of as ordinary trash.

4.3 Off-Gas Treatment

Not applicable.

4.4 Liquid Waste Treatment

Not applicable.

4.5 Solid Waste Treatment

Not applicable.

5. NORMAL OPERATION

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5. NORMAL OPERATION

5.1 Radiological Protection

5.1.1 Radiation Exposure

All material stored in the facility is unirradiated or low activity and presents no radiation exposure hazard during normal operations. Health physics personnel are required to be present and monitor all fuel handling operations in the facility.

5.1.2 Contamination

Contamination release is an unlikely occurrence in the UFSF. Inner cans of powdered, granular, or liquid materials are never opened in the facility. All fuel handling operations are monitored by health physics personnel who use standard INTEC health physics contamination-control practices. Contamination release could occur if an inner container were ruptured through an accident or corrosion. This possible situation is discussed in Section 6.4.2, Contamination Release.

Airborne contamination of particulate fissile material would be detected by Alpha CAMs located in each vault of the facility.

5.2 Nonradiological Protection

5.2.1 Industrial Safety

Standard industrial safety practices are observed in the UFSF. The only unusual safety concerns are the result of the building security features, which are assessed in WIN-160, "Assessment of CPP-651 Safeguards Modifications For Personnel Safety," Addendum C to PSD 4.8.[1]

5.2.2 Fire Safety

The primary defense against fire in the UFSF is the strict limitation of quantities and types of combustible materials allowed to be brought into the facility. This is discussed in detail in Addendum C.[1]

The North and South Vaults of the facility are equipped with Halon fire suppression systems. The North Vault, Receiving Area, and the annulus between the inner vaults and the outer shell of the building have dry-pipe fire systems. Hand-held fire extinguishers are located in the North Vault, South Vault, and the Receiving Area. No hydrocarbon-fueled vehicles are allowed inside the facility. Both particulate and ionization-type smoke detectors are used to activate the fire suppression systems.

A sign with "Code III" Firefighting designation (no water permitted except as high expansion foam) is required on the vault door of the facility's South Vault when fuel is out of storage. When fuel is not being handled in the South Vault it is posted as "Code I."

5.3 Reference

1. WINCO, "Assessment of CPP-651 Safeguards Modifications for Personnel Safety," WIN-160.

6. SAFETY ANALYSIS

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6. SAFETY ANALYSIS

The Unirradiated Fuel Storage Facility (UFSF) operations consist of a wide variety of fuel handling activities that can be broadly categorized as storage, transfer, or inventory. The materials are unirradiated, except for a few items with very low burnup, that have sufficiently low radiation levels that they are handled as unirradiated. A safety analysis for both normal and abnormal conditions has been conducted to assess the adequacy of the equipment and controls used in the facility. The primary concerns are preventing a criticality, preventing contamination release, and personnel safety related to building security features. The latter issue is not addressed in this document but is analyzed in WIN-160, "Assessment of CPP-651 Safeguards Modifications For Personnel Safety,"[1] Addendum C to PSD 4.8.

The analysis includes: (1) nuclear criticality safety, (2) contamination control, (3) industrial safety, (4) fire safety, (5) administrative procedures, and (6) postulated abnormal occurrences. Various abnormal occurrences have been postulated and are tabulated in Table 6-1. Impacts on personnel and the environment were evaluated. A maximum postulated accident for the facility was identified and evaluated.

6.1 Nuclear Criticality Safety

The criteria for nuclear criticality safety in an unshielded area, established by DOE Orders[2] and the WINCO Criticality Safety Control Manual,[3] are listed below:

1. The triple-contingency principle is applied to unshielded areas to determine limits of operation. The UFSF is an unshielded facility, thus triple contingency applies. Triple contingency means that sufficient safety factors are incorporated, in the design or administratively, that after at least three unlikely, independent, and concurrent changes occur, the k_{eff} shall still be less than 1.0.

2. A maximum k-effective (k_{eff}) value of 0.95 is allowed for criticality safety parameters developed from calculations. This value shall be shown to be not more than 0.95 after the first two contingencies fail and must include the effects of equipment tolerances and the uncertainties of the calculational method.

3. If criticality safety is by mass control, then a system must be limited to 45% of the minimum critical mass (for worst-case geometry) unless double batching is not credible, in which case a higher percentage may be used. The higher value normally used at the INTEC is 75%.

Additionally, physical barriers are implemented wherever possible, rather than relying solely on administrative controls to prevent criticality accidents.

6.2 Criticality Calculations

Criticality calculations have been performed for the various types and configurations of fuels to be stored in the UFSF. The calculations address all storage and handling situations and are used to derive the limitations within which the facility must operate. If a new fuel material not enveloped by an already approved fuel material is proposed for storage in the facility, a new analysis, with supporting criticality calculations, must be performed and approved by DOE before it may be handled and stored. This new analysis becomes a part of this PSD section as an addendum.

Table 6-1. Postulated abnormal occurrences — Unirradiated Fuel Storage Facility.

Operation	Postulated Abnormal Occurrence	Cause	Normal Prevention		Detection	Correction	Possible Consequences		
			Primary Safeguard	Secondary Safeguard			Control	This System	Other System
Storing, repackaging, or removing Fluorinel fuel	Pieces fall on floor	Operator error	Bundle taken apart on table	Two certified fuel handlers work together	Visual	Pick up, inspect rebundle	Return bundle to storage	Damaged fuel pieces	None
Storing or removing LANL material	Dropped can opens, bottle breaks open	Operator error	Handling procedure	Plastic inner bottle	a. Visual b. Alpha CAM	Leave building immediately	Replace contents in new bottle, decontaminate	Loss of material accountability	Possible contamination spread, inhalation by personnel
Fuel handling, South Bay	Fire in South Bay	Electrical sparks, combustible material	Hand-held fire extinguishers	Halon system	a. Visual b. Smoke detector	Extinguish fire, call fire dept., leave building	Develop recovery plan, as required	Combustible material burned, possible damage to fuel, smoke	Halon system discharged
Fuel handling, North Bay	Fire in North Bay	Electrical sparks, combustible material	Hand-held fire extinguishers	Halon system, dry-pipe sprinkler	a. Visual b. Smoke detector	Extinguish fire, call fire dept., leave building	Develop recovery plan, as required	Combustible material burned, possible damage to fuel, smoke	Halon system discharged
Loading or unloading fuel shipment	Fire in Receiving Area	Electrical sparks, combustible material	Hand-held fire extinguishers	Dry-pipe sprinkler system	a. Visual b. Smoke detector	Extinguish fire, call fire dept., leave building	Develop recovery plan, as required	Combustible material burned, possible damage to fuel, smoke	None
Storing or removing LANL material	Operator falls from platform	Operator error	Handrails, Traction surface	Low platform height (<6 ft)	Visual	Treat injury if operator injured	Bring in additional operator if required	Personnel injury	None
Removing material from drums for storage or inventory	Material spills from can	Can dropped, punctured, or corroded	Certified fuel handlers	Low drop height (<3 ft)	a. Visual b. Alpha CAM	Replace contents in can or bottle, leave building if CAM alarms	Decontaminate spill area	Loss of material accountability	Possible contamination spread; possible inhalation by personnel

Table 6-1. (continued).

			Normal Prevention				Possible Consequences		
Operation	Postulated Abnormal Occurrence	Cause	Primary Safeguard	Secondary Safeguard	Detection	Correction	Control	This System	Other System
Removing material from drums for storage or inventory	Inside of drum contaminated	Improper packaging or can leaks	Fuel handlers wear gloves	HP monitors removal of material from drum	a. HP smears b. Alpha CAM	Contain can in plastic bag and return to drum; leave building if CAM alarms	Decontaminate area, if contaminated	Contaminated can or cans; possible loss of material	Possible contamination spread; possible inhalation by personnel
Drum handling	Dropped drum, drum damaged	Operator error	Certified fuel handlers	Low lift height; load test lifting equipment	Visual	Inspect drum; leave building if CAM alarms	Replace drum if damaged to lose integrity or configuration	Damaged drum	Possible contamination spread

Table 6-2 describes the criticality calculations that were performed for the UFSF. It tabulates the cases considered, the assumptions and bases, the calculated results, and the references to the studies. Some of the calculation cases are not shown here because they are included in addenda to this PSD and are for specific storage areas. Reference is made to these addenda in appropriate sections of this document.

6.2.1 Approved Shipping or Storage Packages

The criticality safety of closed and sealed (safeguard seal, not hermetic seal), approved shipping or storage packages is assured by maintaining a limit of 50 on the sum of the transport indexes of an array of such packages stored in a CCA. The transport index must be determined on the basis of criticality considerations in accordance with DOT regulations or the SARP for the package.

6.2.1.1 Fuel Handling Limits. An analysis[4] was accomplished to determine fuel handling limits for the removal of contents of these containers or for other fuel handling operations in the UFSF.

The critical mass of a single intact piece of uranium metal, with no commingled or interstitial moderator, fully reflected by water, spherical, and 100% enrichment, was found to be 21.4 kg U-235.

A model was made for fuels consisting of multiple pieces, in which moderator could become interstitially mixed. The model assumed a homogeneous mixture of uranium metal, fully reflected by water, spherical, 100% enrichment, and with various quantities of oil moderator. The critical mass of U-235 was found to be $\geq$21.2 kg for all quantities of oil moderator $\leq$1.3 kg.

The uranium metal at 100% enrichment conservatively envelopes any possible uranium fuel material, including uranium oxides,[4] and the oil moderator conservatively envelopes any possible moderator material which could reasonably be postulated to be present in the UFSF, including water. Since full water reflection was also assumed, one mass and moderator limit may be applied to all uranium fuels to be stored in the facility except Fluorinel, denitrator product, and LANL scrap.

Safe mass and moderator combination limits ($k_{eff} \leq 0.95$) of 16.0 kg U-235 and 1.0 kg moderator; and 9.5 kg U-235 and >2 kg moderator,[4] are used to derive the safety limits for mass and moderator. Forty-five percent of the minimum critical mass, 9.5 kg U-235, is the limiting condition for operation (LCO) for mass. At this LCO, the safety limit for moderator is 2 kg. The LCO for moderator, 1.0 kg, results in a mass safety limit of 16.0 kg U-235.

Since the worst-case geometry and full water reflection were used in the analysis, no geometric control or personnel restrictions are required.

These limits are applicable generically to the handling of any fuel materials approved for storage in the UFSF. Certain materials have specific storage and handling criteria that are not governed by these generic limits.

Table 6-2. Criticality calculations for the Unirradiated Fuel Storage Facility.

Problem (Case)	Assumptions and Bases	Calculated Results	References
1. Find the critical mass of U-235 metal as a single intact piece.	1. Spherical shape 2. 100% enrichment U-235 3. Full water reflection 4. No re-entrant surfaces, no moderation	Critical mass = 21.4 kg U-235	JET-08-88[4]
2. Find the maximum quantity of moderator that would result in the critical mass of U-235 being not less than 21.2 kg.	1. Same as above, except 4 2. Moderator in the form of oil (higher Hydrogen content than water), homogeneously mixed with the U-235	The critical mass of U-235 if ≥21.2 kg for all quantities of moderator ≤1.3 kg oil	JET-08-88[4]
3. Independent CSE for Cases 1 and 2.	1. Same as Cases 1 and 2, except water moderated 2. Compare critical mass with water moderator to oil moderator	Critical mass = 21.6 kg U-235 Moderator / Critical mass U-235 1 kg oil / 21.4 kg 1. kg water / 21.9 kg 1.5 kg oil / 20.0 kg 1.5 kg water / 21.0 kg	NRRT-N-88-033[5]
4. Determine the interaction and k_{eff} of the UFSF with the facility completely loaded with DOT 6M drums, stored by transport index.	1. Each DOT 6 M drum loaded to its maximum limit of 13.5 kg U-235 2. TI = 1.0 for each drum so loaded 3. Areas 105 & 106 – 165 drums each 4. Areas 101 – 104 – 90 drums each 5. Facility dry 6. For interaction with FHU, 22.8 kg U-235, 6 x 5 x 2 array of drums	k_{eff} = .56 +/- 0.002 for the facility thus loaded k_{eff} for Area 105 or 106 (most reactive) = 0.54 +/- 0.002 interaction with most reactive area = 0.0194 +/- 0.0033 interaction with FHU = 0.045 +/- 0.0046	JTT-18-85[6]
5. Determine the k_{eff} of the Fluorinel racks for normal conditions, fully flooded, and for various degrees of moderation.	1. 500 g U-235 per ft in rack position 2. Structural material included 3. All racks modeled as "A" racks (most reactive), 11x17 array x 7 ft long 4. Racks made of iron 5. Cadmium 20 mils thick top, bottom, and sides, all storage positions 6. 2.25" x 3.25" or 4.0" x 4.5" fuel bundles 7. 0.36 void fraction within bundles 8. Reflected by concrete, bottom, back, and sides 9. Degree of moderation as tabulated 10. 2.25" 3.25", .36 void fraction filled with 100% water, low density water around bundle, full reflection (similar conditions to independent CSE)	Degree of Moderation / k_{eff} 100%, 2.25" x 3.25" / 0.538+/-.004 100%, 4.0" x 4.5" / 0.589+/-.004 90% " " / 0.570+/-.004 50% " " / 0.473+/-.004 15% " " / 0.493+/-.003 10% " " / 0.525+/-.003 5% " " / 0.557+/-.003 1% " " / 0.460+/-.003 0% " " / 0.389+/-.003 k_{eff} = 0.84	NRRT-N-88-030[7]

Table 6-2. (continued).

Problem (Case)	Assumptions and Bases	Calculated Results	References
6. Independent CSE for Fluorinel racks.	1. Same as 1-7 in Case 5 2. Water volume fraction in fuel = 0.36, low density between bundles 3. Dry	0.88	IEF-1-76[8]
	4. Find rack loading failure limit	0.34 Loading failure limit ≥3000 g/ft	IEF-25-75[9] IEF-1-76[8]
7. Determine critical volume of a homogeneous spherical mixture of U(100) and water, fully reflected.	As stated 3.5 kg U-235 (maximum loading of Fluorinel rack position)	Critical volume = 5.5 L	JTT-13-88[10]
8. Determine the minimum critical mass of UO_3 denitrator product.	1. 100% enriched UO_3 2. Fully water reflected and flooded 3. Spherical shape 4. Bulk density 4.1 gm/cc	Minimum critical mass = 35.0 kg UO_3, or 29.1 kg U-235	JTT-01-08[11]
9. Independent CSE for minimum critical mass of UO_3 denitrator product.	Same as Case 7, bulk density 4.24 gm/cc, 3.0-kg water fills voids	U(100) mass in UO_3 form for $k_{eff} = 0.95$ is 25.83 kg	WGM-26-80[12]
10. Evaluate k_{eff} for product sample bottles out of storage.	1. Bottles filled (70 g U-235 each) 2. 5 x 5 x 2 array 3. Internally and externally flooded 4. 30-cm tight water reflector	Maximum $k_{eff} = 0.78$	SE-PB-84-062[13]

1. Criticality calculations for storage and handling of LANL fuels in the South Vault are described in Addendum B[14] to PSD 4.8.
2. Criticality calculations for storage and handling of PWR, ANL material, Rocky Flats material, and denitrator product samples in the South Vault are described in Addendum D[15] to PSD 4.8.

6.2.1.2 *Fuel Handling Limits For Denitrator Product.* An analysis[12] was completed which determines fuel handling limits for the removal of denitrator product from approved shipping or storage packages. For $U(100)O_3$, fully saturated and reflected with water, and spherically shaped, the k_{eff} of 31.1 kg $U0_3$ is 0.950 +/- 0.007. The uranium content of this quantity of $U0_3$ is 25.8 kg. The water content in the sphere (not the reflector) was 3.0 kg, compared to the Area 100 limit of 1.0 kg. Conservatively, taking 25.8 kg as the minimum critical mass, 45% of this value yields 11.6 kg U-235 as the allowable out-of-storage limit for denitrator product. Typically, product cans contain between 8 and 10.5 kg total uranium.

6.2.2 Fluorinel Fuels

CSEs[7,8,9,10] were performed to determine safe storage and handling criteria for the Fluorinel fuels.

Storage criteria for bundles of pieces were determined to be a mass loading limit of 500 g U-235 per linear foot of bundle length per rack position, a maximum bundle cross section of 4 x 4.5 in., and a maximum void fraction within a bundle of 0.36.[7] The k_{eff} of the Fluorinel racks was determined for the above conditions with the racks modeled as all "A" racks (the most reactive array), with various degrees of flooding from 0 to 100% water filling the empty spaces and void volume, with cadmium sheets between horizontal rows, and with and without cadmium sheet between vertical columns in the rack.[7] The k_{eff} for the fully flooded case was 0.593, with vertical cadmium sheet (actual condition). For dry storage, the normal storage situation, the k_{eff} was less than 0.40.[7] The independent CSE for dry storage gave a k_{eff} of 0.34.[9]

The model was changed to remove the vertical cadmium sheet, limit bundle size to 2.25 x 3.25 in., and use low-density water between positions. The k_{eff} for this condition was 0.84. For similar conditions, the independent CSEs resulted in a k_{eff} of 0.88 for the bundle flooded, with low-density water between positions.[8]

To preclude the more reactive possibility of the 0.36 void fraction filling with water and the space around the fuel bundle being occupied with low-density water, it is prohibited that the bundles be wrapped with a material impervious to water unless a bundle so wrapped is contained in a watertight container. Any pieces for which the 0.36 void fraction cannot be maintained must be placed in a sealed, watertight container for storage.

The formula for calculating void fraction in the Fluorinel bundles is as follows:

$$V.F. = \frac{Gap\ (N-1)}{Gap\ (N-1) + Fuel\ Dimension(N)}$$

Where Gap is the space between the fuel pieces, N is the number of pieces, and the fuel dimension is measured on the pieces. Gap and fuel dimension measurements are taken in the fuel region of the pieces.

Handling criteria were determined for limits existing for the South Vault and the storage criteria for Fluorinel materials. Fluorinel pieces are stored in bundles in the Fluorinel Racks with a maximum loading of 500 g per linear foot of the bundle and maximum length of 7 ft. Thus, the mass limit is 3.5 kg U-235 by storage criteria. The moderator limit for the South Vault is 1.0 kg. Assuming that the moderator limit is exceeded by violating two contingencies, a means must be employed to prevent Fluorinel fuel containing 3.5 kg U-235 from reaching criticality. The minimum critical volume of a spherical, homogeneous mixture of water and U(100), fully reflected, was found to be 5.5 L.[10] By prohibiting any open containers (single or aggregate) larger than 5 L from being in the South Vault at any time Fluorinel fuel is not securely bundled, the possibility of forming a critical geometry is eliminated.

Since secure Fluorinel bundles with 4 x 4.5-in. cross sections cannot form this critical geometry, the container restriction does not prevent secured bundles from being transferred from storage to DOT-approved 6-L or 6-M shipping packages, or the reverse. The 6-L or 6-M packages, when being loaded or unloaded, do not count in the volume limit, since they are geometrically safe for all degrees of moderation and full water reflection for DOT-approved.

Since pipes or other watertight containers provide a barrier preventing commingling of the moderator with the fuel material, the restriction likewise does not apply to material contained in pipes or other watertight containers.

6.2.3 LANL Materials

LANL fuels are stored in Area 102 of the South Vault in racks specially built for them. LANL material consists of miscellaneous graphite and uranium matrix materials ranging from powders to chunks. They are received in 1- or 2-L plastic bottles containing not more than 4.3 kg U-235. This container is never opened in the UFSF. It is placed inside a nominal 3-L metal can designed specifically for this application to provide proper spacing and mass limitations in the storage racks. The safety analysis, including CSE references, is presented in "Safety Analysis Report CPP 651 Rover Storage Racks (For LANL Fuel Scraps),"[14] Addendum B to PSD Section 4.8.

6.2.4 PWR Fuel Elements and Subassembly

PWR Core 2, Seed 1 fuel elements are stored in SPERT shipping boxes. PWR Core 2, Seed 2 is a subassembly and is stored in a metal box. The boxes containing the PWR materials are stored on the floor in Area 104 of the South Vault. The safety analysis, including CSE references, is presented in WIN-234, "Safety Analysis Report - Unirradiated Fuel Storage In Area 104 of CPP-651,"[15] Addendum D to PSD Section 4.8.

6.2.5 Denitrator Product Samples

CSEs were completed for product sample bottle storage in the Area 104 sample storage steel cabinet, and for handling the sample bottles out of storage.[13] The steel cabinet has five shelves, with each shelf having a sample storage tray made of cadmium sheet. The cadmium forms the bottom of each tray and divides the tray into compartments sized to hold no more than 16 sample bottles. Each tray has a sheet-steel cover that can be bolted down to enclose the sample bottles in the storage positions. The samples are doubly contained in 17-cc glass bottles within close-fitting polyethylene bottles.

Calculations were performed for various loading conditions from 33% overloaded (20 bottles, 1,372 g U-235 per compartment) to approximately 50% loaded (10 bottles, 494 g per compartment). All compartments in the cabinet, in a 6 x 3 x 5 array, were loaded as described. As previously stated, each compartment can physically hold no more than 16 bottles. Cases were performed at the various loadings for a dry rack, for the fuel regions only (2.5 in. high) flooded, for the full storage compartment (4 in. high) flooded, and full compartment flooding plus water volume fractions from 0.02 to 0.20 in the spaces between the shelves. In all cases, a tight-fitting concrete reflector surrounded the cabinet.

For dry conditions, the highest possible loading yielded the highest reactivity. The k_{eff} for the 33% overloaded, dry condition was 0.47. For overloaded and full compartment flooding, k_{eff} was 0.83.

Maximum k_{eff} was 0.84 in which loading was 15 bottles, 1,029 g per compartment, with full storage compartment flooding. In cases with water in the spaces between the shelves, the maximum k_{eff} was 0.81 with 0.02 water volume fraction (wvf). The k_{eff} decreased with increasing wvf. The conclusion of this evaluation was that storage of the denitrator product samples in the cabinet was critically safe for all degrees of moderation.

Additional CSEs were performed on denitrator product sample bottles out of storage to determine fuel handling criteria.[13] A nearly cubic array (5 x 5 x 2) of 50 bottles was modeled in flooded-water reflected, and dry but fully water reflected conditions. Various bottle loadings and edge spacings were considered. The maximum calculated k_{eff} was 0.78 with high-density bottle loading, water-flooded inside and outside of the bottles, 0.79 in (2.0 cm) spacing, with an 11.8-in. (30-cm) water reflector. The dry, water-reflected array yielded a k_{eff} of 0.454.

6.2.6 ANL Materials

Argonne National Laboratory material is received in DOT- or DOE-approved shipping packages with transport index assigned. The loaded shipping packages may be stored in Areas 101, 103, 105, or 106 of the South Vault of the UFSF. However, in order to improve storage density and retrieval efficiency, the inner cans are preferably stored in the can storage racks in Area 104. Cans containing ANL material are removed from the shipping packages, placed in overpack cans, and stored in prescribed positions in the can storage racks. The contents of the overpack can shall not exceed 3.37 kg U-235, or 1 tall ANL can or 2 short ANL cans, or 1 INTEC dissolvable fuel can. The safety analysis, including CSE references, is presented in WIN-234, "Safety Analysis Report - Unirradiated Fuel Storage In Area 104 Of CPP-651,"[15] Addendum D to PSD Section 4.8.

6.2.7 Rocky Flats Materials

Rocky Flats material is received in DOT-approved shipping packages with transport index assigned. The loaded shipping packages may be stored in Areas 101, 103, 105, or 106 of the South Vault of the UFSF. However, in order to improve storage density and retrieval efficiency, the inner cans are preferably stored in the can storage racks in Area 104. Cans containing Rocky Flats material are removed from the shipping packages, placed in overpack cans, and stored in prescribed positions in the can storage racks. The contents of the overpack can shall not exceed 3.37 kg U-235, or 1 Rocky Flats can. The safety analysis, including CSE references, is presented in WIN-234, "Safety Analysis Report - Unirradiated Fuel Storage In Area 104 of CPP-651, Addendum D to PSD Section 4.8.[15]

6.2.8 Denitrator Product

Denitrator product is stored in the UFSF for short times while awaiting shipment. It is stored in approved shipping or storage packages by transport index. The polyethylene product bottles may be removed from the approved shipping or storage packages for inventory purposes, but they are never opened in the UFSF. They are handled under the fuel handling limit of 11.6 kg U-235 for denitrator product.

6.2.9 Interaction

Interaction has been shown to be negligible between storage areas and between a fuel handling unit and the storage areas, for material stored in shipping or storage packages.[6] For material stored in racks, boxes or cabinets, the k_{eff}s are shown to be low by the various CSEs, and interactions are insignificant. Fuel storage in racks or cabinets is permitted only in Areas 102 and 104, and these are separated by Area 103, in which only drum storage is permitted. Interaction between a fuel handling unit out of storage and fuels in nearby storage racks has been evaluated and shown to be insignificant.[14,15] Only one fuel handling unit is allowed out of storage at one time in the South Vault. If the facility became flooded, the interaction in the facility would decrease, since the neutron isolation distances in water are less than in air. No fuel handling would be attempted in a flooded facility.

6.3 Criticality Accident Logic Matrix

The criticality calculations discussed in Section 6.2 show that there are no criticality hazards associated with normal fuel handling and storage operations in the UFSF. Accident scenarios are summarized in Table 6-3 to outline possible criticality accidents and the contingencies provided to render these accidents unlikely. Since the fuel handling and storage occurs in an unshielded area, triple contingency against criticality must be satisfied. The table identifies the postulated accident, the contingencies against each accident, and the concurrent conditions that would be required before a criticality would be possible. For this analysis, it is assumed that no seismic event will occur which will exceed the design basis earthquake (DBE), and that components designed to withstand the DBE do not fail.

6.3.1 Criticality Scenario No. 1

A criticality could theoretically occur in an array of stored approved shipping or storage packages if sufficient packages were stored in a given CCA to greatly exceed the transport index limit of 50. Even though the transport index limit of less than 50 is extremely conservative in storage applications and could be exceeded by a very large margin without approaching criticality, three contingencies are identified to prevent this criticality accident:

1. The UFSF Custodian would have to assign fuel for storage in a CCA that exceeded a transport index 50 limit.
2. A qualified fuel handler would fail to stop the operation upon realization that the transport index 50 limit would be exceeded.
3. A second qualified fuel handler would also fail to stop the operation.

The three contingencies are three independent violations of procedure. The cumulative transport index content of each CCA is posted on the door of that CCA and is recorded and verified before fuel storage begins. The new cumulative transport index for the CCA must be calculated, independently verified, and recorded on both the fuel storage form and on the posted CCA log at the conclusion of the operation. The cumulative transport index for each CCA is maintained in the facility custodian's master record and is updated from the fuel storage form record copy for each operation. It is used for placement of future shipments received in the facility.

The DOT transport index is very conservative as applied to storage. An independent CSE[6] evaluated interaction between the UFSF CCAs with all CCAs (except Area 107) overloaded with a transport index of either 90 or 165, far in excess of the 50 limit, and determined that the total facility would have a k_{eff} of less than 0.6. Because of the conservatism and the three unlikely, independent contingencies, this criticality accident is not credible.

Table 6-3. Logic matrix postulated criticality accident in the Unirradiated Fuel Storage Facility.

Criticality Accident	Contingencies 1	Contingencies 2	Contingencies 3	Required Concurrent Conditions
1. Criticality in array of approved shipping or storage packages due to excess transport index in one CCA	Custodian assigns fuel for storage which will exceed transport index limit for that CCA	Qualified fuel handler fails to stop operation before transport index limit is exceeded	Second qualified fuel handler also fails to stop operation	Conservatism in DOT transport index rules, violation of procedure requiring logging of total transport index present in a CCA
2. Criticality in array of approved shipping or storage packages due to overloading/assigning incorrect transport index by shipper	Shipper Fuel Custodian violates loading limit for package	Shipper Shipping Agent assigns incorrect transport index to package, multiple packages	Receiver Custodian fails to discover variation in fuel receipt criteria from approved limits	Conservatism in DOT transport index rules would require multiple violations before criticality could occur
3. Criticality in fuel storage caused by a major fire in the UFSF	Custodian allows violation of flammable material limits in the UFSF	Two qualified fuel handlers fail to stop introduction of excess flammable material or correct the condition	Fire suppression system and fire department fail to extinguish fire	An ignition source of sufficient energy and at the right location required to start fire
4. Criticality in Fluorinel storage rack because of overloading and flooding	Qualified fuel handler overloads storage position in violation of procedure and TS/S	Second qualified fuel handler fails to correct the situation	Rack becomes flooded	Estimated failure limit of 3,000 g U-235 per ft loading would be difficult to accomplish with physical size limitation of rack storage positions
5. Criticality in Fluorinel storage rack caused by excessive void fraction in fuel bundles	Qualified fuel handler violates void fraction limit by forming a bundle of fuel pieces with a void fraction >0.36	Second qualified fuel handler fails to correct situation	The rack becomes flooded and the void is filled	

Table 6-3. (continued).

Criticality Accident	Contingencies 1	Contingencies 2	Contingencies 3	Required Concurrent Conditions
6. Criticality in LANL racks caused by shipper overloading bottles	Shipper violates 4.3 kg U-235 limit on bottle loading	Custodian fails to detect discrepancy in fuel receipt criteria from approved limit (4.3 kg U-235) per bottle	The rack becomes flooded	Materials Safeguards personnel fail to detect; only a few materials have a sufficient U-235 content to overload a 2-1 bottle; multiple failures (overloaded bottles) would be required, all stored in close proximity to each other, for criticality
7. Criticality in Area 100 while removing material from approved shipping or storage package, excess moderator present	Qualified fuel handler violates moderator limits	Second qualified fuel handler fails to stop or correct the situation	Inner container containing fuel is dropped, breaks, and contents mix with moderator	Quantity of fuel in container would have to be sufficient; critical geometry of moderator and fuel quantities would be required; cans are never opened in UFSF
8. Criticality in Area 100 while removing material from approved shipping or storage package, excess fuel present	Qualified fuel handler violates fuel quantity limit	Second qualified fuel handler fails to stop or correct the situation	Inner container containing fuel is dropped, breaks, and contents mix with moderator	Quantity of moderator present would have to be sufficient; critical geometry for moderator and fuel quantities would be required; cans are never opened in UFSF
9. Criticality in Area 100 while storing or retrieving LANL material	Qualified fuel handler violates handling limits by removing from approved shipping or storage packages or storage more than 6 LANL bottles	Second qualified fuel handler fails to stop or correct the situation	The array of bottles out of storage becomes water flooded	>16 LANL scrap bottled, optimally spaced, would be required for criticality; moderator limit of 1.0 kg water would be 1.0 liters, not sufficient to flood 16 bottles; flooding from other sources unlikely
10. Criticality in Area 100 while repackaging Fluorinel fuels for storage or shipping	Qualified fuel handler exceeds the 1.0 kg moderator limit in the South Vault	Second qualified fuel handler fails to stop or correct the situation	The custodian or alternate custodian allows an open container larger than 5.3 L (the minimum critical volume) during the operation critical volume	The criticality could only occur if the moderator becomes interstitially mixed with the fuel bundle within the minimum

Table 6-3. (continued).

Criticality Accident	Contingencies 1	Contingencies 2	Contingencies 3	Required Concurrent Conditions
11. Criticality in Area 100 while storing or retrieving denitrator product samples	Qualified fuel handler violates handling limits by removing from storage or receiving more than 19 product sample bottles	Second qualified fuel handler fails to stop or correct the situation	The bottles become flooded internally and the array flooded	Optimum array of 5 x 5 x 2 (50 bottles), optimum spacing of 2-cm edge-to-edge, 30-cm water reflector, and fully loaded bottles give $k_{eff} = 0.78$
12. Criticality in CPP-651 due to more than one fuel type out of approved storage at the same time	Qualified fuel handler violates fuel handling limits by removing more than one type of fuel from approved storage at the same time	Second qualified fuel handler fails to stop or correct the situation	Moderator is available and mixes with the different fuel types	Sufficient fuel must be removed from storage and collected in an optimal configuration

Criticality scenarios for various fuels stored in Area 104 are discussed in WIN-234.[6]

6.3.2 Criticality Scenario No. 2

A criticality could occur in an array of DOT- or DOE-approved shipping packages if numerous packages were overloaded and assigned incorrect transport indexes by the shipper. This accident would require three contingencies to occur. The first two contingencies are based on the shipper's accountability procedures and shipping documentation.

1. The shipper fuel custodian violates the loading limit for the package.

2. The shipper shipping agent fails to assign the transport index or assigns incorrect transport index to the package.

3. The UFSF Custodian fails to discover a variation in fuel receipt criteria from approved values.

The three contingencies are independent violations of DOT regulations or procedure. Each approved shipping package has a specific loading limit specified by 49 CFR 173.417 b 2ii. The first contingency would be for the shipper to exceed this loading limit. The second contingency would require that the shipper's shipping agent assign a transport index incorrectly based on material content less than that actually contained in the package. The third contingency would require that the UFSF custodian not discover the discrepancy between actual and approved quantities as shown on the fuel receipt criteria for the shipment. A required concurrent condition would be that this train of occurrences would have to happen numerous times for a criticality to be possible, since DOT transport index rules, as applied to storage, are extremely conservative. For these reasons, this accident is extremely unlikely.

6.3.3 Criticality Scenario No. 3

A criticality could occur in the UFSF if a major fire occurred and caused sufficient damage to fuel storage racks that critically safe configuration were lost. At least three contingencies would be required for this accident to occur:

1. The UFSF custodian would have to allow violation of flammable material limits in the UFSF. The only credible sources of sufficient flammable material to cause a fire of this magnitude would be a hydrocarbon-fueled vehicle in the Receiving Area or large quantities of solvent for cleaning purposes, both of which are expressly prohibited.

2. Certified fuel handlers and others trained in the operation of the UFSF fail to stop the introduction of excess flammable material into the building, or to correct such a condition.

3. Fire suppression systems and the INEEL Fire Department fail to extinguish the fire.

The conditions required for a fire of this magnitude to occur involve (1) administrative control violations by at least three responsible persons and (2) two concurrent conditions, a fuel leak from a (prohibited) vehicle or a cleaning solvent (also prohibited) spill, combined with an ignition source of sufficient energy at the proper time and location. The probability of failure of an administrative control, where the responsible person perceives his or her life to be endangered, is E-04 to E-05 per demand. In addition, a physical barrier must be willfully overridden to admit a vehicle to the UFSF. The probability of a fuel leak is less than E-01 per year. The UFSF is a no smoking area. Conservatively assuming 2 fuel transfers (demands) per month in which a vehicle might be used and ignoring the effectiveness of the third responsible person, the probability of this accident is less than 24 x E-04 x E-04 x E-01, or less than 2.4 E-08.

6.3.4 Criticality Scenario No. 4

A criticality could occur in one of the Fluorinel storage racks if the rack were overloaded and became flooded. Three contingencies would be required for this accident to occur:

1. A qualified fuel handler overbatches the storage position in violation of a storage limit.

1. A second qualified fuel handler fails to stop or correct the situation.

2. The rack becomes flooded.

The procedure for storing Fluorinel fuels clearly specifies fuel loading limits for the Fluorinel racks, in accordance with the administrative controls of this safety analysis. The procedure requires double verification of the U-235 content of the fuel placed into the storage position. The estimated failure limit of 3,000 g per linear foot loading per storage position[9] would be difficult to accomplish with the physical size limitations of the storage positions.

The rack would have to become flooded. This is unlikely for several reasons. The racks are well above the maximum flood level (10,000-year flood) of 4,916 ft.[16] The racks have doors that are kept locked closed except when transferring fuel into or out of them. If a fire occurred when fuel was out of storage, the use of water, except as high expansion foam, to extinguish it is prohibited by the required Firefighting Code III designation. There are no fire water lines or any other water source in the South Vault of the UFSF.

It is extremely unlikely that this accident could occur given the three independent, unlikely contingencies and the concurrent conditions that would be required.

6.3.5 Criticality Scenario No. 5

A criticality could occur in the Fluorinel storage racks if a fuel bundle were stored which had excessive void fraction, and the rack became flooded. At least three contingencies would be required for this to occur:

1. A qualified fuel handler violates an administrative control, forming and storing a bundle of fuel with a void fraction >0.36.

2. A second qualified fuel handler fails to stop or correct this situation.

3. The racks flood; void fills with water.

The procedure for storing Fluorinel fuels specifically describes how the fuel pieces are to be bundled and how void fraction is determined, as required by this safety analysis. It requires recording the various measurements by the fuel handler and verification by the second fuel handler. The filling of the void with water is unlikely, as described in Section 6.3.4. Thus the occurrence of this accident is extremely unlikely.

6.3.6 Criticality Scenario No. 6

A criticality could occur in the LANL scrap racks if the shipper overloaded the bottles containing the material. At least three contingencies would be required for this to happen:

1. The shipper would have to violate the 4.3-kg limit for the U-235 content of each bottle.

2. The UFSF custodian would have to fail to detect the discrepancy between the fuel receipt criteria and the approved limit of 4.3 kg per bottle.

3. The rack would have to become flooded.

It is unlikely that the shipper would violate the 4.3-kg loading limit. The shipper has procedures for loading the bottles prior to shipping, that would have to be violated. In addition, the shipper has accountability requirements for the U-235, which would serve as a double check on the quantity per bottle.

Of the various types of LANL materials approved for storage in the UFSF, only a few contain enough U-235 that a 2-L bottle could physically contain >4.3 kg. In addition, multiple failures (overloaded bottles) would have to occur, and all would have to be stored in close proximity to each other in the LANL racks.

Rack flooding is unlikely for reasons described in Section 6.3.7, and the elevation of the LANL scrap racks is more than 5 ft above the 10,000-yr flood level.

Finally, the UFSF Custodian compares fuel receipt criteria for the material shipped with approved limits before accepting the material for storage.

With these contingencies and required concurrent conditions, this postulated criticality accident is extremely unlikely.

6.3.7 Criticality Scenario No. 7

A criticality could occur in Area 100 while removing sufficient material from an approved shipping or storage package in the presence of excess moderator. At least three contingencies would be required for this accident to occur:

1. A qualified fuel handler violates moderator limits.

2. A second qualified fuel handler fails to stop or correct the situation.

3. The inner container from the approved shipping or storage package, which contains the fuel, is dropped, breaks open, and the contents mix with the moderator.

Moderator limits are clearly specified in this safety analysis for the fuel handling operations in the UFSF. These limits are included in the procedure, which gives detailed instructions for these operations. Qualified fuel handlers are required to perform all operations involving fuel being out of storage, and they are required to follow the procedures.

If excessive moderator were present, it would still not be able to become interstitially mixed with the fuel material if the fuel remained in the inner container. Since inner containers are never opened in the UFSF, only an accident which would break the inner container such as dropping it or having something heavy fall on it could expose the contents to the moderator. Even then, two other concurrent conditions would be required before a criticality would be possible. The quantity of fuel in the container would have to be sufficient, and the geometrical array of the mixed fuel and moderator would have to be a critical configuration.

Because of the three unlikely contingencies and the other required concurrent conditions, this criticality scenario is extremely unlikely.

6.3.8 Criticality Scenario No. 8

A criticality in Area 100 would be possible if excess fuel was removed from an approved shipping or storage package, in the presence of sufficient moderator. At least three contingencies would be required before this criticality could occur:

1. A qualified fuel handler removes fuel material from a shipping package in excess of safety limit.

2. A second qualified fuel handler fails to stop or correct the situation.

3. The inner container from the approved shipping or storage package, which contains the fuel, is dropped, breaks open, and the contents mix with the moderator.

This scenario is almost the same as 6.3.7, and the contingencies are the same, except that fuel quantity is the variable here rather than excess moderator. This scenario is also extremely unlikely.

6.3.9 Criticality Scenario No. 9

A criticality would be possible in Area 100 during storage or retrieval of LANL material. At least three contingencies would be required for this to occur.

1. A qualified fuel handler would have to violate the safety limit by removing more than 8 LANL bottles or cans from DOT- or DOE-approved shipping packages or storage racks.

2. A second qualified fuel handler would have to fail to stop or correct the situation.

3. The array of bottles out of storage would have to become water flooded.

The 8-can safety limit is clearly specified in this safety analysis for LANL fuel handling operations in the UFSF and in the procedure, which gives detailed instructions for these operations. Qualified fuel handlers are required to perform all operations involving handling fuel, and they are required to follow the procedure. Two qualified fuel handlers are required, the second serving to check and verify the actions of the first. In addition, the UFSF custodian or alternate custodian, both of whom are trained in the operational requirements of the UFSF, is required to oversee all fuel handling operations. It is unlikely that the qualified fuel handler would violate the procedure, and it is also unlikely that the second one would make the same error.

If the 8-can out-of-storage limit were exceeded, flooding would be required before criticality would be possible. Flooding would be unlikely, as discussed in Section 6.3.4. The moderator limit of 1.0 kg, even if in the form of water, is insufficient to flood the array of bottles. Even if all of the above contingencies occurred, 16 LANL scrap bottles, fully water-reflected, optimally spaced, fully flooded, would be subcritical.

Because of the contingencies, the required concurrent conditions, and the large margin of safety in this operation, this criticality scenario is not credible.

6.3.10 Criticality Scenario No. 10

A criticality would be possible in Area 100 during the packaging or repackaging of Fluorinel fuels for storage. At least three contingencies would be required for this to occur:

1. A qualified fuel handler would have to violate the 1.0-kg moderator limit for the South Vault.
2. A second qualified fuel handler would fail to stop or correct the situation.
3. The Custodian would have to violate the requirement that no open containers having greater than 5.0 L volume, singly or in aggregate, are in the South Vault.

The 1.0-kg moderator limit is clearly specified in this safety analysis for fuel handling operations in the UFSF. The limit is included in the procedure, which gives detailed instructions for this operation. Qualified fuel handlers are required to perform all operations involving fuel being out of storage, and they are required to follow the procedure. Two qualified fuel handlers are required, the second serving to check and verify the actions of the first. In addition, the UFSF custodian or alternate custodian, who are also trained in the operational requirements of the UFSF, is required to verify that no open containers having greater than 5.0 L volume, singly or in aggregate, are present. This requirement provides a geometrical barrier to criticality.

The 5.0-L container limit is determined to be critically safe for the 3.5 kg of U-235 in a 7-ft-long Fluorinel storage position if the moderator and the fuel materials were interstitially mixed, of optimum geometry, and fully water reflected. Thus, an additional concurrent condition would be required that the array would have to be interstitially mixed and form into a spherical geometrical array. For these reasons, this criticality accident scenario is extremely unlikely.

6.3.11 Criticality Scenario No. 11

A criticality is possible in Area 100 while denitrator product samples are being stored or retrieved. At least three contingencies are required for the criticality to occur:

1. A qualified fuel handler violates the material limit by removing from storage or receiving more than 19 product sample bottles.
2. A second qualified fuel handler fails to stop or correct the situation.
3. The bottles become flooded internally and the array becomes flooded.

The number of denitrator product sample bottles allowed out of storage is 19. Qualified fuel handlers are required to perform all operations involving handling fuel, and they are required to follow the procedure. Two qualified fuel handlers are required, the second serving to check and verify the actions of the first. In addition, the UFSF custodian or alternate custodian, either of whom is trained in the operational requirements of the UFSF, is required to oversee all fuel handling operations. It is unlikely that the qualified fuel handler would violate the procedure, and it is also unlikely that the second one would make the same error.

If the fuel handlers did make the error of having more than 19 sample bottles out of storage, flooding would be required, both inside the bottles and of the array, in addition to the formation of a 30-cm water reflector. The amount of water available, assuming the 1.0-kg moderator limit was all water, would be insufficient. The availability of water from outside sources is unlikely, as discussed in Section 6.3.4. The bottles consist of an inner, sealed glass vial and an outer, sealed polyethylene bottle. For all these double containers to become water filled, even if water were available, is at least extremely unlikely, or not credible.

The CSE for this postulated occurrence showed that even for 50 such containers in optimum (5 x 5 x 2) array with optimum spacing of 2-cm edge-to-edge and 30-cm water reflector, the k_{eff} would be only 0.78. Therefore, this criticality scenario is not credible.

6.3.12 Criticality Scenario No. 12

A criticality is possible in CPP-651 due to having more than one fuel type out of approved storage or out of an approved shipping or storage package at the same time. The contingencies leading to this scenario are:

1. Qualified fuel handler violates fuel handling limits by removing more than one fuel type from approved storage, approved shipping package, or storage package at one time.

2. Second qualified fuel handler fails to stop or correct the situation.

3. Moderator is available and mixes with the different fuel types.

Fuel limits are clearly specified in the safety analysis, the technical standards, and incorporated into facility procedures for fuel handling operations in the UFSF such that no more than one fuel type is allowed out of approved storage at the same time. Qualified fuel handlers are required to perform all operations that involve the fuel being moved out of storage, and they are required to follow the procedures.

Even if the fuel handling limits are violated, a sufficiently reactive configuration (geometry) of fuel and moderator materials is necessary for a criticality to occur. Because of the contingencies and the other required concurrent condition, this criticality scenario is extremely unlikely.

Several other criticality scenarios are considered and described in the various addenda to this PSD section.[1,14,15] Table 6-3 and the explanatory text, along with the referenced addenda, show that for the postulated criticality accidents, three or more unlikely independent events must occur, along with specified concurrent conditions, to produce the accident. From these evaluations, it is concluded that operations in the UFSF are extremely unlikely to cause a criticality.

6.4 Radiation and Contamination Safety

The UFSF is used for storage of unirradiated fuel. In the South Vault, no containers containing powdered, granular, or liquid fuel materials may be opened. No bundles or cans of any kind may be opened in the North Vault or the Receiving Area.

6.4.1 Radiation Exposure

Direct radiation exposure during normal operations is virtually nil, unless the slightly irradiated materials or product bottles are handled. All individual fuel elements or packages stored, moved, or removed from storage are monitored by the health physics technician to ensure radiation exposure control. Because of the low direct radiation levels of all the material stored in the facility, the potential for accidents resulting in external radiation exposure is extremely low.

6.4.2 Contamination Release

Contamination release during normal operations is similarly improbable. All fuel handling operations are performed by fuel handlers wearing appropriate protective clothing. Health physics personnel monitor each operation. If external contamination is detected on the material being handled, the health physics technician directs the application of suitable contamination control procedures and protection. No containers are opened in the facility if they contain granular, powdered, or liquid material. Only intact fuel elements or pieces are ever handled outside of containers. These are handled under controlled conditions monitored by health physics personnel. Thus the potential for contamination release during normal operations is minimal. Alpha CAMs are present and required to be in service during any fuel handling operation, to detect any airborne release of uranium-bearing contamination.

There is some potential for contamination release under accident conditions. Several materials, including LANL scrap, denitrator product samples, ANL scrap, and Rocky Flats scrap, are received in sealed metal cans or plastic bottles. Most of these materials are doubly contained. These materials can be loose, powdered, or granular, and thus present potential contamination problems. The cans or bottles, except denitrator product samples, are placed inside metal storage canisters and stored in storage racks. Denitrator product samples are stored in a special cabinet.

The possibility exists that a container could be dropped during some phase of the storage operation and could break open. The chances of this occurring are unlikely, because the materials are nuclear fuel materials being carefully handled by qualified fuel handlers. In addition, the possible drop distances are small enough that even if a container were dropped it is unlikely that it would break open. Any container, except denitrator product samples, dropped from the maximum possible height (approximately 10 ft) would be at least doubly contained, with the outer storage canister absorbing much of the energy that the fall would generate. Denitrator product samples would not be dropped more than 5 ft and are doubly contained in a glass inner vial inside a plastic outer bottle. Both inner and outer container lids are taped closed and the contents could not spill out even if the inner vial broke.

The allowable quantity of fissile material stored is limited to 1,500 kg U-235 per vault (North Vault and South Vault). This limit meets the compartmentalization requirements of DOE Order 6430.1A,[17] Chapter XXII.[18] In the event of a fire disaster in either vault, radiation exposure to the general public at the site boundary would not exceed DOE Order 6430.1A dose guidelines.[12]

An analysis[19] was performed to determine estimated dose from inhalation of dust resulting from a dropped and ruptured Rocky Flats inner can. The following tabulates the estimated 50-yr committed dose equivalents from this analysis and the committed effective dose equivalent (CEDE).

	Lung	Bone Surface	CEDE
Uranium	5.7 rem	—	6.8 E-1 rem
Plutonium	21.3 rem	66.9 rem	4.6 rem
Totals	27.0 rem	67.0 rem	5.3 rem

This analysis shows that this accident results in doses to an on-site worker that are within DOE Order 5480.11[20] occupational limits.

An inner container received in a DOT or DOE shipping package could be ruptured, punctured, poorly sealed, or perforated by corrosion. Release of contamination in this manner would be possible. Operating procedures, which require handling the material with gloves and HP monitoring of all fuel handling in the facility, offer adequate defense against spread of this potential contamination beyond a small area, probably not exceeding the shipping package from which it came.

6.5 Fire and Explosion Safety

The UFSF is particularly sensitive to fire and explosion safety because of the high value of nuclear materials stored there, because of the potential release of airborne contamination in the event of a fire, and because there is only one entrance/exit in the facility, and that one takes time to open. This subject is discussed in detail in WIN 160,[1] Addendum C to this document.

The primary defense against fire and explosion hazard in the UFSF is the strict limitation of combustible material allowed in the facility. The building itself is of fireproof construction, consisting of reinforced concrete and metal. Storage racks in the North Vault contain wood but are compartmented and equipped with fire shields for fire resistance.

Combustible materials brought into the building are limited to 10 lb per any 10 ft^2 of floor area. Combustible materials used for packaging or cleanup, such as rags, blotter paper, and plastic bags, are brought in for specific operations. These materials are subject to the combustible materials limit, and are removed at the completion of that operation or the end of the shift, whichever is first. Exceptions are permitted to these general requirements, but to do so requires procedures and specific case-by-case approval by the operating contractor's Nuclear and Industrial Safety Department.

Flammable or explosive liquids and gases are prohibited inside the UFSF. This exclusion specifically prohibits all hydrocarbon-fueled vehicles. Hydraulic fluid is permitted in the facility door actuator system and in hydraulic lift equipment. Few ignition sources exist in the UFSF. The building lights, CAMs, electric heaters, the motors which drive the door hydraulic system and two blowers, the monorail hoist, the small, battery-powered forklift, and associated wiring and switchgear are the only facility equipment that are electrical ignition sources. Other possible ignition sources within the facility would be squibs for actuating or testing the Halon or ADS systems, and firearms discharged by security personnel. No smoking is permitted in the facility. Any battery-powered vehicles or lifting devices require analysis and contractor approval before they may be used or stored in the facility.

Fire protection systems are provided in the facility. The North Vault and Receiving Area have dry-pipe water sprinkler systems. The North Vault and South Vault both have Halon systems. All three areas have hand-held extinguishers. Both ionization and particulate smoke detectors are used for alarm and Halon fire suppression system activation. Dry-pipe water fire suppression systems are activated by heat detectors at the sprinkler heads. Any fire detected in the facility alarms locally and at the CFA fire station.

6.6 Maximum Postulated Accident

Two maximum postulated accidents (MPAs) were considered for the UFSF. The first, a major fire in the Receiving Area, is described in WIN 160, "Assessment of CPP-651 Safeguards Modifications For Personnel Safety,"[1] Addendum C to this PSD section. The second is a criticality in the South Vault, Area 100, caused by a fuel handling error.

A criticality in Area 100 could occur if either or both fuel handling or moderator limits were violated during a fuel handling operation. Since all UFSF fuel handling operations are unshielded, such an accident could result in fatalities to personnel in the building, if personnel were unable to evacuate the building immediately. Personnel outside the building and in the remainder of ICPP would be exposed to radiation doses dependent upon their location with respect to the UFSF at the time of the criticality.

The worst-case exposure to personnel outside the UFSF would be to persons walking along Redwood Street. Persons walking along Redwood Street immediately west of the UFSF would be shielded by the equivalent of more than 5 ft of concrete, and would be at least 50 ft from the criticality. The penetrating dose equivalent to these persons would be 40 mrem (neutron plus gamma). However, at one narrow band across Redwood Avenue, depending upon the location of the criticality, it would be possible that somewhat less shielding and 64 ft distance would be between a receptor and the criticality. This potential situation is enveloped by the calculations in Reference 21 for personnel in the trailers formerly located east of the UFSF, which assumed 1 ft of concrete shielding and a 50-ft separation, with a calculated penetrating dose equivalent of 160 rem (neutron and gamma). This was before the security upgrade which provided the additional shielding of the concrete outer shell and the thick, sloping berm. The trailers are no longer there, and with the additional shielding, the doses would be <2.5 rem (neutron plus gamma).

One or two security guards are stationed outside the facility immediately south of the chain-link security fence during any operation in the UFSF. The guards would be approximately 50 ft from the criticality and would be protected by the concrete and the thick, packed stone and gravel berm. The penetrating dose equivalent to the guards would be 2 rem (neutron and gamma). At least one guard would definitely be present because he or she is required at that location for security purposes at all times that the UFSF is occupied. The presence of persons on Redwood Street is strictly a matter of chance, but is much less likely than the presence of the guards.

Plume and inhalation calculations[21] for personnel in the (former) trailers also envelope the guards and pedestrians on Redwood Avenue, since the distances used in the calculations are less than the actual distances for the guards and pedestrians.

The following assumptions were used in the dose calculations in the report:

Criticality Event:

1. Size of criticality: 2×10^{18} fissions

2. Duration of criticality: 10 min

3. Shielding: as described above

Release Conditions:

4. The following percentages of fission products are released:

   Solids 1%

   Halogens 25%

   Noble Gases 100%

   Cesium 1%

   Ruthenium 1%

5. Approximately 6 x 10^5 Ci of activity are released over a 10-min period.

6. Meteorological conditions are Pasquill Class F (stable).

7. Wind speed is 2 m/sec for off-site calculations.

8. Activity is released at ground level.

Dose Receptors:

9. Guards or pedestrian on Redwood Street:

   a. Distance from criticality: as described in previous paragraph

   b. Shielding: as described in previous paragraph

   c. Exposure time to plume (cloud gamma and inhalation): 10 min.

10. Site Boundary:

   a. Distance from criticality: 1.35E4 m

   b. Exposure time to plume (inhalation): 10 min.

Internal Dose Calculations:

1. The ICRP Lung Dynamics Model was used to calculate the dose to the lung.

2. The particle size was 1 micron.

3. All fission products were assumed to be Clearance Class D, except for the following:

Co	Y
Sr	W
Sr	Y
Nb	Y
Ru	Y
Rh	Y
Sb	W
Ce	Y
Eu	Y
U	Y

External Dose Calculations:

14. Prompt gamma and neutron doses calculated using equations of NRC Regulatory Guide 3.33.

15. Cloud gamma doses calculated using the finite-plume model.

Table 6-4 lists the results of the calculations.

These values show that the MPA results in doses to an on-site worker outside of the UFSF that are within the DOE Order 5480.11[20] occupational limits, except for the possible pedestrian in a narrow band of Redwood Avenue. The presence of an individual at that particular spot is of very low probability. The doses to an individual at the site boundary are within the DOE Order 6430.1A[17] guidelines.

Table 6-4. Results of dose calculations for criticality in the Unirradiated Fuel Storage Facility.

Penetrating Dose Equivalents: (rem)			
Radiation Source	On-Site Pedestrian Redwood Street	On-Site Guard Post Near UFSF	Site Boundary Downwind
Prompt Neutron	<1.2E+2	0.5	<0.001
Prompt Gamma	<3.5E+1	1.5	<0.001
Cloud Gamma	2.0	2.0	<0.001
Totals:	<1.6E+2	4.0	<0.001

Inhalation Committed Dose Equivalents (rem)			
Organ	On-Site Pedestrian	On-Site Guard Post	Site Boundary
Lung	5.1	5.1	0.002
Thyroid	5.6	5.6	0.002
Red Bone Marrow	1.1	1.1	<0.001
Whole Body	0.1	0.1	<0.001
CEDE	9.1E-1	9.1E-1	9.1E-1
Total (CEDE + penetrating)	1.6E+2	4.9	1.4E-3

It should be noted that the DOE Order 6430.1A guideline doses are not intended to imply that these doses constitute acceptable limits for emergency doses to the public under accident conditions. Rather, these doses are reference values that can be used in the evaluation of facility design and site evaluation with respect to potential accidents of exceedingly low probability of occurrence and low risk of public exposure to radiation.

In addition, the risk of receiving the doses listed in Table 6-4 to an individual at the INEEL site boundary is even lower due to the remote location of the INEEL in relationship to population centers, plus the fact that the highways and roads on the INEEL are patrolled by security forces, and traffic can be interrupted during emergency situations.

6.7 References

1. WINCO, "Assessment of CPP-651 Safeguards Modifications for Personnel Safety," WIN-160.

2. DOE Order 5480.5, "Imposition of Proposed Nuclear Safety Requirements, U.S. Department of Energy."

3. WINCO, "Criticality Safety Control Manual," IPM-IV-1, Revision 2, January 1987.

4. J. E. Tanner, letter JET-08-88, to G. T. Paulson, "Critical and Safe Masses of Lightly Moderated U-235 Metal," July 22, 1988.

5. R. R. Jones, NRRT-N-88-033, "Independent Criticality Calculations for Lightly Moderated U-235 Fuel Spheres," September 1988.

6. J. T. Taylor, letter JTT-18-85, to R. E. Wilson, "Handling and Storage of DOT Shipping Containers in the Unirradiated Fuel Storage Facility," August 19, 1985.

7. J. B. Briggs, "Criticality Safety Evaluation of the Fluorinel Storage Racks in CPP-651," NRRT-N-88-030, September 1988.

8. I. E. Fergus, letter IEF-1-76, to R. E. Wilson, "Additional Information on A and B Racks and Transfer Rack," January 26, 1976.

9. I. E. Fergus, letter IEF-25-75, to R. E. Wilson, "Addendum to A and B Rack Criticality Evaluation," November 14, 1975.

10. J. T. Taylor, letter JTT-13-88, to G. T. Paulson, "Minimum Critical Volume for Fluorinel Fuel Bundles in the UFSF," September 20, 1988.

11. J. T. Taylor, letter to G. T. Paulson, JTT-01-88, "CSE for the Minimum Critical Mass of $U0_3$ Product," January 25, 1988.

12. W. G. Morrison, letter to P. Fineman, WGM-26-80, "Independent Criticality Review: $U0_3$ Spheres," December 22, 1980.

13. R. R. Jones, "Criticality Safety Evaluation for Product Sample Cabinet, Area 104, CPP-651," SE-PB-84-062, October 1984.

14. WINCO, "Safety Analysis Report CPP-651 Rover Storage Racks (for LANL Fuel Scraps)."

15. WINCO, "SAR For Area 104 of Unirradiated Fuel Storage Facility (CPP-651)," WIN-234.

16. K. N. Koslow, letter to J. E. Johnson, Jr., KNK-04-88, "Transmittal of Peak Flood Evaluation at CPP from Addendum to the 1986 Flood Study," September 20, 1988.

17. DOE Order 6430.1A, "General Design Criteria," Draft, December 25, 1987.

18. D. R. Wenzel, letter to J. E. Johnson, WEN-3-84, "Evaluation of U-235 Storage Limit for CPP-651," July 31, 1984.

19. S. R. Bolton, letter to J. E. Johnson, SRM-08-88, "Dose Estimate for U_30_8 Inhalation Accident in CPP-651," May 25, 1988.

20. DOE Order 5480.11, "Radiation Protection for Occupational Workers," U.S. Department of Energy, Draft, April 5, 1988.

21. D. R. Wenzel, letter to P. Fineman, WEN-40-81, Radiological Consequences of a Criticality in the Unirradiated Fuel Storage Facility," October 9, 1981.

7. PROVISIONS FOR OPERATIONAL SAFETY

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7. PROVISIONS FOR OPERATIONAL SAFETY

7.1 Operational Safety Requirements

The operation of the UFSF requires engineered safety features and administrative controls. This section contains the safety features that are engineered into the facility and the required administrative controls. Those engineered safety features and administrative controls required by the addenda to this PSD section (Addenda B,[1] C,[2] and D[3]) are contained in the addenda and are not repeated here.

7.1.1 Engineered Safety Features

1. Each compartmented storage CCA in the facility shall have a lockable limited access that exits only to the main fuel transfer corridor (Area 100), or to the Receiving Area in the case of Area 107.

2. A criticality alarm system is provided to detect a criticality and initiate an alarm for personnel evacuation in accordance with the requirements of DOE Order 5480.5, DOE-ID Order 5480.5A, and ANSI/ANS-8.3-1986.

3. The racks for storage of Fluorinel fuel shall be as described in Section 3.3.1.1 and shall have cadmium sheet inserts separating the compartments both horizontally and vertically. The cadmium sheets shall be at least 0.020 in. thick.

4. The cabinet for storage of denitrator product samples shall be as described in Section 3.3.1.4. Each shelf shall be compartmentalized with cadmium sheet bottom and sides with a steel cover which can be bolted closed. The cadmium shall be $\geq$0.040 in. thick and the compartments shall be sized to physically prevent more than 16 sample bottles from being stored.

7.1.2 Administrative Controls

7.1.2.1 Fuel Handling, North Vault (Area 107). Fuel in the UFSF North Vault shall be handled only by persons qualified in fissile material handling, or by persons directly supervised by qualified fissile material handlers.

7.1.2.2 Fuel Storage, North Vault (Area 107).

1. The U-235 content of material in the North Vault (Area 107) of the UFSF shall not exceed 1,500 kg.

2. Only materials approved by WINCO and DOE-ID and certified by the shipper as meeting approved ICPP fuel receipt criteria shall be stored in the North Vault of the UFSF.

3. Fissile material in approved shipping or storage packages may be stored in the North Vault (Area 107). The total transport index of all approved packages stored in Area 107 shall not exceed 50.

4. The contents of approved shipping or storage packages shall not be removed (but the packages may be opened) in Area 107.

7.1.2.3 Fuel Handling, South Vault.

1. A sign with "Code III" firefighting designation shall be required at the entrance to the South Vault at any time fuel is out of storage in the South Bay.

2. Removal of fuels from approved shipping or storage packages or Fluorinel bundles shall be permitted only in Area 100.

3. Area 100 shall not be used as a criticality control area, except as required for transfer or packaging of fuel.

4. Containers of granular material, powders, or liquid shall not be opened in the South Vault of the UFSF.

5. The quantity of hydrogenous moderator in the South Vault shall not exceed 1.0 kg at any time that fuel is out of storage. The moderator materials permitted may include liquids, solids, or combinations thereof, provided they do not contain special reflecting materials (such as heavy water, beryllium, or graphite) in greater than trace amounts.

6. The quantity of U-235 (except for Type 1 Fluorinel fuel pipes,[4] Fluorinel pieces, and LANL fuel) that may be removed from a shipping package shall not exceed 11.6 kg for denitrator product (UO_3) or 9.5 kg for all other materials.

7. The number of Type 1 Fluorinel fuel pipes allowed to be contained in the Rover Unirradiated Fuel Transfer Container in Area 100 shall not exceed 21 pipes or 7.5 kg U-235.

8. The quantity of U-235 in Fluorinel pieces (except Type 1 Fluorinel Fuel pipes) that may be removed from a shipping package or from storage shall not exceed 3.5 kg.

9. A UFSF Custodian shall verify that no open containers of greater than 5.0 L (single or aggregate) capacity are in the South Vault any time that Fluorinel bundles are to be assembled or disassembled. A single approved shipping container for shipping fissile material having an inner container of not more than 5.25 in. in diameter (currently 6-L or 6-M drums) being loaded or unloaded is excepted from the single container limit, but no other open containers are allowed at the same time.

10. During Fluorinel fuel handling, no more than the approved contents of a single storage position shall be out of storage at one time.

11. The contents of approved shipping or storage packages shall not be removed (but the packages may be opened) in the storage rooms (Areas 101 through 106).

12. Criticality safety evaluations and an approved SAR shall be required prior to handling fissile materials which contain more than trace amounts of special moderators such as heavy water, beryllium, graphite, etc., or which contain more than trace amounts of fissile materials other than U-235. Material contained in sealed, approved shipping or storage packages is exempted from this restriction.

13. Handling of fuel in the UFSF South Vault shall be done only by persons qualified in fissile material handling, or by persons directly supervised by qualified fissile material handlers.

14. Except in case of emergency exit, all fuel materials shall be in storage or in approved shipping containers before vacating the facility.

15. It shall be verified that no other fuel type is out of storage or out of an approved shipping or storage package prior to beginning a fuel handling operation in which fuel is removed from storage or from an approved shipping or storage package.

7.1.2.4 Fuel Storage, South Vault.

1. General

   a. Only materials approved by INEEL and DOE-ID and certified by the shipper as meeting approved INTEC fuel receipt criteria shall be stored in the South Vault of the UFSF, except for short-term safe haven storage in DOT- or DOE-approved shipping containers.

   b. The U-235 content of material stored in the South Vault of the UFSF shall not exceed 1,500 kg.

2. Approved Shipping or Storage Packages

   a. The total transport index of all approved shipping or storage packages stored in any one CCA in the South Vault shall not exceed 50.

   b. Approved shipping or storage packages shall be stored in a CCA only if no other fuel storage method is being used in that CCA.

3. Fluorinel

   a. Each Fluorinel rack position shall contain no more than a total of 500 g U-235 per linear foot as Fluorinel fuel pieces, and the fuel in each position shall be confined to a 4- x 4.5-in. cross section.

   b. Bundles of Fluorinel pieces stored in the Fluoriner racks shall not be wrapped in material impervious to water unless the wrapped bundle is enclosed in a watertight container in storage.

   c. Fluorinel fuel pieces shall be securely bundled for storage in the Fluorinel racks, and the void fraction within the fuel region shall not exceed 0.36 unless the material is contained in a watertight container.

   d. No Pu, Be, C, D_20, U-233, or H_3 is permitted in the Fluorinel storage configuration, except in trace amounts.

4. Denitrator Product Samples

   a. Denitrator product samples shall be stored in bottles in covered shelf storage trays in the denitrator product sample cabinet.

b. The denitrator product samples shall be contained in a nominal 15-ml glass bottle inside a polyethylene bottle, with both inner and outer bottles sealed with tape.

7.2 References

1. WINCO, "Safety Analysis Report CPP-651 Rover Storage Racks (for LANL Fuel Scraps)."
2. WINCO, "Assessment of CPP-651 Safeguards Modifications for personnel Safety," WIN-160.
3. WINCO, "SAR for Area 104 of Unirradiated Fuel Storage Facility (CPP-651)," WIN-234.
4. DOE Order 5480.1A, Chapter III, "Safety Requirements for the Packaging of Fissile and Other Radioactive Materials," U.S. Department of Energy.