CSE LICENSE ANNEX

FINAL ASSEMBLY

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REVISION RECORD

REVISION NUMBER	DATE OF REVISION	PAGES REVISED	REVISION REASON
1	7 SEP 99	All	Complete Re-write

Process Summary

Final Assembly includes the following process operations; a brief description of each operation is provided.

1. Storage of Fuel Rods
2. Transportation Carts
3. Rod Loading Magazines
4. Fuel Assembly Loader
5. Overhead Trolley Crane System
6. Fuel Assembly Wash and Vacuum Pits
7. Channel Spacing Pit
8. Fuel Assembly Storage
9. Final Inspection Pit

STORAGE OF FUEL RODS

The finished fuel rods range in length from approximately 136 to 178 inches. The nominal outer diameter of the fuel rods varies from .361 to .440 inches. These rods are stored in aluminum fuel rod storage channels. The channels are either 156 or 180 inches in length, 9.75 inches in width and 4.50 inches in depth. The storage channels, which are open at both ends, are fitted with aluminum end covers prior to transport to the Frazier racks, where they are stored unless they are transported directly to final assembly. Welded to the bottom of the channels are fork lift sleeves which extend 3.25 inches beneath the bottom of the channel. The Frazier racks allow the horizontal storage of four channels in each storage position. The arms of the racks have a 17.75 inch vertical separation which maintains > 12 inches vertical edge-to-edge separation between the storage channels stacked in each storage position. There are ten shelves on the racks, allowing ten vertical storage positions.

TRANSPORTATION CARTS

After fuel rods pass final inspection, they are loaded into fuel rod storage channels. When the channel is filled, it is either taken on a transportation cart directly to Final Assembly, or, more commonly, temporarily stored in the Frazier racks. The channels are either 156 or 180 inches in length, 9.75 inches in width and 4.50 inches in depth. The storage channels, which are open at both ends, are fitted with aluminum end covers. Welded to the bottom of the channels are fork lift sleeves which extend 3.25 inches beneath the bottom of the channel. Only one channel is allowed per transfer cart. A pair of triangular "dimples" on each end of the cart define the position of the channel on the cart and serve to prevent stacking two channels horizontally in the same cart. The transportation carts are designed to maintain a minimum 12-inch spacing side-to-side between adjacent channels. End-to-end spacing is maintained by administrative control.

The carts have a flip-up/flip-down feature which allows changing the rod storage channel elevation from the QC inspection block height (0 inches) to that needed for loading rods into magazines (+4 inches).

ROD LOADING MAGAZINES

Fuel rods transported to the Final Assembly Area on transportation carts are manually loaded into horizontal storage magazines. In the magazines, the rods are loaded into stainless steel tubes. These tubes are arranged to match the geometry of the fuel assembly into which the rods will be inserted. A second variety of magazine contains nylon block rod guides instead of stainless steel tubes. Each magazine is surrounded by a stainless steel shell approximately 0.25 inches thick which is open on the sides in a region 3.5 inches above the base and 3.5 inches below the top. Extending from the base of each magazine are 4 U-shaped weldments which have holes in them to align the magazine with the assembly loader by mating with pins. A pair of triangular "dimples" (or brackets, depending on type) at each end of the magazine carts prescribe the magazine's position and prevent two magazines from being stacked horizontally on the same cart. The magazine carts are designed to maintain a minimum 12-inches spacing side-to-side between adjacent magazines.[1] End-to-end spacing is maintained by administrative control.

FUEL ASSEMBLY LOADER

After performing computer transactions to verify that the rods are placed in the correct pattern based on the Bill of Material, the magazine is affixed adjacent to a fuel assembly loader. From the loaded rod magazine, the rods are pulled into a fixtured skeleton assembly to form a fuel assembly. The fuel assembly is completed by installing the top nozzle, lock tubes, bottom nozzle, and thimble screws.

ASSEMBLY OVERHEAD TROLLEY CRANE SYSTEM

Following inspection in the fuel assembly loader, the assembly is raised to the vertical position and moved by a system of overhead trolley cranes on monorails. The overhead trolley crane system is a passive engineered control for all processes prior to fuel assembly storage. The design of the trolley crane system allows two assemblies to get no closer than 30 inches centerline-to-centerline. At any point where the assembly must wait while attached to the overhead trolley crane system, it is lowered to rest vertically on a stainless steel floor pad. The trolley cranes are able to transport assemblies to the fuel assembly envelope inspection fixture, the wash and vacuum pits, the inspection station,

[1] Note: dimensions addressed in this section refer to distances between fissile material.

and the channel spacing pit. This section covers generic trolley crane operations, the fuel assembly envelope inspection fixture, and the inspection station.

FUEL ASSEMBLY WASH AND VACUUM PITS

Following envelope inspection, the fuel assemblies in the overhead trolley crane system are queued for submersion into a series of 3 tanks: wash, center rinse, and final rinse. This process removes debris which may contribute to fuel failure at the reactor site and improves their cosmetic appearance before shipping. After final rinse, the assemblies are moved to the vacuum pits for further cleaning and water removal. In the wash tanks, the assemblies are submerged in water, resulting in full interstitial moderation and full external moderation.

CHANNEL SPACING PIT

After washing, cleaning and inspection, certain assemblies may be moved on the overhead trolley crane system to the channel spacing pit for further inspections, or to have alignment pins welded to the top nozzle. The channel spacing pit has four openings in which assemblies may be inserted. Each opening is > 12 inches from any other. Assemblies are lowered until they contact an elevated base pad in the pit and then raised 2 inches. No more than one assembly is allowed in the pit if there is visible moisture beneath the base pads. The assemblies are dry inside the pit.

FUEL ASSEMBLY STORAGE

After QC inspection, assemblies are wrapped in fire-retardant bags and stored in "trees" to await loading into shipping containers. The bags are waterproof and open at the bottom of the assembly such that any water in the assembly would drain out through the bottom nozzle. The storage "trees" consist of a central pole and 4 storage locations with bottom base plates and top clamps to secure each assembly in a prescribed location. These structures maintain a minimum of 12 inches edge-to-edge spacing between assemblies.

FINAL INSPECTION PIT

Fuel assemblies are inserted into the final inspection pit for inspection immediately prior to loading into shipping containers. In the final inspection pit, the flame retardant bag is removed and a protective yellow translucent bag is put on. The protective bag is open at the bottom to allow any moisture to drain out the bottom nozzle. The final inspection pit contains a storage "tree" which consists of a central pole and 4 storage locations with a bottom base plate and top clamps to secure each assembly in a prescribed location. These structures maintain a minimum of 12 inches edge-to-edge spacing between assemblies.

Procedures and Drawings

Key procedures and drawings for the Final Assembly Area are identified in the tables below:

MANUFACTURING OPERATING PROCEDURES

Document Number	Document Title
MOP-500201	Fuel Assembly Wash Tank
MOP-730102	Load Fuel Rods into Skeleton Assembly - Pull Loaded Assemblies
MOP-730103	Fixture Skeleton Assembly
MOP-730104	Fixture Magazine
MOP-730105	Remove Assembly from Fixture
MOP-730106	Fixture Skeleton Assembly and Magazine - Pull Loaded Assemblies
MOP-730108	Fixture Bottom Nozzle to Assembly
MOP-730109	Fixture Top Nozzle - Welded Top Nozzle Assemblies
MOP-730110	Weld Top Nozzle to Assembly
MOP-730112	Prep Top Nozzle to Grid Sleeve/Thimble Weld Sample
MOP-730152	Crimp Thimble Screws - Reconstitutable Fuel Assembly
MOP-730209	Install Guide Pins into Top Nozzle
MOP-730502	Fuel Assembly Cleaning - General
MOP-730503	Fuel Assembly Vacuuming and Clean Check
MOP-730601	Load Rods in Magazine
MOP-730708	Moving Fuel Assembly In and Out of Storage Racks
MOP-730712	Wrap Fuel Assembly or Skeleton for Storage or Shipment
MOP-730752	Final Cosmetic Check
MOP-730808	Remove Guide Pins from Top Nozzle - XL
MOP-730809	Insert Lock Pins into Top Nozzle & Weld - XL
MOP-730905	Stamp Weight on Dummy Fuel Assembly
MOP-732401	Fuel Assembly Tilt Alignment
MOP-732501	TIG Manual Welding - General
MOP-735202	Replace Bottom Grid/Bottom Nozzle or Adjust Nozzle Parallelism
MOP-735301	General Handling Instructions for Skeleton Assemblies
MOP-735303	General Operating Procedure - Fuel Assembly Area
MOP-735472	RAMS Terminal Operation - Final Assembly

Document Number	Document Title
MOP-735473	Rework Grid Deviations - General
MOP-735475	Rework/Adjust Top Nozzle Guide Pins - XL
MOP-735502	Handling Fixture Procedure
MOP-735504	Position F/A into Final Assembly Fixture - Final Assembly
MOP-735505	Criticality Control
MOP-735507	Check/Inspect and Adjust Nozzle "S" Holes - Chamfer and/or Straight Section
MOP-735701	Rework Scratches
MOP-735903	Remove Damaged Dimple from Fuel Assembly
MOP-735906	Remove Top Nozzle - 16X16 WTN Design
MOP-735908	Removal of Small Visual Defects from Zircaloy Components
MOP-735910	Removal & Reinsertion of Fuel Rods in a Fuel Assembly
MOP-735911	Removing Rust on Stainless Steel, Inconel, & Zirc Components
MOP-735919	Ream Top Nozzle Thimble Location
MOP-735926	Blend Nicks & Gouges on Machined Components and Cleaned Assemblies
MOP-735939	Reset Lock Tube Position
MOP-735940	Rework Bent or Distorted Top Nozzle Inserts
MOP-735941	Loading Fuel Rods with Strippen End Plugs - Rework
MOP-736505	Process Materials - Fuel and Skeleton Assembly
MOP-737001	Remove Bottom Nozzle - Welded Design & Reconstitutable
MOP-737008	Remove (RTN) Top Nozzle Assembly
MOP-737009	Install (RTN) Top Nozzle Assembly
MOP-737010	Assemble Pin/Center Screw and Locking Cup
MOP-737015	Crimp Thimble Screws - VVER-1000
MOP-737016	Fixture Bottom Nozzle to Assembly - VVER-1000
MOP-737017	Fixture Skeleton Assembly and Magazine - VVER-1000
MOP-737018	Load Fuel Rods into Skeleton Assembly - VVER-1000
MOP-737019	Remove Assembly from Fixture - VVER-1000
MOP-737020	Install Top Nozzle Assembly - VVER-1000
MOP-737021	Operation of VVER-1000 Top Nozzle Manipulator

REFERENCE DRAWINGS

Drawing Number (s)	Equipment
N/A	Rod Channel Storage Rack
SKF-90040	Rod Channel Cart Modification
SKC-86005	Fuel Rod Storage Channel (XL)
1962F21	Fuel Rod Magazine Assembly

448F03EQ11 448F09FX04 C639F987 SKF-96299 SKF-96280	VVER-1000 Fuel Rod Magazine Generic Fuel Rod Magazine 16x16 Fuel Rod Magazine Assembly XL Fuel Rod Magazine Fuel Rod Magazine (w/ nylon spacers)
SKF-91117	Fuel Rod Magazine Cart (TVA)
3TN-3051-F	"Coffing" Hoist Crane (1 Ton Capacity)

FINAL ASSEMBLY EQUIPMENT

Drawing Number (s)	Equipment
448F03EQ14 448F03EQ05 448F03EQ10 SKF-94014 SKF-94020 SKF-94139 SKF-94142 SKF-90008 SKF-91075 SKF-92056 SKF-96206 SKF-88053 C639F936	Fuel Assembly Loader(s)/Strongback(s)
TDMJ46228F-3 (SKE95TB-1)	Fuel Assembly Envelope Inspection Fixture
SKB-587	Round Fuel Assembly Wash Tank for Columbia (20-inch diameter, 228-inch depth)
SKB-854	Rectangular Fuel Assembly Wash Tank - Columbia (20-inch x 35-inch x 228-inch)
SKA-583	Fuel Assembly Wash Pit Layout for Columbia
448F17EQ03 448F03EQ04 C883D607 SKF-94147	Fuel Assembly Storage Rack F/A Storage Rack Interface Ft. Calhoun and B&W Fuel Assembly Storage Rack F/A Storage Rack Drive

Environmental Protection and Radiation Safety Controls

To be provided in a future Integrated Safety Assessment.

STORAGE OF FUEL RODS

Control Parameters and Safety Limits

Control Parameters
- Moderation
- Geometry
- Spacing

Safety Limits
- See Margin of Safety

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

Controls

Safety Significant Controls

- None

Margin of Safety

The nuclear criticality margin of safety for the rod storage system is evaluated to be very strong. The parameters which directly affect neutron multiplication in the rod storage system are geometry, spacing and moderation. Criticality would be possibly in the rod storage system if there was a failure of multiple passive engineered controls on spacing and geometry combined with sufficient moderation. This evaluation has determined criticality in the rod storage system to be not credible.

The design of the Frazier racks is described in Regulatory Affairs Review Request #104-1-591. The rack arrangement furnishes 17.75 inches of vertical separation between storage positions which provides > 12 inches edge-to-edge vertical separation between channels, with a maximum of four channels loaded horizontally in each storage location.

Calculations[2] performed on the Frazier rack demonstrated a 95/95 k_{eff} of 0.91614 for the most reactive case under the following conditions:
- Close-packed rods in a square lattice
- Rods completely filling a channel measuring 9.933 inches by 4.515 inches, failing conservatively to whole rods outside actual channel dimensions
- Full interstitial moderation with water

[2] CN-CRI 99-018 Frazier Racks Analyis

- Full external reflection (12 inches of water)
- Rods containing the most reactive pellet diameter (0.40 inch)
- Four channels in each storage location with a fifth channel "double stacked" in the center
- Channels infinite in length
- Frazier rack infinite in height

These conditions are extremely conservative. The rods, as found in the storage channels, are in a close-packed triangular or hexagonal pitch, which is a less reactive arrangement than the assumed square pitch. Full interstitial moderation is very unlikely due to the construction of the storage channels. The channels are open at each end and the end covers are not water tight. Full external reflection is not credible. In order to surround the lowest storage location on the Frazier rack with 12 inches of water, the depth of water in the entire facility would need to be 32 inches. Further, the "double stacking" of a single channel in a single storage location requires extreme skill and precision by the operator. The fork lift sleeves are the same width as the channel and would have to serve as "feet" for a double stacked channel. It is unlikely that a channel could be balanced on its "feet" in such a scenario. Additionally, the fork lift sleeves make the effective height of the channel 7.75 inches, which is a tight fit in an 8.0 to 8.5 inch space with a fork lift. It is not credible to expect double stacking, much less, repetitive double stacking.

TRANSPORTATION CARTS

Control Parameters and Safety Limits

<u>Control Parameters</u>

- Moderation
- Geometry
- Spacing

<u>Safety Limits</u>

- See Margin of Safety

Bounding Assumptions

- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

Controls

<u>Safety Significant Controls</u>

- None

Margin of Safety

The nuclear criticality margin of safety for the transportation carts is evaluated to be very strong. The parameters which directly affect neutron multiplication are geometry, spacing and moderation. A nuclear criticality would be possible in the case of multiple failures of passive engineered controls on geometry and configuration combined with sufficient moderation. This evaluation has determined nuclear criticality to be not credible for this system.

Calculations[3] on the transportation carts demonstrated a maximum 95/95 k_{eff} of 0.89834 under the following conditions:

- Close-packed rods in a square lattice
- Full interstitial moderation with water
- Full external reflection
- Most reactive pellet diameter (0.40 inch)
- An infinite slab, 17 rods high

These conditions are extremely conservative. The rods, as found in the storage channels, are in a close-packed triangular or hexagonal pitch, which is a less reactive arrangement than the assumed square pitch. Full interstitial moderation is unlikely due to the construction of the storage channels. The channels are open ended and the end covers are not water tight. Full external reflection is even less likely. In order to surround the storage location on the transportation cart with 12 inches of water, the depth of water in the entire facility would need to be 52-56 inches. The elevation difference possible for channels on the storage carts is 4 inches. If two channels were overlapped end-to-end, the resulting total channel height for the two would be eight inches. The design of the carts does not permit the channels to overlap in a single vertical plane; therefore, this is NOT a slab 8 inches high, but two finite 4.5-inch slabs next to one another, overlapping in a horizontal plane by the thickness of approximately one rod. Additionally, the maximum end-to-end overlap is 24 inches. Therefore, this finite slab with a single rod overlap in the horizontal plane is extremely conservatively bounded by an infinite slab 17 rods high.

ROD LOADING MAGAZINES

Control Parameters and Safety Limits

Control Parameters
- Moderation
- Geometry
- Spacing

Safety Limits
- See Margin of Safety

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation

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[3] CRI-90-002, Fuel Rod Channel Criticality Evaluation

- Partial Reflection

Controls

Safety Significant Controls

- None

Margin of Safety

The nuclear criticality margin of safety for the storage magazines is evaluated to be very strong. The parameters which directly affect neutron multiplication are geometry, spacing and moderation. A nuclear criticality would be possible in the case of multiple failures of passive engineered controls on geometry and spacing combined with sufficient moderation. This evaluation has determined nuclear criticality to be not credible for this system.

Calculations[4] on an assembly magazine demonstrated a maxi.num 95/95 k_{eff} of 0.97970 under the following conditions:

- A finite array of 6 magazines overlapping end-to-end 84 inches
- Magazines 3.5 inches apart in the overlapping region
- 5 w/o UO_2 fuel
- Full interstitial moderation with water
- One inch external reflection
- Most reactive fuel assembly lattice manufactured at CNFD (17OFA)
- No IFBA rods
- Longest fuel manufactured at CNFD (XL, 14 feet)

These conditions are extremely conservative. The placement of six carts overlapping end-to-end in a finite array is not credible. The nature of the work space where magazines are loaded and moved to fuel assembly loaders does not encourage operators to bring magazine carts near one another. The assembly loaders are more than 8 feet apart and magazine carts tend to be staged near the end of the fixture into which the rods will be loaded. Carts placed close to one another would congest the work area. The magazines are centered on their carts. Alignment markings are provided to assist operators in centering the magazines. When the longest assembly magazine is centered on shortest cart, the maximum overlap at each end would be 41 inches. 47 inches is chosen as a credible process upset to indicate a six-inch displacement from a centered position. An 84-inch overlap is not credible because a displacement of the magazine from the center of a cart to a point which would allow an 84-inch overlap would upset the cart. The 3.5-inch separation is also conservative. The closest the weldments will allow two magazines to come together is 3.75 inches. Full interstitial moderation is not credible for the magazines. The top of the magazines are not open. The sides of the magazines are open and would drain any water which might be introduced to a maximum level of 3.5 inches inside the magazine. External reflection is also not credible. There would have to be at least 56 inches of water in the facility before a loaded magazine could be surrounded by

[4] CN-CRI-99-017 Final Assembly Magazine Overlap Analysis

moderator. The most reactive lattice and the longest fuel are modeled with no IFBA rods. The assembly magazines are dry and greater than 12 inches from one another in normal operations. For reference, the 95/95 k_{eff} of a dry 17OFA/XL assembly in the nylon magazine is calculated at 0.30886.[5]

FUEL ASSEMBLY LOADER

Control Parameters and Safety Limits

<u>Control Parameters</u>

- Moderation
- Geometry
- Spacing

<u>Safety Limits</u>

- See Margin of Safety

5.3.4.7 Bounding Assumptions

- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

5.3.4.8 Controls

<u>Safety Significant Controls</u>

- None

Margin of Safety

The nuclear criticality margin of safety for the fuel assembly loader is evaluated to be very strong. The parameters which directly affect neutron multiplication are geometry, spacing and moderation. A nuclear criticality would be possible in the case of multiple failures of passive engineered controls on geometry and spacing combined with sufficient moderation. This evaluation has determined nuclear criticality to be not credible for this system.

Calculations[6] on an assembly demonstrated a maximum 95/95 k_{eff} of 0.93022 under the following conditions:

- 5 w/o UO_2 fuel
- Full interstitial moderation with water
- One inch external reflection
- Most reactive fuel assembly lattice manufactured at CNFD (17OFA)
- No IFBA rods
- Longest fuel manufactured at CNFD (XL, 14 feet)

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[5] CRI-97-019, Criticality Safety Analysis of the Assembly Magazine
[6] CRI-97-019, Criticality Safety Analysis of the Assembly Magazine

- Cladding gap flooded

These conditions are extremely conservative. Full interstitial moderation is not credible for assemblies in the fuel assembly loaders. The assembly is open and free to drain out any moderator. External reflection is also not credible. There would have to be 56 inches of water in the facility before an assembly in a loader could be surrounded by moderator. The most reactive lattice and the longest fuel are modeled with no IFBA rods. Additionally, there is no credible mechanism for achieving flooding in the cladding gap of the fuel in the magazine. For reference, the 95/95 k_{eff} of a dry 17OFA/XL assembly in the nylon magazine is calculated at 0.30886.

ASSEMBLY OVERHEAD TROLLEY CRANE SYSTEM

Control Parameters and Safety Limits

Control Parameters
- Moderation
- Geometry
- Spacing

Safety Limits
- See Margin of Safety

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

Controls

Safety Significant Controls

- None

Margin of Safety

The nuclear criticality margin of safety for the overhead trolley crane system is evaluated to be very strong. The parameters which directly affect neutron multiplication are geometry, spacing and moderation. A nuclear criticality would be possible in the case of failure of passive engineered controls on geometry and spacing combined with sufficient moderation. This evaluation has determined nuclear criticality to be not credible for this system.

Calculations[7] on an assembly demonstrated a maximum 95/95 k_{eff} of 0.93022 under the following conditions:
- 5 w/o UO_2 fuel

[7] CRI-97-019, Criticality Safety Analysis of the Assembly Magazine

- Full interstitial moderation with water
- One inch external reflection
- Most reactive fuel assembly lattice manufactured at CNFD (17OFA)
- No IFBA rods
- Longest fuel manufactured at CNFD (XL, 14 feet)
- Cladding gap flooded

These conditions are extremely conservative. Full interstitial moderation is not credible for the vertical fuel assemblies in the trolley crane system. The assembly is fully open and any moderator introduced would drain through the bottom nozzle. After the assembly is wrapped in the protective bag, the bag is open at the bottom to allow drainage of moderator out of the bottom nozzle. External reflection is also not credible. There would have to be 12 to 14 feet of water in the facility before a vertical fuel assembly could be surrounded by moderator. The most reactive lattice and the longest fuel are modeled with no IFBA rods. Additionally, there is no credible mechanism for achieving flooding in the cladding gap of a fuel assembly in the trolley crane system. For reference, the 95/95 k_{eff} of a dry 17OFA/XL assembly in the nylon magazine is calculated at 0.30886.

FUEL ASSEMBLY WASH AND VACUUM PITS

Control Parameters and Safety Limits

Control Parameters
- Geometry
- Spacing

Safety Limits
- See Table 1

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation
- Full Reflection

Controls

Safety Significant Controls

Passive engineered controls (PEC)

Passive engineered controls are described in License SNM-1107 and in Regulatory Affairs Procedure RA-108. The requirements for functional verification are determined by this evaluation.

Control ID	Control Function/ Failure Condition/ Action	Procedure Number	Funct. Verif. Required	Initiating Event (IE) No.
P-WT-1	Overhead trolley crane design prevents <30 inches centerline-to-centerline (<20.7 inches edge-to-edge) spacing between assemblies/ Assembly spacing <12 inches edge-to-edge (Failure not credible)/ Overhead trolley crane design prevents <30 inches centerline-to-centerline spacing between assemblies.	N/A	No	IE #1a,b,c,d,e

Active engineered controls (AEC)

Active engineered controls are defined in License SNM-1107 and in Regulatory Affairs Procedure RA-108. They are also called safety-significant interlocks. The requirements for functional verification are defined in Procedure RA-108 and/or area operating procedures.

- None

Administrative controls with computer or alarm assist (AC)

Administrative controls with computer or alarm assist typically consist of operator actions which are prompted or assisted by computer output. The requirements for functional verification are determined by this evaluation.

- None

Administrative controls

Safety-significant administrative controls are required operator actions which usually occur without prompting from a computer/ control panel alarm or indication. These controls may require documentation via Control Form or some other record. Functional verification is not normally required.

Control ID	Control Function/ Failure Condition/ Action	Procedure Number	Funct. Verif. Required	Initiating Event (IE) No.
A-WT-1	Procedure directs operator to not move a failed trolley crane/ Operator moves a failed trolley crane after an assembly is dropped/ Procedure directs operator to not move a failed trolley crane.	MOP-730502	No	IE#2

A-WT-2	Procedure directs operator to not position a second assembly over the center rinse tank / Operator moves a failed trolley crane and positions second assembly over the center rinse tank/ Procedure directs operator to not position a second assembly over the center rinse tank.	MOP-730502	No	IE#3
A-WT-3	Procedure directs operator to not lower a second assembly into the center rinse tank / Operator moves a failed trolley crane, positions a second assembly over the center rinse tank and lowers a second assembly into the center rinse tank/ Procedure directs operator to not lower a second assembly into the center rinse tank.	MOP-730502	No	IE#4

Margin of Safety

The nuclear criticality margin of safety for the wash tanks is evaluated to be strong. The parameters which directly affect neutron multiplication are geometry, spacing and moderation. A nuclear criticality would be possible in the case of failure of passive engineered controls on spacing combined with violation of administrative controls.

The only credible location where nuclear criticality could be achieved in the wash tanks area is in the center rinse tank. The possibility of two assemblies being placed in the center rinse tank is highly unlikely, but cannot be regarded as not credible.

For the wash tank and final rinse tank, it was determined that nuclear criticality was not credible. Nuclear criticality is only possible if two assemblies are able to be submerged less than 4 inches from one another in the tank. It is not credible for 2 assemblies to be placed in these tanks for the following reasons:

- The overhead trolley cranes provide 30 inches centerline-to-centerline spacing. The diameter of these cylindrical pits is 20 inches.
- The top of each tank has a square sparger for water and/or air which measures 13.5 inches x 13.5 inches. The smallest base dimension of a fuel assembly manufactured at CNFD is 7.756 x 7.756 inches. Two assemblies will not fit through the sparger.

Summary Of Initiating Events Which Lead To Credible Process Upsets

Failure of trolley crane allowing an assembly to fall into the center rinse tank:

IE #1a Failure of latch plate.

IE #1b Failure of clasp.

IE #1c Failure of chain.

IE #1d Failure of crane motor.

IE #1e Failure of monorail.

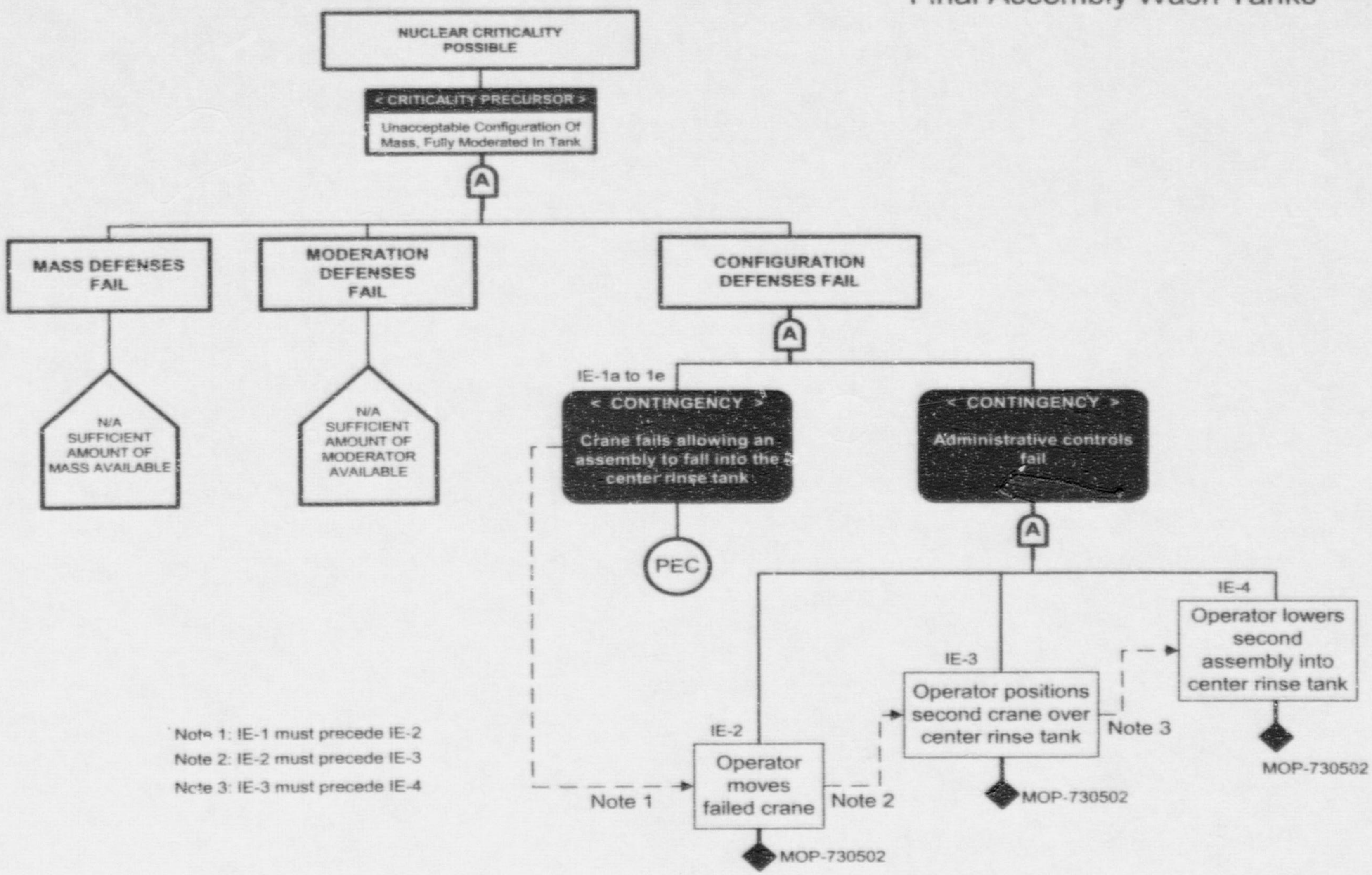
Failure to prevent a second assembly from being inserted in the center rinse tank:
IE #2 Operator moves failed trolley crane.
IE #3 Operator positions second trolley crane over center rinse tank.
IE #4 Operator lowers second assembly into center rinse tank.

Table 1 Nuclear Criticality Safety Limits for k_{eff} 0.95 and 0.98 for the Wash Tanks

Parameter	Normal Operating Conditions	Bounding Assumption	Criticality Safety Limit ≤ 0.95	Criticality Limit ≤ 0.98
^{235}U MASS	19-28 kg ^{235}U per assembly	Most reactive fuel design		
MODERATOR/ CONCENTRATION	Full interstitial moderation	Full interstitial moderation		
GEOMETRY	Rods in a fuel assembly; either a square or hexagonal pitch lattice	Rods in a fuel assembly; either a square or hexagonal pitch lattice		
SPACING	30-inch centerline-to-centerline spacing	12-inch edge-to-edge spacing	Not Applicable	6 inches or less edge-to-edge spacing
DENSITY	UO_2 95±0.5% theoretical density	UO_2 96.5% theoretical density		
ABSORBERS	If > 4.65w/o ^{235}U , minimum of either 16 2x or 32 1x IFBA rods (B-10 absorber)	None	5.00 w/o ^{235}U and <16 2x or <24 1.5x or <32 1x IFBA rods or 4.65 w/o ^{235}U with no IFBA rods	None
ENRICHMENT	≤5.0 w/o ^{235}U	5.0 w/o ^{235}U	See absorber	
REFLECTION	Full reflection	Full reflection		

FIGURE 1

Final Assembly Wash Tanks



Note 1: IE-1 must precede IE-2
Note 2: IE-2 must precede IE-3
Note 3: IE-3 must precede IE-4

CHANNEL SPACING PIT

Control Parameters and Safety Limits

Control Parameters
- Moderation
- Geometry
- Spacing

Safety Limits
- See Margin of Safety

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

Controls:

Safety Significant Controls

- None

Margin of Safety

The nuclear criticality margin of safety for the rod channel spacing pit is evaluated to be very strong. The parameters which directly affect neutron multiplication in the channel spacing pit are geometry, spacing and moderation. Nuclear criticality would be possibly in the channel spacing pit if there was a failure of multiple passive engineered controls on spacing and geometry combined with sufficient moderation. This evaluation has determined nuclear criticality in the channel spacing pit to be not credible.

The design of the channel spacing pit allows four assemblies to be lowered into fixed locations which provide a minimum of 12 inches edge-to-edge spacing. The base pads are elevated above the bottom of the pit. By procedure, the operator lowers an assembly until it contacts the base pad and then elevates it approximately two inches before fixing the assembly in a fixture.

Calculations[8] on an assembly demonstrated a maximum 95/95 k_{eff} of 0.93022 under the following conditions:

- 5 w/o UO_2 fuel
- Full interstitial moderation with water
- One-inch external reflection
- Most reactive fuel assembly lattice manufactured at CNFD (17OFA)
- No IFBA rods

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[8] CRI-97-019, Criticality Safety Analysis of the Assembly Magazine

- Longest fuel manufactured at CNFD (XL, 14 feet)
- Cladding gap flooded

These conditions are extremely conservative. Full interstitial moderation and reflection are not credible in the channel spacing pit. The assembly is dry. For reference, the 95/95 k_{eff} of a dry 17OFA/XL assembly in the nylon magazine is calculated at 0.30886.

FUEL ASSEMBLY STORAGE

Control Parameters and Safety Limits

Control Parameters
- Moderation
- Geometry
- Spacing

Safety Limits
- See Margin of Safety

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

Controls

Safety Significant Controls

- None

Margin of Safety

The nuclear criticality margin of safety for assembly storage is evaluated to be very strong. The parameters which directly affect neutron multiplication in the assembly storage area are geometry, spacing and moderation. Nuclear criticality would be possibly in the event of failure of multiple passive engineered controls on spacing and geometry combined with sufficient moderation. This evaluation has determined nuclear criticality in the assembly storage area to be not credible.

The design of the assembly storage "trees" places four assemblies in fixed locations which provide a minimum of 12 inches edge-to-edge spacing. The fire retardant bag which wraps the assemblies is open at the bottom nozzle to allow drainage.

Calculations[9] on an assembly demonstrated a maximum 95/95 k_{eff} of 0.93022 under the following conditions:
- 5 w/o UO_2 fuel

[9] CRI-97-019, Criticality Safety Analysis of the Assembly Magazine

- Full interstitial moderation with water
- One inch external reflection
- Most reactive fuel assembly lattice manufactured at CNFD (17OFA)
- No IFBA rods
- Longest fuel manufactured at CNFD (XL, 14 feet)
- Cladding gap flooded

These conditions are extremely conservative. Full interstitial moderation and reflection are not credible in the assembly storage area. The assembly is dry. For reference, the 95/95 k_{eff} of a dry 17OFA/XL assembly in the nylon magazine is calculated at 0.30886.

FINAL INSPECTION PIT

Control Parameters and Safety Limits

Control Parameters
- Moderation
- Geometry
- Spacing

Safety Limits
- See Margin of Safety

Bounding Assumptions
- Heterogeneous UO_2
- Full Interstitial Moderation
- Partial Reflection

Controls

Safety Significant Controls

- None

Margin of Safety

The nuclear criticality margin of safety for final inspection pit is evaluated to be very strong. The parameters which directly affect neutron multiplication in the final inspection pit are geometry, spacing and moderation. Nuclear criticality would be possibly in the event of failure of multiple passive engineered controls on spacing and geometry combined with sufficient moderation. This evaluation has determined nuclear criticality in the final inspection pit to be not credible.

The design of the final inspection pit "trees" places four assemblies in fixed locations which provide a minimum of 12 inches edge-to-edge spacing. The protective bag which wraps the assemblies is open at the bottom nozzle to allow drainage.

Calculations[10] on an assembly demonstrated a maximum 95/95 k_{eff} of 0.93022 under the following conditions:

- 5 w/o UO_2 fuel
- Full interstitial moderation with water
- One inch external reflection
- Most reactive fuel assembly lattice manufactured at CNFD (17OFA)
- No IFBA rods
- Longest fuel manufactured at CNFD (XL, 14 feet)
- Cladding gap flooded

These conditions are extremely conservative. Full interstitial moderation and reflection are not credible in the final inspection pit. The assembly is dry. For reference, the 95/95 k_{eff} of a dry 17OFA/XL assembly in a nylon magazine is calculated at 0.30886.

[10] CRI-97-019, Criticality Safety Analysis of the Assembly Magazine