70-1100

RETURN TO ~~396-SS~~ P1-137

COMBUSTION ENGINEERING

July 28, 1988
LD-88-064

License No. SNM-1067
Docket 70-1100

Mr. L. C. Rouse
Fuel Cycle Safety Branch
Division of Fuel Cycle, Medical,
Academic and Commercial Use Safety
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: License SNM-1067 Amendment Request

References: (A) Letter, P. L. McGill (C-E) to L. C. Rouse (NRC), dated January 20, 1988

(B) Letter, George H. Bidinger (NRC) to P. L. McGill (C-E), dated July 7, 1988

Dear Mr. Rouse:

Reference (A) requested U. S. Nuclear Regulatory Commission approval of an amendment to the Combustion Engineering Windsor Fuel Fabrication Facility license to increase the weight percent of enriched uranium that can be processed from $\leq$ 4.1% to $\leq$ 5.0% U-235.

Questions raised during the review of the license amendment were discussed with C-E representatives on June 29, 1988, and resulted in a request for additional information [Reference (B)]. Subsequently, a meeting was held on July 25, 1988, to discuss our proposed responses.

This letter transmits the additional information and clarifications requested. Enclosure (1) provides a tabulation of affected pages and their respective revision numbers. Enclosure (2) provides the proposed change pages supporting our amendment request. Three copies of the enclosures are included for your use.

FEE NOT REQUIRED
Supplemental info.

OF03
1/1

Power Systems
Combustion Engineering, Inc.

1000 Prospect Hill Road
Post Office Box 500
Windsor, Connecticut 06095-0500

(203) 688-1911
Telex: 99297

24571

In order to support our existing commitments Combustion Engineering requests that if at all possible the remaining review of this license amendment be performed such that approval can be granted on or before August 15, 1988. Your attention to this important matter is very much appreciated. If I can be of any additional assistance, please feel free to call on me.

Very truly yours,

COMBUSTION ENGINEERING, INC.

A. E. Scherer
Director
Nuclear Licensing

AES:ss

Enclosures: As Stated

DOCKET NO. 70-1100

CONTROL NO. 24571

DATE OF DOC. July 28, 1988

DATE RCVD. August 4, 1988

FCUF ✓ PDR ✓

FCAF ✓ LPDR

I & E REF. ✓

SAFEGUARDS ✓

FCTC OTHER

DATE 8/4/88 INITIAL Elc

Docket No. 70-1100

License No. SNM-1067

ENCLOSURE 1

COMBUSTION ENGINEERING, INC.

WINDSOR FUEL FABRICATION FACILITY

REQUEST FOR LICENSE AMENDMENT

LIST OF AFFECTED PAGES

WINDSOR FUEL FABRICATION FACILITY

REQUEST FOR LICENSE AMENDMENT

Combustion Engineering requests that the license (SNM-1067) for its Windsor Fuel Fabrication Facility be amended to increase the weight percent of enriched uranium that can be processed from ≤4.1% to ≤5.0%. The license pages affected by this amendment and their respective revision numbers are listed below. The proposed change pages are provided in Enclosure 2.

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PART I LICENSE CONDITIONS

SECTION

Docket No. 70-1100
License No. SNM-1067

ENCLOSURE 2
COMBUSTION ENGINEERING, INC.
WINDSOR FUEL FABRICATION FACILITY
REQUEST FOR LICENSE AMENDMENT
PROPOSED LICENSE CHANGE PAGES

JULY 1988

1.3 License Number

Activities are covered by the License SNM-1067; Docket 70-1100.

1.4 Possession Limits & Location

Combustion Engineering, Inc., requests authorization to receive, use, possess, store and transfer at its Windsor site, the following activities of radioactive materials.

	Isotope	Form	Quantity	Location
1) *	Uranium enriched to ≤5.0% weight percent U235 *	Uranium Oxides	500,000 Kg U	Manufacturing-Bldgs. #17 & #21 & storage in trailers adjacent to Bldgs. #17 & #21. Bldg 1, 1A, 2, 2A, 8, 3A, 5, 6, 16 and 18.
2)	Uranium enriched to less than 20 weight percent U235 *	Any	4800 gms U^{235}	Bldg. 1, 1A, 2, 2A, 3, 3A, 8, 6, 16, 17, 18 & 21 (Bldg. 17 & 21 limited to 350 gm U235 each for enrichments exceeding 5.0 weight percent U235).
3)	Natural and/or Depleted Uranium	Any	10,000 KgU	Bldg. 1, 1A, 2, 2A, 3, 3A, 5, 6, 16, 17, 18 & 21
4)	Pu238	Encapsulated Neutron Sources	5 sources, each containing less than 2.0 gm Pu238	Building #17
5)	Pu	Any Form	160 micrograms as analytical samples	Bldg. 1, 1A, 2, 2A, 3, 3A, 5, 6, 16, 17, 18 & 21
6)	Encapsulated Neutron sources	U_3O_8	20 sources, each containing 1.7 gm U235	Bldg. 1, 1A, 2, 2A, 3, 3A, 5 6, 16, 17, 18 & 21
7)	Uranium enriched to or greater than 20 weight percent U235	Residue	1000 gms U235	Windsor Site

1.5 Section Deleted

1.6 Authorized Activities

The primary activities carried out in buildings at the Windsor site include, but are not limited to the following:

Bldg. #1 & 1A - Storage and use of small quantities of Radioactive

* Material ($\leq$740 GMS U235)

* Bldg. #2 & 2A - Product Development Activities. ($\leq$740 GMS U235)

Bldg. #3 & 3A - Storage of small quantities of Radioactive Material

* ($\leq$740 GMS U235)

Bldg. 5 - Product Development Activities.

Bldg. 6 - Waste water processing from manufacturing and product development activities.

* Bldg. 16 - Product Development Activities ($\leq$740 GMS U235)

Bldg. 17 - Manufacture of fuel assemblies utilizing low enriched

* uranium (up to 5.0 weight percent U235) in the form of uranium oxide powder, pellets, rods, and in assemblies.

* Bldg. 18 - Product Development Activities ($\leq$740 GMS U235)

Bldg. 21 - Storage of SNM in shipping containers.

Windsor Site - Residue from prior operations, not to exceed 350 gms U235 in any one location. Additional locations to be separated from one another by a minimum of 12 feet.

1.7 Exemptions and Special Authorizations

Licensed activities in Bldgs. 1, 1A, 2, 2A, 3, 3A, 5, 6, 16 and 18 shall first bank of absolute filters. The pressure drop for all systems shall be checked monthly and documented. When the face velocity at a ventilated hood drops below 100 fpm, the hood filters or ventilation system filters will be changed, brushed, or knocked down to increase the air flow to 100 fpm minimum or the hood will not be used to handle radioactive material. Face velocities will be checked monthly in Product Development.

The filters in these stacks shall be tested either by 1) counting samples immediately after 1/2 hour of operation or 2) DOP testing the filters in accordance with ANSI standards. Such testing shall be done after all filter changes or movement of the filters to assure they are adequately filtering the exhaust air. The results of these tests shall be documented. Each ventilating filter system described in Section 3.2.3 shall be equipped with an instrument that measures the pressure drop continuously.

* 3.2.4 Instrumentation

Capabilities of radiation detection and measurement instrumentation shall be as follows:

Alpha Counting System	10 - 10,000 dpm
Alpha Survey Meters	0 - 50,000 counts per minute
Beta-Gamma Survey Instruments	.05 mR/hr - 200 mR/hr
Neutron Survey Instruments	.5 - 5,000 mrem/hr

A sufficient number of the instruments, meters and systems listed above shall be maintained operational to adequately conduct our Health Physics program. Additional instrumentation is maintained for emergency use as outlined in Part I Section 8. The detectors for the criticality alarm system are calibrated semi-annually and following any repair that affects the accuracy of the measurements. All other instruments are calibrated semi-annually and following any repair that affects the accuracy of the measurements. The calibration of the survey instruments shall meet the specifications described in Section 1.11 of Regulatory Guide 8.24, "Health Physics Survey During

Enriched Committee. He shall meet the minimum qualifications for a Nuclear Criticality Specialist and shall not be the initial reviewer.

As stated in section 4.1.3, all such approvals shall be recorded in a log maintained under the supervision of the Supervisor, Health Physics & Safety,

4.1.6 Marking and Labeling of SNM - All mass-limited containers shall be labeled is to enrichment and content. All geometry limited containers and processes are safe up to the maximum
* allowable enrichment of 5.0% U235.

* 4.1.7 Section Deleted

* 4.1.8 Section Deleted

4.2 Technical Requirements

4.2.1 Preferred Approach to Design - It is the intent of Combustion Engineering to use physical controls and permanently engineered safeguards on processes and equipment in the establishment of nuclear safety limits wherever practical. Use of administrative controls in the establishment of safety limits will be minimized.

4.2.2 Basic Assumptions and Analytical Methods - Written health and safety restrictions for all operations on radioactive material shall be provided in the form of approved Radiation Work Permits or approved detailed procedures, and appropriate operational limits shall be posted in the vicinity of work stations in both the manufacturing facility and Product Development. Each operation on fissile material in

* Building 5 shall be limited to 350 gm U235 for uranium

* enriched to more than 5.0% U235, and to 740 gms U235 for

* uranium enriched to $\leq$5.0% U235, as specified in Table 4.2.5 and

shall be separated from any other fissile material by 12 feet. Rods containing sintered UO2 pellets enriched to a maximum of
* 5.0% U235 shall be stored in Building #5. Slab storage
* in Building #5 shall be in accordance with Table 4.2.5.

A continuous log shall be maintained for each mass limited work station or storage area in Product Development to assure that the limit is maintained and that the enrichment of all material is recorded. No additional criticality controls are required for Product Development.

Criticality safety of the less complex manufacturing operations is based on the use of limiting parameters which are applied to simple geometries. Safe Individual Units (SIU) shall be selected from Table 4.2.5. These units shall be spaced using the surface density method.

The remaining manufacturing operations are evaluated using two dimensional transport and/or 3 dimensional Monte Carlo Codes. The sixteen group Hansen-Roach cross section library is used
* for homogeneous systems, while NITAWL and XSDRNPM are used to
* generate multigroup cross sections for heterogeneous systems. All calculational methods involving computer codes shall be validated in accordance with the criteria established in Regulatory Guide 3.4, "Nuclear Criticality Safety in Operations with Fissionable Materials at Fuels and Materials Facilities."

* - Optimum conditions of water moderation, reflection, and heterogeneity for the system shall be determined in all calculations.

- The analytical method(s) used for criticality safety analysis and the source of validation for the method(s) shall be specified.

- Safety margins for individual units and arrays shall be based on accident conditions such as flooding, multiple batching, and fire.

*

*4.2.4 A <u>Moderation Control</u>

* - For moderation control a maximum K_{eff} of 0.95 shall apply for validated computer calculations. The 0.95 K_{eff} value shall be reduced by (1) the applicable 2 sigma statistical uncertainty associated with Monte Carlo calculations and (2) the applicable uncertainties and bias associated with the bench marked calculations.

The basic assumptions used in establishing safe parameters for single units and arrays shall be as follows:

- Nuclear safety shall be independent of the degree of moderation between units up to the maximum credible mist density of 0.1% H_2O) (0.001 gm H_2Occ) as demonstrated in Sections 7.2.1 and 8.7.
- Criteria used in the choice of fire protection in areas of potential criticality accidents (when moderators are present) shall be
* justified in writing. An audit of the existing fire sprinkler
* system in building 17 (Figure 4.2.3) shall be conducted once a quarter (Sprinkler Heads, Risers, Distribution Lines, and Pumps) to see to it that it has not been modified or added to in any way that would impair its performance or have an effect on calculated mist density. All proposed changes to the fire sprinkler system, that
* could affect building 17 will be reviewed and approved in
* accordance with the procedures described in Section 2.7.2 as regards
* facility changes affecting criticality for their effect on mist density, before such changes are implemented.
- Plastic bags which are placed around the fuel assembly shall be left open at the bottom at all times including the period in which the
* assembly is in storage.

Combustible materials in the area shall be minimized at all times.

* - In any area where unsealed powder or randomly loaded pellet
* containers are exposed to the fire sprinkler system they will be
* assumed to fill with water. Hard scrap (pellets or pieces thereof)
* shall be assumed as optimally moderated.
* - Possible moderating material around fissile materials will be
* included in the analysis.

4.2.5 Limits for Safe Individual Units (SIU's)

Table 4.2.5

	Type of Limit	Maximum Limit
*	Pellet Shop	
*	Mass (powder or randomly loaded pellets in ≤ 5 gal containers)	35.0 kg's UO_2 ≤5.0% U235
*	Coplanar Slab (Powder/Pellet) (Pellets Randomly Loaded)	4.0" Maximum Height.
*	Coplanar Slab (Hexagonally stacked rods) (Sintered pellets up to 0.4" diameter) (Green pellets up to 0.43" diameter)	6.0" Maximum Height.
*	Hard Scrap	16.0 kg UO_2 ≤5.0% U235
*	Cold Shop	
*	Slab (Hexagonally stacked rods)	6.0" Maximum Height.
*	Fuel Assemblies	keff ≤ 0.90

	<u>Building 1, 1A, 2, 2A, 3A, 16, and 18</u>	
*	Mass	740 gms U235 ≤5%
*	<u>Building 5</u>	
*	Mass in each designated area	350 gms U235 ≥5.0 wt% enrichment
*	Mass in each designated area	740 gms U235 ≤5.0 wt% enrichment
*	Slab (Hexagonally stacked rods)	6.0" Maximum Height
*	<u>Building 21</u>	
*	Storage of SNM in approved shipping containers	
*	(Ti-80 per array)	
*	<u>Building 6</u>	
*	Mass per tank	740 gms U235

4.2.6 Interaction Criteria - Activities involving SNM may be conducted in single or two level areas of the facility.

* All mass units shall have a separation of at least one foot, edge to edge.

* Spacing for mass unit activities carried out in the single level portions of the facility shall be such that the contained UO2 and moderator, if "smeared" over the allowed spacing areas would not exceed 50% of the critical water-reflected infinite slab surface density assuming optimum water moderation for

* minimum mass per unit area. Co-planar slabs specified in Table

* 4.2.5 require no additional spacing if on the same plane.

* Non-co-planar slabs within 4 feet of each other are limited to

* a maximum of 12-inch vertical differences, and must be

* separated by a 12-inch minimum horizontal spacing.

Portions of the facility contain two levels, each of which may

* be used for SNM. Mass limits on each level shall be spaced such that the contained UO2 and moderator, if "smeared" over the allowed spacing areas would not exceed 25% of the critical water-reflected infinite slab surface density assuming optimum

* water moderation for minimum mass per unit area.

*

All array calculations have been performed assuming a doubly infinite planar system, based on the consideration that components of subcritical infinite arrays can be combined where the unit size and cell spacing is preserved. Array reflection consists of a 16" concrete floor, and a 4" thick concrete roof 25 feet above the floor.

Table 4.2.6

The spacing requirement for mass SIU's specified in Table 4.2.5 is shown below. Spacing areas shall be established to provide equal distances from the edges of the units to the spacing boundary in all directions.

Limit	Spacing Areas
Mass	6.73 ft2

Justification for this spacing criteria is provided in Part II of this application.

Whenever more than one mass SIU is allowed in any given hood or box, positive spacing fixtures shall be used to assure spacing. Carts, limited to one mass SIU shall measure at least 2.6 feet on a side, and shall be designed to assure that the Mass SIU is centered.

In cases where the spacing area extends beyond the equipment boundaries, such as the storage facilities, the spacing boundary

4.3.1 All incoming UO2 powder shall be stored in 9.75" diameter x 11" long stainless steel cans. All powder shall be sampled before being placed in the virgin powder storage area to demonstrate on a 95/95 confidence level that the moisture content of powder lots is less than 5.0 wt.%. In addition, all damaged packages where containment is breached shall be sampled. The area in and around the virgin powder storage area shall be kept free of combustibles.

4.3.2 The fire door on the virgin powder prep storage area shall close
* automatically on activation of the fire alarm or upon electrical power failure. The automatic closing feature of the door on the virgin powder storage area shall be verified quarterly and records of its performance shall be maintained.

4.3.3 A maximum of three 9.75" diameter x 11" long stainless steel powder
* containers and one 5 gallon powder container or two 9.75" diameter x
* 11" long stainless steel powder containers and two 5 gallon powder
* containers shall be allowed in the batch make-up hood in the
* position shown in Figure 8.2.

*4.3.4 The one 5-gallon pail being filled from the three other containers in the batch Make Up Hood shall be limited to 35 Kg UO2 and shall be
* sealed with a water tight cover prior to being stored on the conveyor.

*4.3.5 The blender hoods shall be restricted to 35 Kg UO2 per hood. This
* does not include the UO_2 in the transfer tube which was assumed to
* be full of UO_2 in the analysis.

4.3.6 The wiper blade, powder plenum, and the drying belt at the Powder Preparation Station shall be inspected once per week to assure that the wiper blade is functioning properly and that no fuel is accumulating in the plenum below the belt. The depth of the powder

* on the drying belt is limited mechanically to 1/2" thickness. The drying belt shall be completely enclosed. The powder accumulation under the drying belt shall be less than 1/2".

* Records of these inspections shall be maintained.

*4.3.7 In the Concrete Block Storage Area, A maximum of 35.0 Kgs
* UO2 may be contained in 5-gallon or smaller containers. Each
* storage position shall be limited to one container.

*4.3.8 UO2 pellet thickness on each of the Pellet Storage Shelves
* shall meet the slab limit specified in Table 4.2.5. The shelves shall be covered from above by a sheet metal top.

*4.3.9 Storage of sintered pellets shall be limited to the slab limit specified in Table 4.2.5.

*4.3.10 Touching clad rods in horizontal storage shall be close packed
* in a hexagonal lattice and shall meet the slab limit specified
* in Table 4.2.5.

*4.3.11 A maximum of 32 fuel rods shall be allowed in each autoclave.

*4.3.12 The boxes on the Double Shelf Rod Storage Racks shall be covered with a tight fitting aluminum cover which overlaps the outside edge of the box by a minimum of one inch. Fuel rods
* shall be close packed in a hexagonal lattice and shall meet the
* slab limit specified in Table 4.2.5 within the individual rod boxes. One box may

remain uncovered for short periods of time to allow for the addition or removal of rods for inspection purposes provided that personnel are in attendance. Boxes shall be a minimum of 6 inches edge-to-edge both vertically and horizontally. The center-to-center distance between adjacent racks shall be at least 55 inches.

*4.3.13 In the Fuel Rod Storage Area fuel rods shall be close packed
* in a hexagonal lattice and shall meet the specified limit in Table 4.2.5 within the individual rod boxes. The entire
* storage array is covered by a fire resistant roof to assure the exclusion of sprinkler water. Large signs are posted over the storage array that say "Do Not Use Fire Hoses in this Area."

*4.3.14 Fuel assemblies shall be stored only in positions described in
* Figure 8.11, Part II. The assemblies in the storage positions only shall be wrapped with polyethylene with the bottom ends
* open to assure drainage. Fire fighting in the assembly
* storage room with fire hoses is prohibited.

*4.3.15 Shipping containers, each containing 2 fuel assemblies, shall be stored outdoors in arrays up to three high. Containers shall be stored on pavement or blacktop within an 8 foot high chain link fence.

*4.3.16 Waste drums shall be stored in designated areas of the pellet shop or on a concrete pad contiguous to the south wall of the Bldg. #21 warehouse. Packages on the pad will be stored up to
* two high and contain less than 350 grams U235 each which
* meets the surface density criteria. Maximum residence time for packages stored on the pad shall be twelve months.

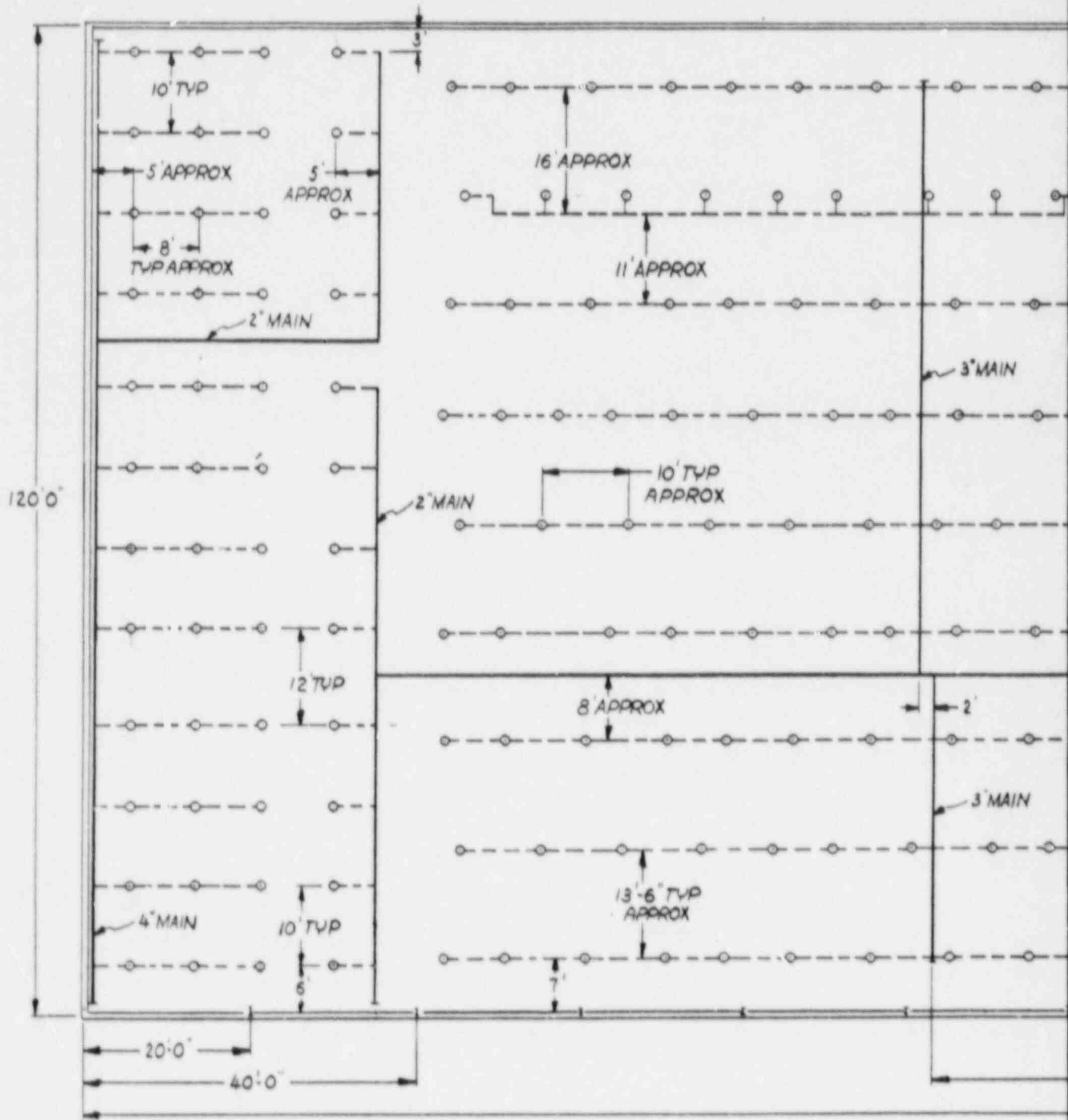
*4.3.17 Incoming virgin powder in CE-250-2 shipping container
* (Certificate of Compliance No. 9022) shall be stored in the Bldg. #21 warehouse or in the truck unloading area in the northwest corner of Building 17 in their original shipping containers only. The size of the array of the containers shall be in accordance with the requirements specified in the NRC Certificate of Compliance and all DOT regulations.

*4.3.18 Incoming pellets in the UNC-2901 shipping containers
* (Certificate of Compliance No. 6294) shall be stored either
* within the transport vehicle or inside Building 17/21 complex.
* If stored within the transport vehicle said vehicle shall be
* inside the Building 17/21 security fence. Two UNC-2901
* shipping containers are strapped to a pallet. Three pallets
* can be stored in the Building 17 Pellet Shop Annex and four
* pallets can be stored in the Building 17 Pellet Loading Area.
* The containers are received in a horizontal position. This
* position will be maintained when inside the Building 17/21
* complex and the pallets shall be at least 1 foot from process
* equipment in the area.

*4.3.19 The size of any array of shipping containers, with the exception of the 927A1 and 927C1 Fuel Bundle Shipping containers, shall be limited to a total transport index of 80.
* The 927A1 and 927C1 Fuel Bundle Shipping Container arrays shall
* not be more than three high. Shipping container arrays of different types shall be separated from one another by at least 20 feet.

*4.3.20 All storage containers of UO_2 5 gallons or less located outside
* of hoods or in storage spaces shall be covered. Any storage
* containers accidentally internally moderated shall be handled as
* individual mass units and stored in the concrete block storage
* area.

*4.3.21 The UNC-2901 Shipping Containers mounted on the shipping pallet
* can be opened only one at a time when located in an area free
* of other fissile material. This area shall be at least 21 ft^2.



SI
APERTURE
CARD

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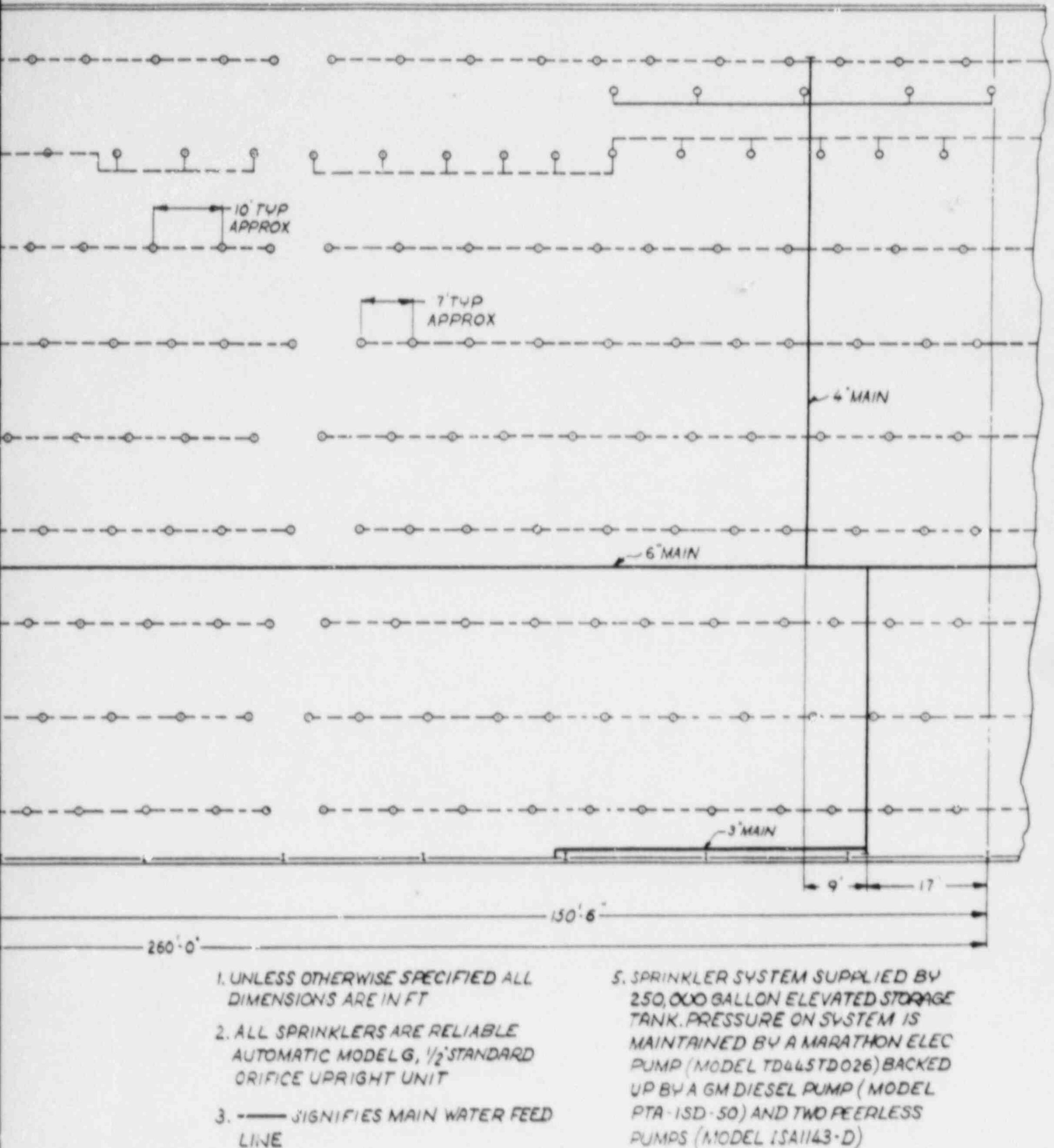
LICENSE No SNM-1067
DOCKET 70-1100

FIGURE 4.2.3
LAYOUT OF SPRINKLER SYS
REVISION



1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN FT
2. ALL SPRINKLERS ARE RELIABLE AUTOMATIC MODEL G, 1/2" STANDARD ORIFICE UPRIGHT UNIT
3. ——— SIGNIFIES MAIN WATER FEED LINE
4. – – – SIGNIFIES SPRINKLER DISTRIBUTION LINE
5. SPRINKLER SYSTEM SUPPLIED BY 250,000 GALLON ELEVATED STORAGE TANK. PRESSURE ON SYSTEM IS MAINTAINED BY A MARATHON ELEC PUMP (MODEL TD445TD026) BACKED UP BY A GM DIESEL PUMP (MODEL PTA-ISD-50) AND TWO PEERLESS PUMPS (MODEL 1SA1143-D)

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area in Building #5.

Product Development maintains equipment for mechanical testing, X-ray diffraction, vacuum and inert atmosphere heat treating, radiography, powder processing, and ceramics processing.

1.1.4 Information Known to Applicant Regarding Foreign Control

There is no information known to Combustion Engineering, Inc. of any control exercised over it by any alien, foreign corporation, or foreign government. The stock of Combustion Engineering is traded on the New York Stock Exchange. According to the stock records of Combustion Engineering maintained by its Transfer Agent, The Chase Manhattan Bank, as of December 81, 1979, there were approximately 26,742 stockholders of record, holding 16,337,119 shares of Combustion capital stock issued and outstanding. Of this number less than 1 percent of all stockholders gave foreign addresses.

1.1.5 Financial Qualifications

Combustion Engineering's 10-K which details its financial position is attached as Appendix B.

1.2 Operating Objective and Process - Summary

The process at the manufacturing facility begins with receipt of UO2
* powder enriched to a maximum of 5.0% U235 from Combustion Engineering's

7.0 NUCLEAR CRITICALITY SAFETY

7.1 Use of Surface Density Technique

7.1.1 Use of Surface Density Criteria of 50% for Mass Limited Units on Single Levels

* Mass limited units as specified in Table 4.2.5 are to be spaced
* to a maximum array surface density of 50% of the optimum
* critical surface density based on mass per unit area. The
* criteria is supported as follows: Consider the following
* analysis at a infinite planar array of 5 gallon steel
* containers containing 35 kilograms of 5.0 wt % U235 with the
* remaining volume of the 5 gallon container filled with water.
* The UO_2 water mixture is assumed to be uniformity distributed
* within the container. The 5 gallon steel container is 14.25
* inches high, with a bottom diameter of 10.25 inches and a top
* diameter of 11.25 inches. In this analysis, this container has
* been modeled as a carbon steel cylinder with a diameter of
* 10.75 inches, with a wall thickness of 0.0275 inches. A 12
* each reflector was placed above and below the array. The
* results of the KENO IV using 16 energy groups are:

Distance Between Containers	K-effective
12 inches	0.9584 ± 0.0065
14 inches	0.9414 ± 0.0081
16 inches	0.9268 ± 0.0070

* From this analysis it is concluded that use of a limit equal to
* 50% of the minimum critical slab surface density (at optimum
moderation) express in terms of mass per unit surface

* area is safe, with a maximum nominal array reactivity of less
* than 0.95.

* Allowable Surface
* density - The minimum mass surface density for U(5)02 is calculated to be 10.4 kgU/square foot (Reference 1). The safe limit is therefore 5.2 KgU/square foot.

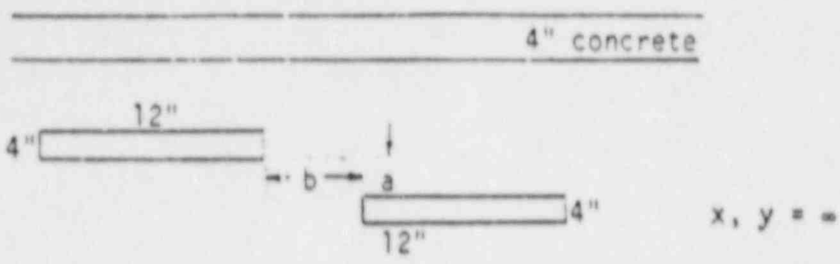
* Spacing
* Requirement - 20.33 inches for a 35.0 kilogram mass to meet the surface density criteria

Reference 1): R. L. Stevenson and R. H. Odegaarden, "Studies of Surface Density Spacing Criteria Using KENO Calculations," Transactions of the American Nuclear Society, 12, 890 (1969).

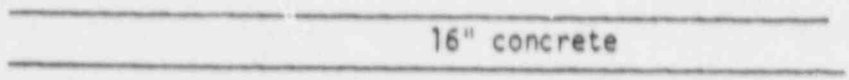
*7.3 Non-co-planar Slabs

* An array of slabs has been evaluated using ANASIN code. The

* configuration is shown below:



* (Slabs are U (3.5) O_2 + H_2O, 2.4 gm U/cc)



* Evaluations of this configuration yield the following:

a	b	Δke
0	0	0.0
6	0	+0.022
12	0	+0.029
28	0	+0.039
12	0.75	+0.0139
12	1.5	-0.0009

* Accordingly, a 1.5-inch horizontal spacing counters the reactivity
* increase from a non-co-planar configuration. The change in reactivity
* for U(3.5)O_2 is so small that the effect for U(4.1)O_2 would not be
* significantly different. Additional safety is provided by the
* requirement that non-co-planar slabs be limited to 12-inch vertical
* differences and separated by at least 6-inch horizontal spacing.

8.0 PROCESS DESCRIPTION AND SAFETY ANALYSES

This section contains detailed descriptions of all operations in the Manufacturing Facility (Building #17 and #21). Sufficient detail is provided to permit an independent verification of the adequacy of the controls for the purpose of assuring safe operations. Nuclear criticality limits are taken from Table 4.2.5 of Part I. In certain operations, the intricacies of the equipment require further analysis, which is provided herein. Details of specific calculations used to support various aspects of this analysis, and several statements and considerations in Section 4 of Part I are discussed in this section. This section provides typical analyses for operations conducted within the scope of this license. Present arrangements of the equipment in the pelletizing facility are shown in Figure 8-1. (Drawing No. NFM-J-4077).

* This arrangement may be changed in accordance with the procedures in

* Section 4 of Part I of this license.

8.1 UO2 Processing

8.1.1 Receipt of Material

* The as-received 9.75" diameter stainless steel UO2 powder cans,

* to be stored in the virgin powder storage area (Figure 8.1) and shall be sampled before being placed in the storage area to demonstrate on a 95/95 confidence level that the moisture content of powder lots is less than 5.0 wt%. In addition, all damaged packages where containment is breached

will be sampled.

* The pellets are received in UNC-2901 shipping containers which
* may be brought into Bldg. 17 as discussed in Section 4.3.18.
* Three pallets (six UNC-2901 containers) can be brought into the
* Bldg. 17 Fuel Pellet Shop Annex and four pallets (eight
* UNC-2901 containers) can be brought into the Bldg. 17 Pellet
* Loading Area for storage and unloading. The sealed containers
* on the pallets can be stored next to each other but must be at
* least 1 foot from process equipment in the area. Prior to
* opening a shipping container the pallet must have an area of
* 21 ft^2 (4.6 ft. x 4.6 ft.) in which the pallet is located.
* This area will meet the surface density limit specified in
* Section 4.2 for a mass of 110 kilgrams of UO_2. The pellets in
* the shipping container are received in 2 inch deep pellet trays
* with covers. These pellet trays are stored in the pellet
* storage shelves. The pellets are then treated the same as
* pellets made in the Bldg. 17 pellet shop.

8.1.2 Virgin Powder Storage Area

The virgin powder storage area is isolated from the remainder of the plant on all sides by concrete block walls, a double
* steel roof, and a metal fire door. If the door is in the
* open position, it is automatically closed upon activation of
* the fire alarm, or on failure of electrical power. The automatic closing feature of this door shall be verified quarterly and records of its performance shall be maintained. These engineered safety features are considered adequate to prevent the introduction of water in the event of a fire. This area will be kept free of combustibles, and located such that there are no potentially hazardous items such as boilers in the vicinity of the area.

An ammonia cracker is housed in a concrete block building which is located some 25 feet northwest of Building #17. In view of its many redundant safety features, it is not viewed as a potentially hazardous item.

Criticality Safety Analyses

The following assumptions were incorporated into the calculational model of the Virgin Powder Storage Area:

1) All steel structural materials were neglected.
* 2) The fuel was assumed to be a homogeneous mixture of UO2
* containing 5.0 wt% H2O.
* 3) All storage positions were filled and each individual
* can was assumed to contain 35.0 kg's of UO_2 at 5.0 wt%
* U235.
* 4) No interspersed water moderation was considered.

The KENO-IV Code with sixteen group Hansen-Roach cross sections was used to determine the reactivity of the Virgin Powder Storage Area under the condition noted above. Dimensional details of the
* model are provided in Figure 8.1. A Keff of 0.7781 ± 0.0043 was
* obtained for an infinite system in the horizontal direction.

8.1.3 Batch Make-Up

Powder containers are removed from the virgin powder storage area
* and placed on a conveyor for transfer to the Batch Make-Up Hood.
* Two 9.75 inch diameter x 11 inch long stainless steel powder
* containers shall be placed on fixtures in the left side of hood and either a powder container or a 5 gallon pail on the right
* side of the hood when an appropriate batch of less than 35 Kg UO2
* is weighed out and put into a 5-gallon pail. The batch weights and enrichment are recorded on the container. A water tight cover is secured to these batch containers and they are
* then conveyed to the cone change hood. The cover is placed in
* the change hood with a water tight blender feed cone and then
* transferred to the blender hood. The batch make-up operation
* and the cone change are enclosed in ventilated hoods. Sufficient negative pressure is provided to assure a minimum face velocity of 100 fpm.

* Criticality Safety Analysis

The following conservative assumptions were incorporated in the
* calculational model of the Batch Make-up Hood and Conveyor Change
* Lift areas:
* 1. All steel structural materials were neglected.
* 2. An external mist of .001 g/cc was assumed.

3. The stainless steel powder make-up cans (9.75" diameter and 11" long) on the conveyor were modelled as a single cylinder in the horizontal direction based on the can containing a homogeneous mixture of 35 kg UO_2 at 5.0 wt % U235 and 5 wt % H_2O. This mixture was assumed to be uniformly distributed within the can.

4. Two stainless steel powder cans and two 5-gallon stainless steel buckets (10.75" diameter and 14.25" high) in the batch make-up hood were assumed to each contain a homogeneous mixture of 35 kg UO_2 at 5.0 wt % U235 with maximum moderation. The batch make-up hood was assumed to be covered with a 0.25" film of water.

5. The 5-gallon stainless steel buckets on the conveyors and in the cone change hood and hopper lifts are assumed to contain a homogeneous mixture of 35 kg UO_2 at 5.0 wt % U235 and 5 wt % H_2O. This mixture was assumed to be uniformly distributed within the can. It has been assumed that there is no distance between buckets on the conveyors. A single 5-gallon bucket of UO_2 has been assumed in each hopper lift area and three 5-gallon buckets of UO_2 have been assumed in the cone change hood. All 5-gallon buckets in the cone change hood, the vertical conveyor, and in the hopper lift areas are assumed to be covered with a 0.25" film of water.

The KENO-IV code with sixteen group Hansen-Roach cross sections was used to determine reactivity of the Batch Make-up and Conveyor Change Lift areas under the conditions noted above. A Keff of 0.7940 $\pm$ .0053 was obtained for an infinite system in the x and y directions.

* Dimensional details of the calculational model are shown in
* Figure 8.2.

*

8.1.4 Powder Preparation and Blending

UO_2 powder from one sealed batch container (moderation control assured) is transferred to a blender where it is mixed with a binder. Two separate blenders feed a common powder spread funnel by a means of individual powder transfer pipes entering at a 45 degree angle. An identical powder preparation line runs parallel to this one at a centerline distance of 13 feet. The blending operation is enclosed in a ventilated hood. Each 15.2 liter blender is charged with 34 Kg of UO_2. The total water content of 7 wt% is blended into the powder to form agglomerates. The UO_2 is pre-dried in the blender for 30 minutes, minimum, with hot air prior to transferring onto the dryer belt. The powder after being dried has a water content of less than 5 wt%. At 9 wt% water the blender UO_2 is a slurry, not an agglomeration mixture. The slurry is not transferred onto the dryer belt. It is either processed as recycle material or is dried in the blender.

Sufficient negative pressure is provided to assure a minimum face velocity of 100 fpm.

8.1.4.1 Drying

Agglomerated UO2 powder is spread onto the dryer belt
* from the powder spread funnel to a controlled depth of 1/2". A complete enclosure is provided around the dryer belt assembly and this enclosure is maintained at a slight negative pressure. The discharge end of the dryer belt utilizes a wiper blade to prevent the flow of significant amounts of material to the plenum under the belt. Nevertheless, the wiper blade and plenum shall be inspected once per week to assure that the wiper blade is functioning properly and that fuel is not accumulating in the plenum below the belt. Records of these inspections are maintained. The belt dryer
* operates on a 1/2" slab limit. The criticality safety analysis also assumed an accidental accumulation of up
* to 1/2" of powder under the dryer belt. The wiper blade
* scrapes the powder from the belt into the granulator.
* The wiper blade is inspected weekly as well as the UO_2
* depth under the belt. If the accumulation exceed 1/2"
* it is cleaned up. Even if the above was not done, the
* accumulation under the belt would not exceed 3.5 inches
* due to the physical space limitations. The 3.5" below
* and the 1/2" above which meets the slab thickness limits
* in Table 4.2.5. The safety of the dryer assembly is assured by this restricted slab thickness. The granulator

controls are wired to the motor control such that the dryer belt cannot be activated unless the granulator is turned on. An over temperature condition will shut off the heating elements and light a warning light.

8.1.4.2 Granulation

* Dried oxide is gravity-fed into a granulator where it is sized for subsequent pressing. The granulated powder is then gravity-fed through a discharge funnel ending in a 2 inch square opening. A short adapter of 2 inch circular cross section is welded to the funnel to allow connection of a 2" diameter hose which is then connected to a portable hopper below. *

A complete enclosure is provided around the granulator screening mechanism. The enclosure contains a level probe which will shut off the drier belt and heaters should the granulator discharge funnel fill with UO2 powder. It is maintained at a negative pressure to preclude dusting.

Criticality Safety Analysis

* The powder blending, drying, and granulation stations were divided into two parts for calculational purposes. The back end of the stations included the blenders, the powder transfer pipes leading to the powder spread funnel, and the first 10 feet of the 30" wide dryer belt. The spread funnel is fixed in position to restrict the powder discharge from it to a 24" wide and 1/2" deep layer of UO2. The front end of the station included the last 10 feet of the 30" wide dryer belt, the granulator, the discharge funnel and hose and the large cylindrical press feed hopper.

The following conservative assumptions were incorporated into both calculational models:

1. An external mist of 0.001 g/cc was assumed.

* 2. The UO2 powder was assumed to have a density of 3.5 g/cc at an enrichment of 5.0 wt% U235 and a water content of 15 wt %, which is the water content if two times the normal amount is placed in the blender.

* 3. Any structure containing UO2 powder was assumed filled to capacity.

* 4. Although the belt dryer is limited by a mechanical feeder to 1/2" of UO2 powder, the model allows for an accidental accumulation of 1/2" under the dryer belt in the event of malfunction of the wiper blade.

* 5. All surfaces of the structures containing UO2 powder and the surface of the powder in the blender hood and on the dryer belt were assumed to be covered with a 0.25" film of water.

* 6. The concrete floor and ceiling have been accounted for in the models.

* 7. An infinite array of stations was analyzed although there are only two parallel stations.

* In the analysis of the back end of the stations it was assumed that the blender hoods are restricted to a maximum of 35 kg UO2 per station, that this mass of UO2 was located at the base of each blender hood directly above each powder transfer pipe and was hemispherical in shape.

* In the analysis of the front end of the stations it was assumed that the large hopper (11"OD x 40"L cylinder) contained the UO2 powder at 5 wt % U235.

Sixteen-group Hansen-Roach cross sections were used in
* KENO-IV to determine the reactivity of the system. Based on

* the conditions described above, the following Keff were *

* obtained.

* back end of station Keff = 0.5164 ± .0057

* front end of station Keff = 0.8372 ± .0061

* Dimensional details of the calculational model are shown in Figures

* 8.3 and 8.4.

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* 8.1.5 Press Feed Hopper

* Criticality Safety Analysis

* Although only one press feed hopper is permitted in any
* designated area, an analysis was performed in order to account
* for the possibility of one press feed hopper being immediately
* adjacent to another press feed hopper. The following
* conservative assumptions were incorporated into the
* calculational model:

* 1. Two large hoppers (11 inch O.D. x 40 inch long cylinders)
* were assumed filled to capacity with UO_2 powder with density
* of 3.5 g/cc at an enrichment of 5.0 wt % U235 and a water
* content of 5.0 wt %, which is twice the water content after
* drying on the belt dryer.
* 2. Both hoppers were assumed to be covered with a 0.25" film
* of water.
* 3. An external mist of 0.001 g/cc was assumed.
* 4. The concrete floor and ceiling have been accounted for in
* the models.

* Sixteen group Hansen-Roach cross sections were used in KENO-IV
* to determine the reactivity of the system. Based on the
* conditions described above, a $K_{eff} = 0.3633 \pm .0042$ was
* obtained.

* 8.1.6 Final Mixing

Filled press feed hoppers may be rolled to assure complete
* blending of the die lubricant. The press feed hopper roller is
* limited to one press feed hopper and the roller is surrounded by
* a wire mesh enclosure. The calculated Keff is less than the Keff
* for the two touching press feed hopper stated in Section 8.1.5.

* 8.1.7 Pressing

The filled portable hoppers are transferred to the pelletizing

* presses and secured to assure their stability and the containment of powder. Powder is gravity fed to the press, and compacted to

green pellets which are placed into furnace boats, The
* pellets in the boats have to meet the slab height limit in
* Table 4.2.5. Only one boat shall be at each press at any one time. Each press is provided a spacing area of at least 20 square feet. The press is provided with enclosures which assure adequate ventilation at the opening face, and at the junction of the portable hopper with the press. Air flow rates are sufficient to assure face velocities of at least 100 fpm.

* 8.1.8 Dewaxing and Sintering

Furnace boats containing green pellets are charged in a single
* line [illegible] dewaxing furnace, and then to a sintering furnace, where under controlled conditions, the pellets attain the desired
* properties. Because the UO2 is in a compacted form, dusting is minimal. Hydrogen burn-off exhaust is vented from the building, and is filtered and monitored as specified in section 3.2.3 of Part I. The furnaces and their interconnecting conveyors are
* slab limited, with pellet slab heights as specified in Table 4.2.5.
* Stored furnace boats containing sintered pellets are limited to
* a maximum slab thickness specified in Table 4.2.5.

* 8.1.9 Final Sizing

Sintered pellets are transferred to the grinder feed system
* where they are aligned for the grinding operation which is carried out under a stream of coolant. The coolant is
* centrifuged to remove solids, and is recirculated at a uranium
* concentration considerably less than one gm/liter. The infeeder,
* grinder and outfeeder have pellet configurations limited to a
* slab thicknesses as specified in Table 4.2.5.

Grinder sludge is removed from the centrifuge and dried in an

* oven. The dried material is subsequently stored in the concrete
* block storage area awaiting final disposition. An enclosure is provided around the grinder to preclude the dusting of UO2. The enclosure is maintained at a negative pressure with respect to the room.

* The grinder coolant may collect in a one inch deep sump in the
* grinder and in a 22 liter sump behind the grinder, as shown in
* Figure B-1. A 25.3 liter volume is a safe volume for a optimum
* concentration of UO_2, full reflected system as shown in Hugh Clark's
* report DP-1014. Experience has shown that no appreciable sludge accumulates in the grinder sump. The centrifuge is cleaned periodically as required to permit continued operation.
* Nevertheless, Figure B-1 does show spacing for the grinder sump to allow for any UO2 settling which may occur. Grinder coolant is normally recirculated, but may be disposed of by evaporation, or by
* discharge to the radiation waste system. Pellets are
* transferred by hand in a 2 inch high covered pellet tray to a
* storage rack or to a low temperature bulk drying furnace where any trace amounts of moisture are removed prior to rod loading. Both are limited to a slab thickness of 4.0".

8.2 Scrap Recycle

All clean scrap is accumulated for reprocessing and recycle with the feed material. Scrap may be milled to yield desired particle size best suited for the processing, oxidized and reduced to assure removal of volatile additives and to achieve the desired ceramic properties of the resulting recycle U02, and blended to assure uniformity. The following equipment is included in the pellet shop annex:

* a) Oxidation and reduction furnace

* b) Milling equipment

* c) General purpose

* d) Filter Knockdown Hood

* e) Blender

* f) Micronizer

* a) Oxidation and Reduction Furnace

* This furnace is made up of two individual sections connected
* together. Product moves through both furnaces on a wire mesh
* belt. The oxidation section is used to heat sintered scrap in
* air to convert the UO_2 to U_3O_8. The reduction section is used
* to convert U_3O_8 to UO_2 in a heated gas atmosphere of H_2 and N_2.

* b) Milling Equipment

* This is a mechanical impact type grinder which uses a rotor blade
* assembly to grind UO_2 powder to a finer particle size so that the
* UO_2 powder can be recycled back into the pellet process. The UO_2
* powder is fed through the top of the mill, passes into the milling
* chamber, passes through a screen and into a pail connected to the

* discharge of the mill. Connected to the discharge section is a
* vacuum cleaner to prevent the air pressure build-up in the
* milling during the chamber operation.

* c) General Purpose Hood
* This is a ventilated hood which is used for miscellaneous work
* involving handling of UO_2 powder or UO_2 contaminated material.

* d) Filter Knockdown Hood
* This is a ventilated glove box hood which is used to remove loose
* UO_2 powder from used absolute filters and prefilters.

* e) Blender
* The blender houses a sealed pail which contains UO_2 powder. The
* sealed pail is tumbled by rotating the pail in a non-concentric
* rotating motion. This action mixed recycle powder into a
* homogenous type mixture for use in the production pellet line.

* f) Micronizer
* This is an air impacting type of grinder. Fine particles of UO_2
* powder are fed into the micronizer grinding chamber using a
* vibratory type feeder. High pressure air is then introduced into
* the grinding chamber. This action causes UO_2 particles to impact
* other UO_2 particles at high velocity resulting in finer particles.
* The powder fines and air mixture enters a bag house (sock filters)
* where the UO_2 particles are separated from the air. The UO_2 powder
* is collected in a pail while the air is exhausted into the FA-4
* HEPA filter system.

* The criticality safety for the furnace is based upon the slab limit as
* specified in Table 4.2.5. The remaining operations except blending, are
all carried out in hoods with sufficient ventilation to assure a face

velocity of 100 fpm. These operations are controlled by use of a 35.0 kg
* mass limit in accordance with Table 4.2.5 with spacing provisions taken
* from Table 4.2.6 of Part I of the application as shown in Figure B-1.
Positive spacing fixtures are used to assure spacing wherever more than one SIU is allowed in any given hood or box. A material balance log is maintained at the Milling Hood and Micronizer to provide
* additional assurance that the criticality limit of a 35.0 kg UO_2 mass limit will not be exceeded at these locations.

8.3 Storage and Transfer

8.3.1 Concrete Block Storage Area

A concrete block storage area is provided as shown in Figure B-1.
* This storage area is intended for 5 gallon pails containing a
* maximum of 35.0 kg of UO2 and has a maximum height of 7 feet. The blocks are of solid 10" thick concrete, having a minimum density of 125 lb/ft3. Mortar is used to join the blocks and to secure the structure to the building wall. Steel shelves, of at least 16 ga. thickness are built into the structure with a vertical spacing of at least 16 inches. Each storage position measures 16" wide x 14" deep, and is lined on three sides with 1/4" thick mild steel. The criticality safety analysis demonstrates that the spacing boundary can be located 48 inches from the front of the shelves.

* Criticality Safety Analysis

The following conservative assumptions were incorporated in the calculational model of the Concrete Block Storage Areas:

1. All steel structural materials were neglected.
2. An external mist of .001 g/cc was assumed.
3. Each storage position was assumed to be full with a 5-gallon steel bucket containing a homogeneous mixture of 35 kg UO2 at 5.0 wt % U235 and 5 wt % H2O. This mixture was assumed to be uniformly distributed within the bucket.
4. A 0.25" film of water has been assumed on the exterior steel walls of the shelving, the top of the shelves, and the exterior of each bucket.

The KENO-IV code with sixteen group Hansen-Roach cross sections was used to determine reactivity of the Concrete Block Storage Areas under the conditions noted above. A Keff of 0.3104 ± .0049 was obtained for an infinite system in the horizontal direction. The dimensional details of the calculational model are shown in Figure 8.5.

* Another analysis was done for the Concrete Block Storage Area which
* includes a 12" water reflector in front of the storage area. The
* resulting Keff is 0.4698 ± 0.0070. A further analysis was done
* assuming the same bucket was completely flooded with water and
* reflected in front with 12" of water. The resulting Keff is 0.9221
* ± 0.0070. This analysis did not include the steel structures, which
* includes the 1/4" steel on each side and the 1/4" steel shelves.

8.3.2 Pellet Storage Shelves

* Steel shelves are provided for pellet storage. The shelves are 3 high. They have a width of 30" and are limited to a slab thickness of 4.0". The slab thickness of 4.0" is assured by limiting the number of fuel pellet trays stacked at any position. The entire storage array is covered by a sheet metal top which would prevent significant moderation of the array from discharge of the overhead sprinkler system. Water firefighting is not
* permitted in the pellet shop. Even though the pellet trays are
* normally covered and the storage shelves are covered, it was
* assumed in the analysis that the pellet trays were filled with water.

* Criticality Safety Analyses

The following conservative assumptions were incorporated in the
* calculational model of the Pellet Storage Area:

* 1. All steel structural materials were neglected.
* 2. An external mist of .001 g/cc was assumed.
* 3. Each of the three storage shelves were assumed to hold a 4" thickness
* of a homogeneous mixture of UO2 at 5 wt % U235 at a
* density of 5.686 g/cc based on the random loading of pellets
* and water at maximum moderation (volume-weighted based on a UO2 density of 10.96 g/cc).
* 4. A 0.25" film of water has been assumed on the top shelf, which is
* empty and the back wall of the shelving.
* 5. The concrete ceiling (4"), floor (16") and the back wall (8"
* concrete block equivalent to 5" solid concrete) were also
* included.

The KENO-IV code with sixteen group Hansen-Roach cross sections was

* used to determine reactivity of the Pellet Storage Area under the
* conditions noted above. A Keff of 0.7468 $\pm$ .0049 was obtained for an
* infinite system in the horizontal direction.
* The UO2 loading of the trays was determined by doing a total of 14
* mesurements. The pellets pack to an average density of 5.95 gm UO2
* per cc (5.24 gm U per cc, with a 2 sigma variation of 0.264).
* The 16 group cross sections for the pellets were calculated for
* 0.3766" diameter pellets. Dimensional details of the calculational
* model is shown in Figure 8.6.

8.3.3 Rod Transfer

Flat carts measuring 3' x 13'-1/2" are used for transporting up to two steel boxes with inside dimensions of 5-1/2" x 8" x 14'4" long, each containing over 300 fuel rods. The rods are assumed to be in a close packed hexagonal lattice with a maximum water to UO_2 volume ratio of 0.48, based on a rod O.D. of 0.44" and a pellet O.D. of 0.3765".

* From Figure 1.E.16 of UKAEA handbook AHSB 1, the critical infinite slab thickness for 5.0% enrichment fully reflected is about 8 inches for this degree of moderation. Applying the safety factor of 1.2 yields an allowable slab thickness of about 6.7 inches. Accordingly, the rod transfer cart with two 5-1/2" deep boxes is safe as long as the rods are not stacked higher than 6" in each box. Carts may be placed alongside each other, or will be spaced a minimum of 1 foot from other fissile material.

8.3.4 Transfer of Material

Material may be transferred on carts which accommodate one mass or slab limited SIU, or may be transferred by hand, one SIU at a time. Carts used for mass limited SIU's shall provide for centering of the unit, and shall measure at least 2.6 feet on a side as specified in Table 4.2.6. Because most spacing areas do not extend beyond the physical boundary of the equipment, spacing between transfer carts and the equipment is of no concern. In cases where the spacing area extends beyond the equipment boundaries, such extends beyond the equipment boundaries, such as the storage facilities, the spacing boundary will be indicated by a colored line. The line may be crossed by carts only when they contain no more than one mass or slab limited SIU, and then only to permit an operator to transfer that SIU to an available storage position.

8.4 Pre-Treatment of Low Level Liquid Wastes

In order to effect a reduction in the quantities of UO2 released to the retention tanks in Building #6, low level liquid wastes, consisting primarily of floor mop water will be pumped into a 10 inch diameter, 11 foot long settling tank with a release line located 18 inches above its lowest point.

The water is then passed through a high efficiency closed loop centrifuge system, sampled to verify acceptable discharge levels, and transferred to the retention tanks in Building #6. The settling tank
* is located in the rod loading area, and is shown in figure B-1.

Based on past experience, wash water may contain up to 0.001 uCi/cc (0.5 gm U/liter).

* The diameter of the tank (10 inches) is less than the critical,
* infinite water reflected cylinder diameter of 10.5" at optimum UO_2 to
* water concentration as shown in Figure I.D. 11 of UKAEA Handbook, AHSB
* 1. In addition, the optimum concentration necessary to achieve
* criticality in a 10.5 inch cylinder is between 1500 and 2000 gm
* U/liter for 5.0% enriched UO_2, a factor of 3000 higher than the uranium concentrations observed in the mop water handled. The volume
* of the settling tank is 23.2 liters. The allowable surface density is taken as 25% of the critical infinite slab thickness. Accordingly,
* Surface Density = 1.38" or 3.26 liter/square foot. The required spacing area for the tank is therefore 7.11 square feet.

Sludge and other uranium bearing solids will be collected in volume

* limited SIU's. This material may be subsequently loaded into trays which
* meet the slab limit as specified in Table 4.2.5, dried in an oven and stored in authorized packages awaiting final disposition.

8.5 Rod Loading and Assembly Fabrication

8.5.1 Pellet Stacking

Pellets from the pellet fabrication facility, or from outside
* vendors are placed on a table where they are aligned for rod loading. On the table, the pellet configuration is limited to
* the slab limit as specified in Table 4.2.5. The UO2 pellets are placed on troughs one pellet high before being loaded into rods.

8.8.2 Rod Loading and Fuel Rod Transport Carts

Pellets are transferred from the stacking troughs into rods. The
* loaded rods are placed into carts each of which can hold up to 250 fuel rods in parallel sleeves which are spaced on four rings in an annular fixture with an I.D. of approximately 10 inches and an O.D. of approximately 22 inches. Guard rails prevent the carts from coming any closer than three feet center-to-center. The carts are used in normally dry areas to transfer the rods to
* operations which include end plug welding, weld deflashing and
* leak testing. The welding and deflashing operations are performed on one rod at a time. The leak testing operation is performed on two rods at a time. Welded and deflashed rods are immediately returned to the cart after each step is completed.
* Finished rods are fluoroscoped and are checked for enrichment
* with a maximum slab limit as specified in Table 4.2.5.

Criticality Safety Analysis

The following conservative assumptions are incorporated into the calculational model of the Rod Loading and Fuel Rod Transport Carts:

1) Only the 1/4 inch thick, 8" O.D. inner steel cylindrical annulus was accounted for in the model. All other construction material was neglected.

2) The carts were assumed to be infinite array in the x and z directions.

3) A mist of .001 g/cc water was assumed for all air spaces.

4) The fuel rods are contained in 1/2 inch, Sch 40 PVC tubes, each 134 inches long. There are 250 tubes arranged in 4 concentric rings with an average pitch of 1.303 inches. The fuel tube region of the cart is thus a cylindrical annulus beginning at 7.445" from the centerline of the cart and extending to a radius of 12.711 inches. On either side of the fuel tube region, is a weld sample box (4.375" x 4.375") attached to the inner side of the cart. The weld sample boxes contain a 5x5 array of the PVC tubes which hold empty fuel rods for the purposes of weld sampling only. A cover of 1/4 inch aluminum with plexiglass areas encloses the top, sides, and back of the cart.

   In the calculational model it has been assumed that all 250 positions in the cylindrical area and all 50 positions in the weld sample boxes were occupied by the largest diameter rods (0.3765" O.D. U02 pellets at 10.061 gm/cc stacked density with a Zr-4 cladding thickness of .028 inch) at the maximum enrichment of 5.0 wt % H20. It was also assumed that the fuel rods and the

* PVC tubes extended the full length of the cart (165 inches). The
* moderation effects of the PVC have been included in the analysis,
* however the absorption effects have been neglected. A 0.25" film of
* water has been assumed on the exterior sides of the cover. The
* concrete floor and ceiling have also been modelled.

* The NITAWL and XSDRNPM codes were used to obtain 16-group cross
* sections from the 123-group GAM-THERMOS library for input to
* KENO-IV. A reactivity for the Rod Loading and Fuel Rod Transfer
* Cart, keff = 0.873 $\pm$ .0058, was obtained based on the conditions
* described. Dimensional details of the calculational model are shown
* in Figure 8.7.

8.5.3 <u>Autoclave Corrosion Test</u>

Two autoclaves used for corrosion testing of finished fuel
* rods are shown in Figure B-1. The stainless steel tanks are 14
feet long and have an inside diameter of 14 inches with wall
thickness of 1.5 inches. The center line distance between
autoclaves is a minimum of 66 inches. Each

autoclave is limited to 32 fuel rods by administrative control. The fuel rods are held by stainless steel fixtures consisting of eight plates which are five inches wide and 1/8 inch thick. During operation, the interior of the autoclave could conceivably experience all conditions of water moderation, from completely dry to full density water. Criticality safety of the autoclaves is based on dimensional comparison with the fuel assembly storage area. The fuel assemblies have been designed for maximum reactivity and have a keff of less than 0.90 in full density water. (See section 8.5.7). The rod spacing in the fuel assembly is thus the optimum. If the fuel rods were aligned in the autoclave at this optimum spacing, it would thus take 256 rods to achieve a keff of approximately 0.90. The maximum number of rods allowed (32) provides a large margin of safety under all conditions of moderation and reflection. Even with all autoclaves filled, the number of fuel rods present (192) would be less than the number required for one fuel assembly of the 16 x 16 type.

8.5.4 Fuel Rod Storage Area

* The multi-level storage area shown in Figure 8-8 for boxes of fuel rods consists of up to 10 tiers of 32 locations each. The steel fuel rod boxes have a maximum length of 14'-4" and an inside width and depth of 8 inches and 5-3/8 inches, respectively. A vertical spacing of 12-1/2 inches between boxes is maintained, the first tier being 18 inches above the concrete floor. Lateral spacing is restricted

by physical barriers to a minimum of 4 inches. The rod boxes rest on roller conveyers to facilitate movement in and out of the storage array and are held in place by a fixed brace. The entire storage array is covered by a sheet metal roof to assure the exclusion of sprinkler water. The fire resistant roof has 3% pitch to assure adequate drainage to the floor. Water accumulation in the vicinity of the storage rack is not considered credible in view of the close proximity of an open equipment pit in the floor which is 30 feet x 60 feet x 18 feet deep. A 3 foot deep sump at the bottom of the pit is equipped with a level detector which activates a pump to transfer any accumulated water to the industrial sewer system.

<u>Criticality Safety Analysis</u>

The following conservative assumptions were incorporated in the calculational model of the Fuel Rod Storage Area (Figure 8.8):

1) Each of the rod boxes was assumed to contain the smallest diameter fuel rods (0.382") at an enrichment of 5.0 wt % U235 with a density of 10.061 g/cc. The fuel rods were assumed to be tightly packed in an hexagonal array. The 8" wide box was filled to a height of 6.25" containing 371 fuel rods, which is greater than the slab limit (6 inches) as specified in Table 4.2.5. The fuel was assumed to be dry. The fuel and clad were homogenized over the volume of the box.
2) A vertical spacing of 11.5" between rod boxes was assumed.

3) A lateral separation distance of 3.5 inches between rod boxes was assumed. Interspersed moderation was not
* considered credible since moderation control is assured by
* the cover, walls, and doors and the storage
* area.

4) All steel construction material was neglected.

* 5) The concrete ceiling (4") and floor (16") have been
* included in the calculation.

* 6) The rubber pad was modeled as water in the position in
* the box as shown in Figure 8.8.

* The NITAWL and XSDRNPM codes were used to obtain 16-group
* cross sections from the 123-group GAM-THERMOS library for
* input to KENO-IV, the code which was used to determine
* reactivity of the Fuel Rod Storage Area under the conditions
* noted above. A keff = 0.6850 $\pm$ .0032, was obtained for a
* system with four tiers in the vertical direction and
* infinite array of boxes in the horizontal direction.

8.5.5 Double Shelf Rod Storage Rack

The double shelf storage racks for fuel rods hold a maximum of 12 steel boxes identical in all respects to those in the multi-tier array described above. Each box is equipped with a tight fitting Aluminum cover which overlaps the outside edge of the box by a minimum of one inch. One box may remain uncovered for short periods of time to allow for the addition or removal of rods for inspection purposes provided that personnel are in attendance. Spacing between boxes in both a vertical and horizontal direction is a minimum of 6 inches. Minimum center-to-center spacing between storage racks is 55 inches and the racks are considered to be present in an infinite array in the horizontal plane. The
* location of these racks is shown as in Figure B-1.

* Criticality Safety Analyses

* The following conservative assumptions were incorporated in the
* calculational model of the Double Shelf Rod Storage Racks (Figure
* 8.9):

* 1. Each of the steel boxes was assumed to contain the smallest
* diameter fuel rods (0.382") at an enrichment of 5.0 wt %
* U235 with density of 10.061 g/cc. The fuel rods were
* assumed to be tightly packed in an hexagonal array. The 8"
* wide box was filled to a height of 6.25" containing 371 fuel
* rods. The fuel was assumed to be dry. The fuel and clad
* were homogenized over the volume of the box.

* 2. The 0.125" pad at the bottom of the box was modelled as water.

* 3. All structural materials were neglected.

* 4. An external mist of 0.001 g/cc was assumed.

* 5. A 0.25" film of water has been assumed on the cover and
* sides of the box and on the supports on either side of the
* box, which were conservatively assumed to extend the full
* length of the box.

* 6. The concrete ceiling (4") and floor (18") have been included
* in the calculation.

* The NITAWL and XSDRNPM codes were used to obtain 16-group cross
* sections from the 123-group GAM-THERMOS library for input to
* KENO-IV, the code which was used to determine reactivity of the
* Double Shelf Rod Storage Racks under the conditions noted above.
* A keff = 0.9144 $\pm$ .0065, was obtained for an infinite system in
* the horizontal plane.

8.5.6 <u>Fuel Assembly Fabrication</u>

Fuel rods are loaded into the assembly skeleton in a fixture
* which provides a lubricating water spray. These fixtures
* are designed to assure that water cannot be retained. The Keff
* for an isolated assembly is less than 0.90. See Figure 8.10
* for all Dimensions of the Fuel assembly.

8.5.7 In-Plant Storage of Fuel Assemblies

Fuel assemblies are stored in a vertical position using
* racks of adequate strength to preclude loss of the design spacing. The assemblies in the storage positions only shall be wrapped with polyethylene with the bottom ends open to assure free drainage. There are 440 storage positions and an adjacent inspection area consisting of 16 positions. Within the same room, (but at greater separation distances)
* there are two horizontal loading tables where the fuel rods are initially loaded into the assembly skeletons, a vertical wash tank where the assemblies receive a final demineralized water rinse, two fixed vertical inspection stands equipped
* with elevator platforms to allow final Q.C. dimensional checks, and a marked floor area where the assemblies are loaded into shipping containers prior to outdoor storage. Each of these stations is physically limited to one fuel assembly except the shipping container which holds two. The assembly storage room can thus contain a maximum of 465 fuel assemblies, 440 storage positions, plus 25 additional locations. All assemblies outside of shipping containers shall be stored vertically within the design spacing criteria of the Assembly Storage Room shown
* on Figure 8.11.

* 1) A 20 x 34 array of assemblies was conservatively modeled at a 9.75 inch center-to-center spacing of fuel assemblies within the double rows. The actual average minimum center to center distance within the fuel storage racks is 10 inches. The distance between rows of fuel assemblies within any given double rack is 35 inches center-to-center while the aisle between the double racks is 37 inches (center-to-center). This
* calculational array effectively brings the 25 additional assemblies closer together and provides greater interaction with the 440 assemblies in the storage area than is actually possible. The calculational array thus contains 680 assemblies while the maximum number in the room is limited to 465. (See Appendix B-1, drawing No. NFM-E-4229, "Criticality Model Fuel Assembly Storage Room." By squaring off the racks and totaling the number of fuel assemblies the
* number 680 is arrived at).

* 2) All steel construction material was neglected.

3) The water mist density has been calculated to be 0.000075 grams per cubic centimeter (see section 8.7). For conservatism a water-mist density of 0.001 grams per cubic centimeter was assumed to be in and around the fuel assemblies in the storage array. (This is a factor of about 13 times higher than the mist density calculated in section 8.7 or about 17 times higher than the mist density calculated in Appendix D for a single sprinkler head at maximum flow and pressure). A uniform

* water film thickness of 0.025 centimeters was assumed on the fuel assembly surface. The actual calculated film thickness with a 15% uncertainty was 0.0094 centimeters (see Section 8.8). This calculated film thickness is for 50 degrees F water, while the minimum ambient temperature is actually higher.

4) One hundred twenty three (123) DLC-16 energy group cross sections were used to calculate the reactivity for an infinite fuel storage array using KENO. The 123 group was collapsed to 16 groups using XSDRNPM end the reactivity calculated for an infinite fuel storage array. The resultant reactivities for 4.1 wt % U235 Fuel were 1.00158 $\pm$ 0.00608 and 1.00074 $\pm$ 0.00569 for the 123 and 16 groups, respectively. Since the reactivities are essentially the same within the statistical uncertainty of KENO the 5.0 wt % U235 finite fuel storage array was done using 16 energy groups.

5) The 16 energy group cross sections were generated using XSDRNPM for the 8" concrete walls, 16 inch concrete floor, 4 inch concrete ceiling and the external water mist between the fuel assembly array and the ceilings and the walls. The 16 group cross section sets described above were then used in KENO-IV to determine the reactivity of the fuel assembly storage area under the above noted conditions for the most reactive assemblies (the 16 x 16 type with the grids being neglected). Dimensional details of the calculational model and the fuel results obtained are shown in Figures 8.10 and 8.11.

* The resulting Keff for the finite fuel storage array is
* 0.842 ± 0.004 which is well below a Keff of 0.95. Using the
* same methodology additional cases were analyzed for a fuel
* enrichment of 4.1 wt % U235 where the fuel assembly center to center spacing and the water film thickness were varied to determine the effect on reactivity.

A tabulation of Assembly Spacing/Mist Density/Film Thickness Reactivity Values follows:

Assembly c/c Spacing	Mist Density	Film Thickness	Reactivity for a Finite Array
9.75"	0.001 gms/cc	0	0.69575 ± 0.00397
9.75"	0.001 gms/cc	0.0094 cm	0.732 ± 0.004 (see note 1)
9.75"	0.001 gms/cc	0.025 cm	0.77224 ± 0.00349
9.75"	0.001 gms/cc	0.055 cm	0.89932 ± 0.00341
10"	0.001 gm/cc	0	0.69913 ± 0.00422
10"	0.001 gms/cc	0.055 cm	0.904562 ± 0.00367

A validation of the methodology used to calculate the reactivity values noted is contained in Appendix C.

The local fire departments have been instructed to use only dry chemical extinguishing methods in the fuel assembly storage room

NOTE 1: This is an interpolated value

and the pellet shop. Signs restricting fire fighting in this area to dry chemical methods only have been posted at each entrance to the assembly storage room. There is only one vehicle access gate to the fuel fabrication facility. Thus, criticality safety is assured under all credible conditions of moderation.

8.5.8 <u>Shipping Container Storage</u>

* Fuel bundle shipping containers (Models 927A1 and 927C1), each containing two fuel assemblies, are stored outdoors in arrays up to three high. The width and length will vary; thus, the quantity of containers is limited only by the width and length of the space allocated for storage. The steel shipping container, approximately 3 feet in diameter and up to 217" long, houses two fuel bundles of the types previously described in this license. The two bundles in each container are separated by six inches. An eight foot high chainlink fence encloses the storage area.

<u>Criticality Safety Analysis</u>

The following conservative assumptions were incorporated into the calculational model of the Shipping Container Storage Area:

* 1) The fuel assemblies are assumed to be made of 5.0 wt.% U235 enriched UO2 with no poison shims. The most reactive assemblies (the 16 x 16 design) were used.

2) The three high double infinite array of shipping
* container was analyzed.

* 3) The containers were assumed to be flooded and the array
* was reflected by 12" of water on the top and bottom of
* the array.

The NITAWL and XSDRNPM codes were used to obtain 16-group cross sections from the 123-group GAM-THERMOS library for input to KENO-IV, the code which was used to determine reactivity of the Shipping Container Storage Area under the conditions noted above. A keff = 0.9245 ± .0057 was obtained for the [illegible] peak reactivity of the system. The density of water within the exterior to the containers was made identical.

Details of the calculational model are shown in figure 8.12. This analysis also provides the basis for considering an open or closed assembly shipping container as an SIU which requires no spacing beyond the physical boundaries of the container. Accordingly, individual containers may be stored in the facility in unrestricted numbers.

8.5.9 Fuel Salvage

Off-specification fuel rods are received one rod at a time in a ventilated hood. The end cap is cut off and zirc chips are vacuumed from the rod. If the rod is not to be unloaded a temporary plug is installed in the rod before it is removed from the hood. If the rod is to be unloaded, the pellets are placed in a 2 inch high pellet grinder tray. The unloading operation is performed with ventilation being drawn across the tray.

This operation is considered a mass limited SIU, with limits taken from Table 4.2.5.

8.5.10 <u>In-Process Storage of Fuel Pellets in Containers</u>

Incoming drums of pellets shall be stored in their original containers only. Two containers are strapped to each

* pallet, one pallet high as required by the NRC certification of compliance. The pallets may be stored inside the Building

* 17/21 complex security fence or inside Building #21 within the

* limits of a Transport Index of 80. In Building #17 three

* pallets can be stored in the Pellet Shop Annex and four pallets

* can be stored in the Pellet Shop Rod Loading Area as discussed

* in Section V.3.18. During storage in Building #17 the pallets

* can be stored next to each other but must be at least one foot

* from process equipment in the area. Arrays of different

* shipping containers shall be separated from each other by at

* least 20 feet.

* 8.5.11 <u>Buckets containing 35.0kg UO_2</u>

* The UO_2 powder and UO_2 pellets may be stored in 5 gallons or

* less enclosed buckets. Normally the powder and pellets will be

* dry. The only time the buckets will be open will be in hoods,

* which will limit the amount of water that can be introduced in

* the bucket from the fire sprinklers.

* <u>Criticality Safety Analysis</u>

* A very conservative analysis was done for the following array

* of buckets filled with UO_2 powder. The conditions,

* assumptions, and results are as follows:

* 1) The steel cylindrical container has an effective inner

* diameter of 10.75" and an effective height of 14.25". A

* 2x2x2 array of containers was analyzed with the buckets in

* the array separated by 1 foot.

2) Each container was filled with 35.0 kg UO_2 enriched at 5.0 wt % U235 and water. The UO_2 was assumed to have a density of 10.96 g/cc. The water was assumed to fill the space not occupied by the UO_2 forming a mixture.

3) The KENO-IV code with sixteen group Hansen-Roach cross sections was used to determine the reactivity at the array of 8 containers. The K_{eff} for the full water density within the array is 0.91011 ± 0.01013. The K_{eff} for an external mist of 0.001 gm/cc is 0.76685 ± 0.00495.

4) To insure that the container with less than 35 kilograms of UO_2 was not more reactive an analysis was done as a function of UO_2 mass in the container. The reduction in the mass in the container results in a higher water to fuel ratio. The KENO results for a 2x2x2 array of containers are shown in Figure 8.13. It can be seen the maximum activity occurs at the 35.0 kilogram limit.

The following analysis was done for a bucket filled with 0.4" diameter pellets.

1) Sintered pellets, when randomly loaded pack to an average density of 5.95 gm/cc, with a one sigma variation of 0.264 as determined from a series of 14 measurements. Thus, at a 95% confidence level, the VH_2O/VUO_2 ratio does not exceed

1.0 and from Fig 1 E.1 of UKAEA Handbook AHSB1, the critical mass for 5.0 wt % U235 at the $VH2O/VUO_2$ of 1.0 is in excess of 200 kg Uranium.

* 8.5.12 Slab Limits for Pellets

* The following analysis was done for a slab filled with 0.4" diameter pellets.

* Pellets, when randomly loaded, pack to an average density of 5.95 gm/cc, with a one sigma variation of 0.264, as determined from a series of 14 measurements. Thus, at a 95% confidence level, the Volume of H_2O to Volume at UO_2 ratio does not exceed 1.0 and from Fig. 1.E.16 of UKAEA Handbook ASHB1, the critical slab thickness is 6.2 inches. Dividing by the safety margin of 1.2 results in a slab thickness of 4.8 inches.

* 8.5.13 Fuel Rod Pre-Stacking Station

Criticality Safety Analysis

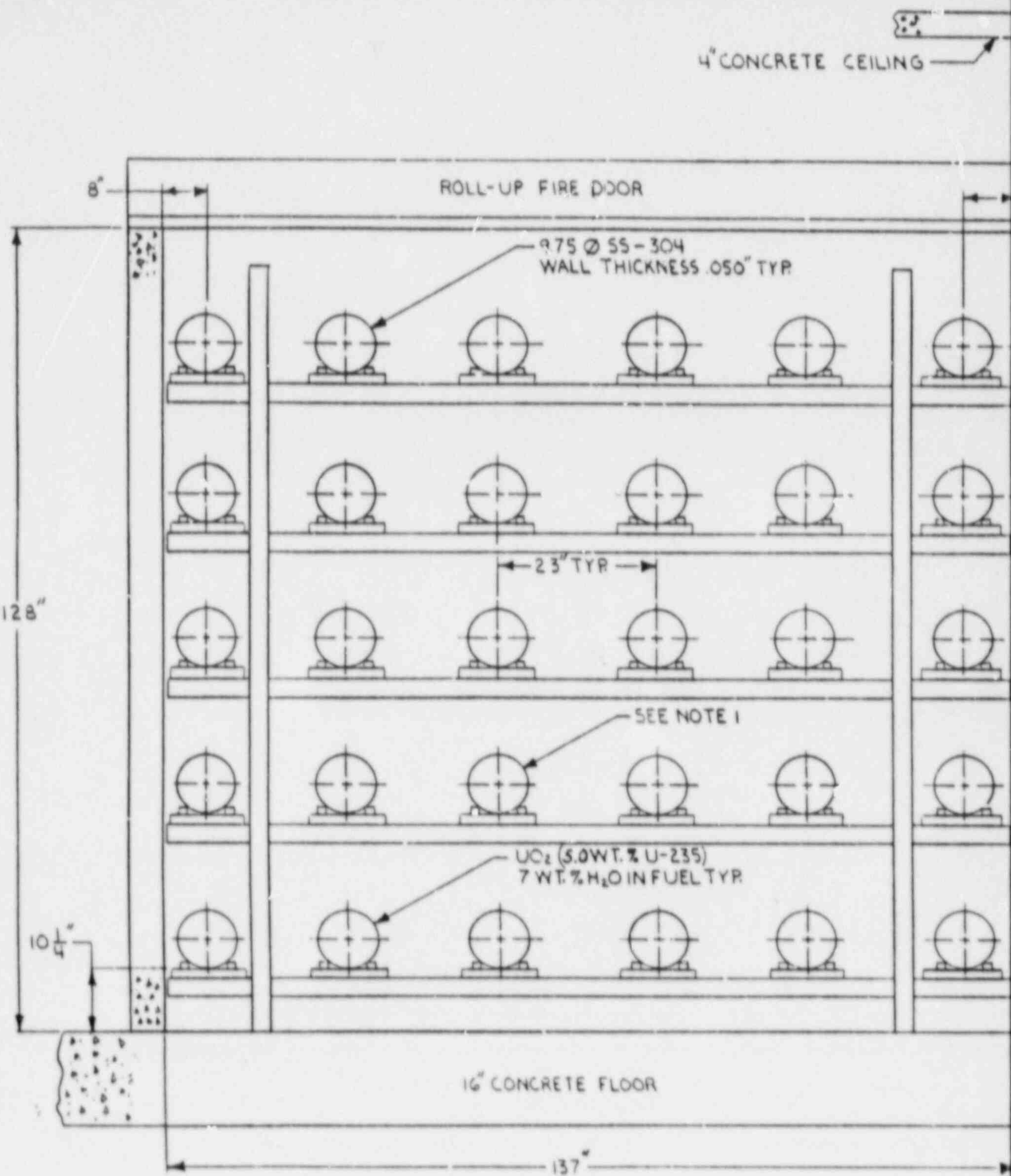
* The following conservative assumptions were incorporated in the calculational model of the Fuel Rod Pre-Stacking Station.

* 1. The three trays on the positioner table are stacked vertically with a distance of 8.5" between the bottom of one tray and the bottom of the next. Each tray was assumed to contain the largest diameter fuel rods (0.44")D) at an enrichment of 5.0 wt % U235. The fuel rods were assumed to be tightly packed in a hexagonal array. The trays were assumed to be 9" wide and filled to a height of 6.1" containing 312 fuel rods each. Each tray was flooded with water. The fuel, clad, and water were homogenized over the volume of the box.
* 2. All structural materials were neglected.
* 3. An external mist of 0.001 g/cc was assumed.
* 4. The concrete ceiling (4") and floor (16") have been included in the calculation.

* The NITAWL and XSDRNPM codes were used to obtain 16-group
* cross sections from the 123-group GAM-THERMOS library for
* input to KENO-IV, the code which was used to determine
* reactivity of the Fuel Rod Pre-Stacking Station under the
conditions noted above. A $k_{eff} = 0.8475 \pm .0054$, was
* obtained for an infinite array of systems 21.0"
* center-to-center in the horizontal direction.

8.6 <u>High Enriched Uranium</u>

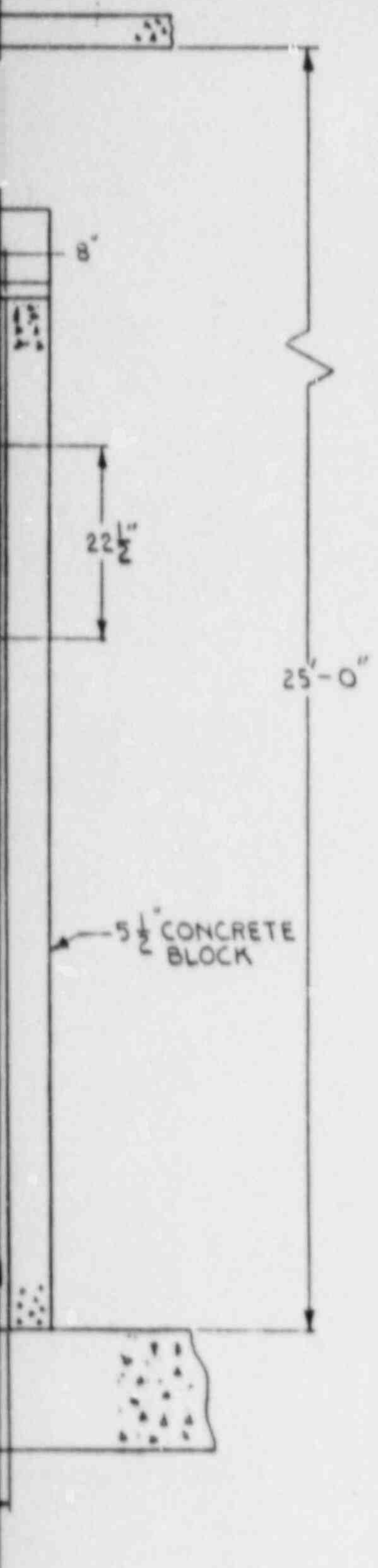
Up to 350 gms U235 of <20% enriched uranium compounds may be allowed in Building #17 and #21 for purposes of evaluation, analysis, or waste management which consists of scanning drums in preparation for their burial. Such material will be transferred, controlled, and accounted for in accordance with currently approved nuclear material control plans, and except for the drums, all material will be placed in discrete locations specifically designated and posted for this material. None of these materials will be processed through manufacturing operations in Building #17 and #21.



VIRGIN POWDER STORAGE AREA

FIGURE 8.1

VIRGIN POWDER STORAGE AREA



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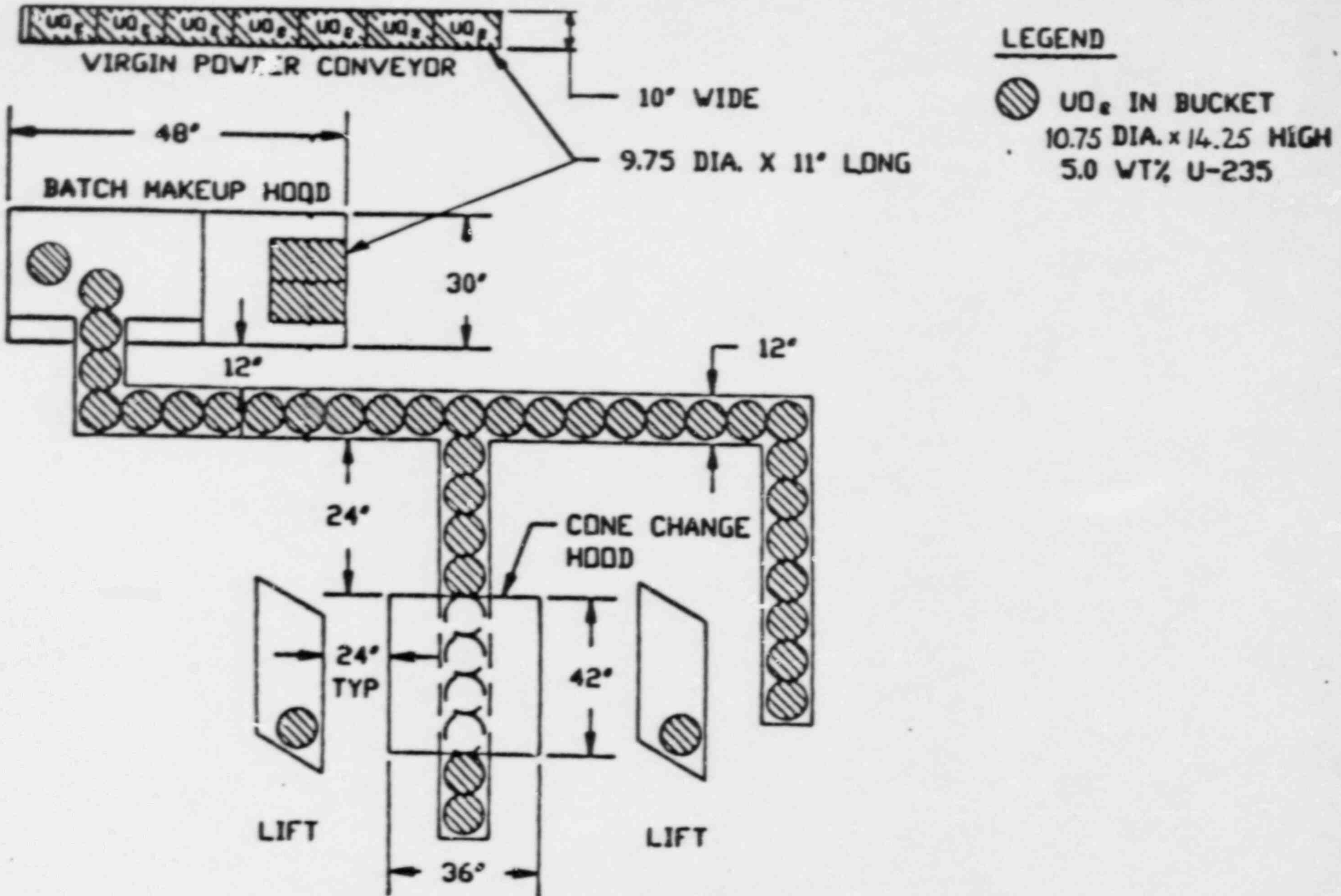


FIGURE 8.2

BATCH MAKEUP HOOD

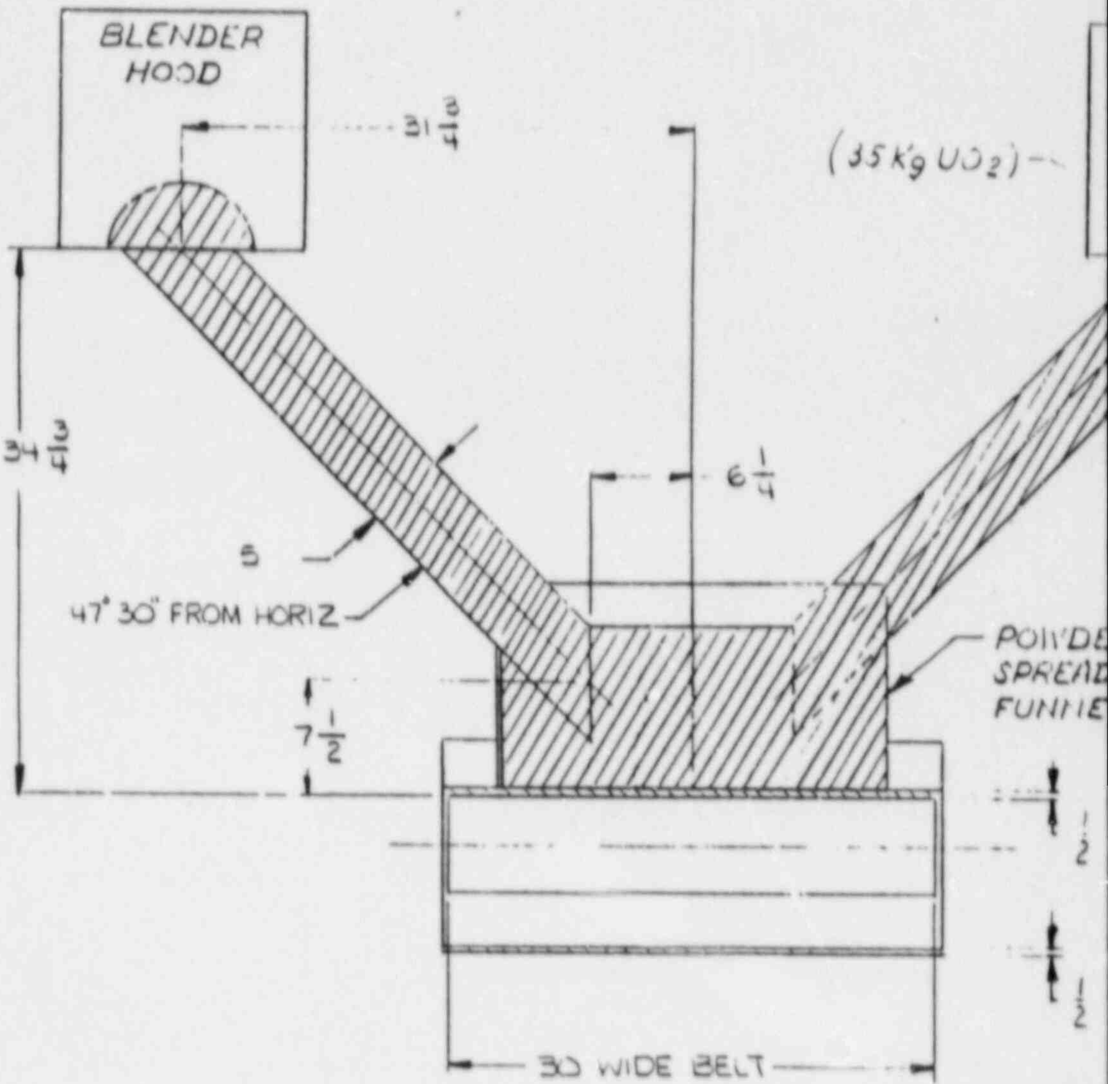
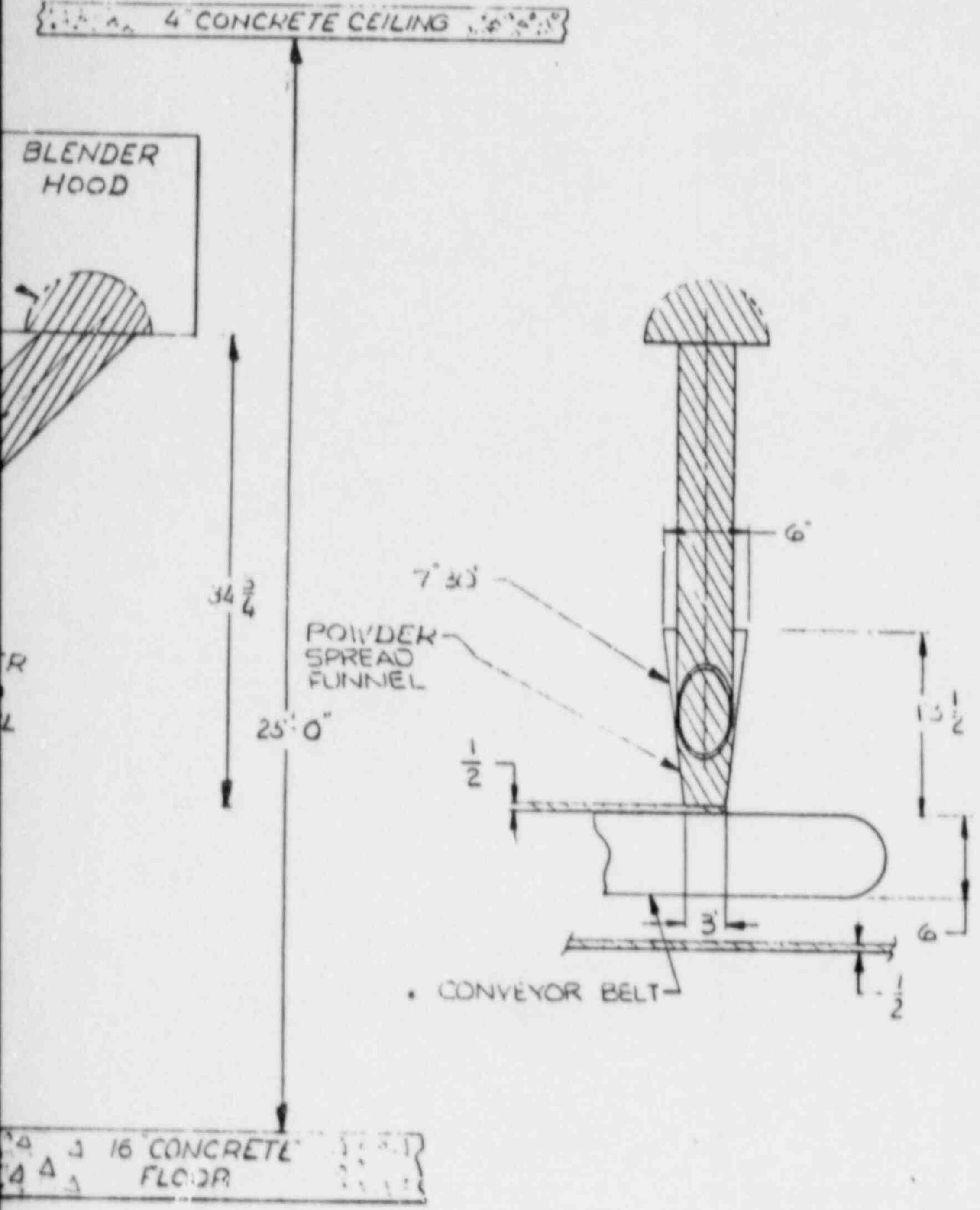


FIGURE 8.3
POWDER PREPARATION STATION-BACK END



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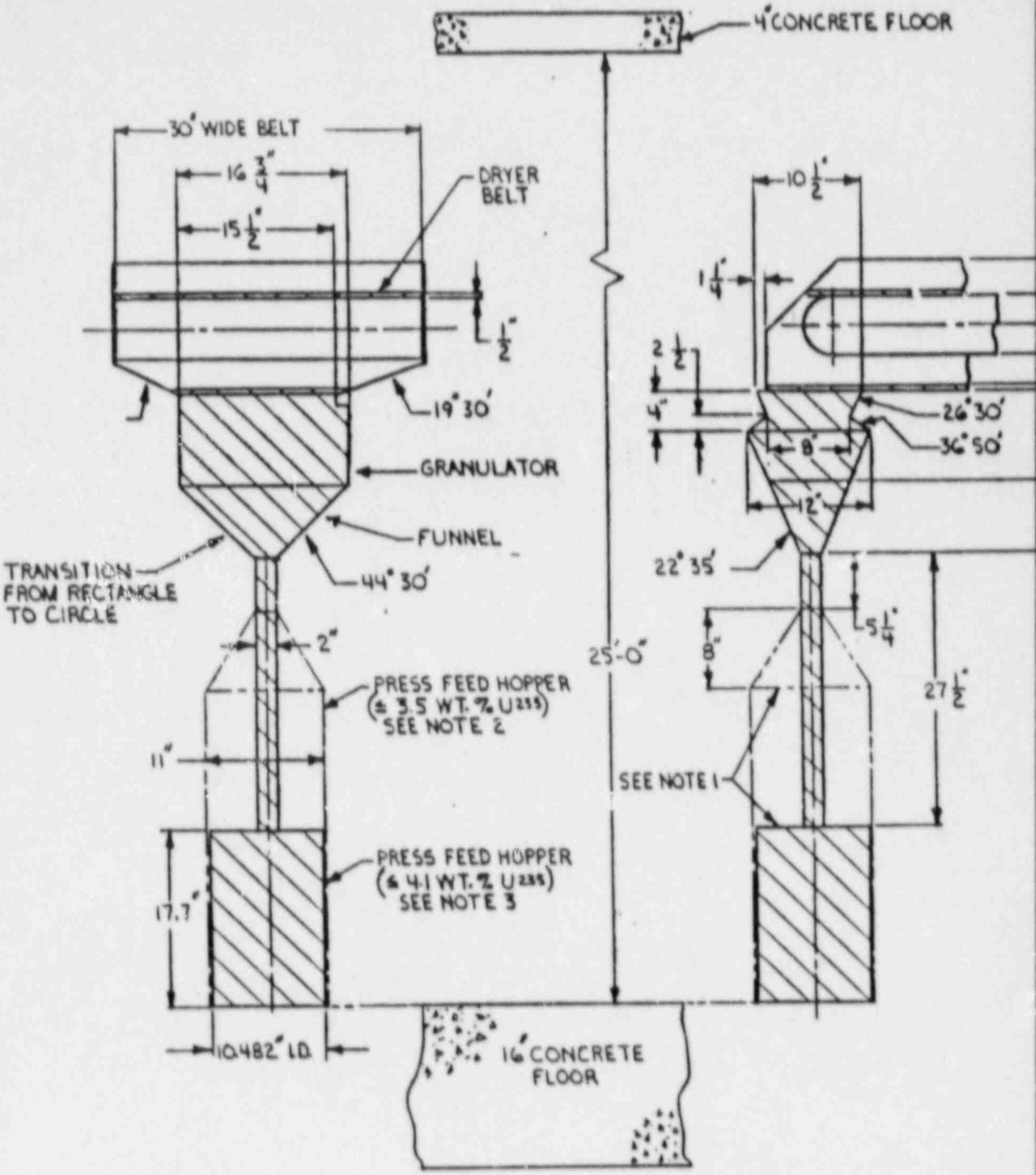

POWDER PREPARATION STATION
(FRONT END)

LEGEND

UO_2 (5.0) - H_2O

3. THE 17.7 HIGH HOPPER IS USED FOR (≤ 4.1 WT % U^{235})

2. THE 40" HIGH HOPPER IS USED FOR (≤ 3.5 WT. % U^{235})

1. TWO PORTABLE PRESS FEED HOPPERS ARE AVAILABLE. DEPENDING ON ENRICHMENT BEING PROCESSED.

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FIGURE 8.4

POWDER PREPARATION STATION - FRONT END CRITICALITY MODEL

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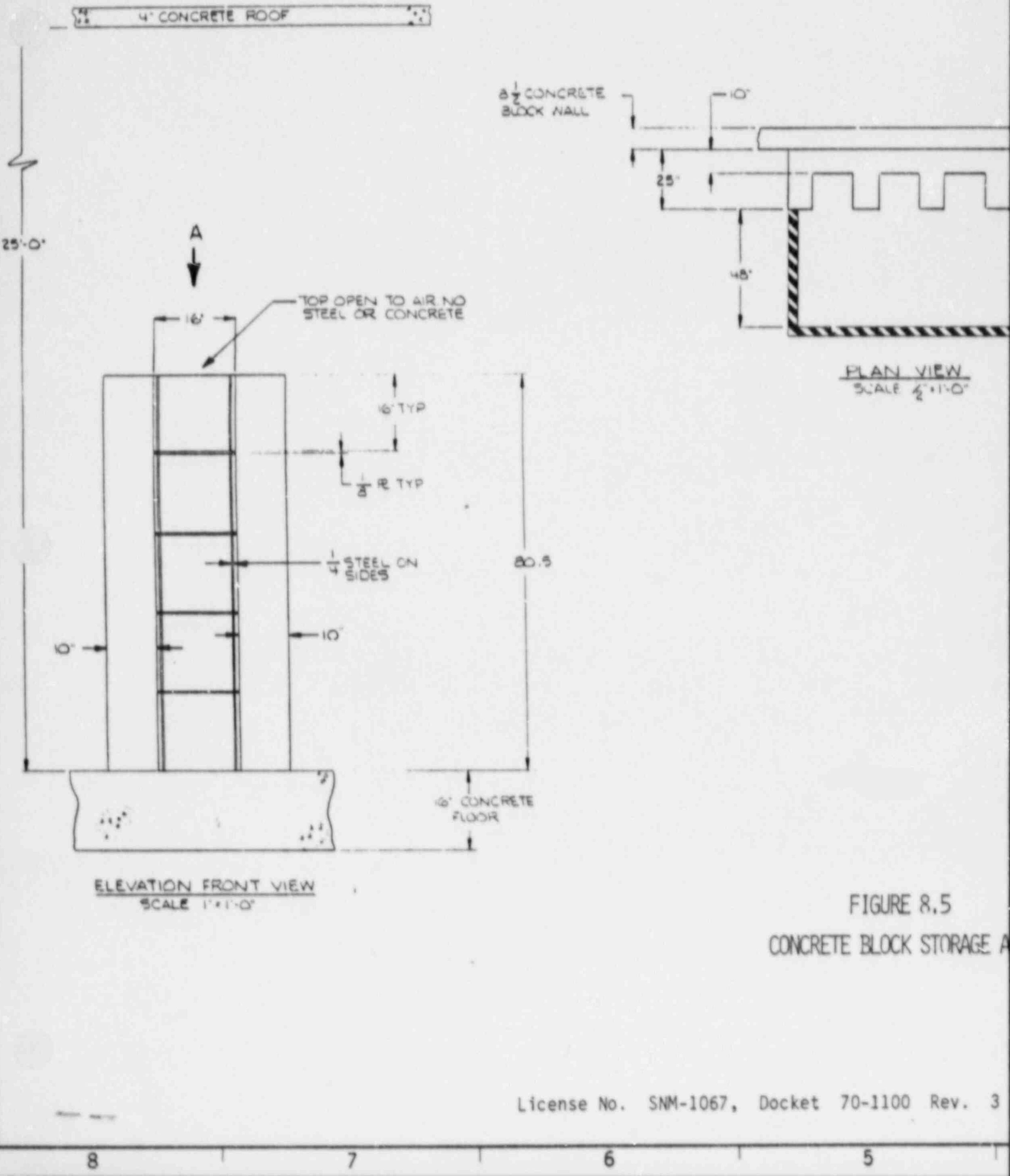
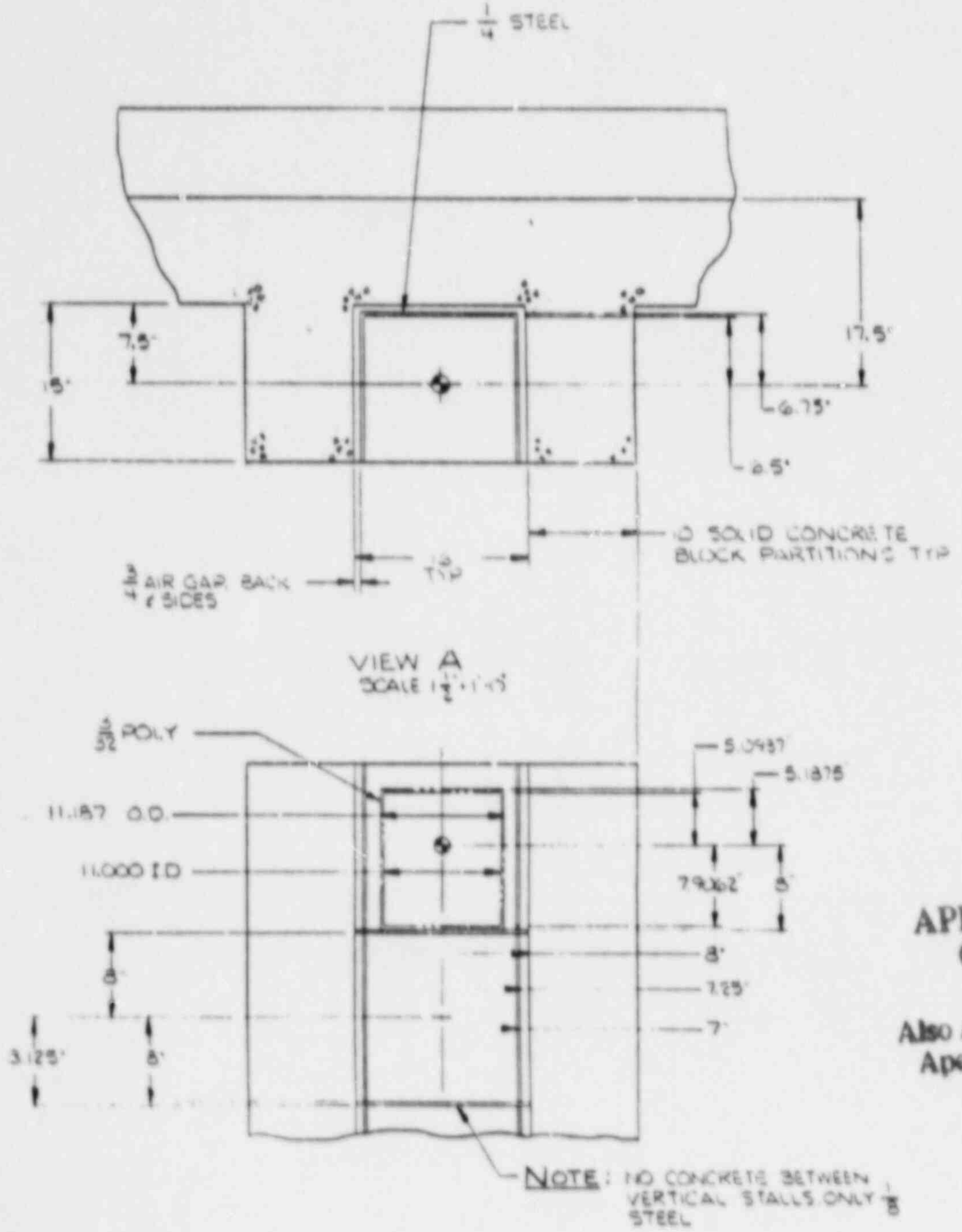


FIGURE 8.5

CONCRETE BLOCK STORAGE A



REA

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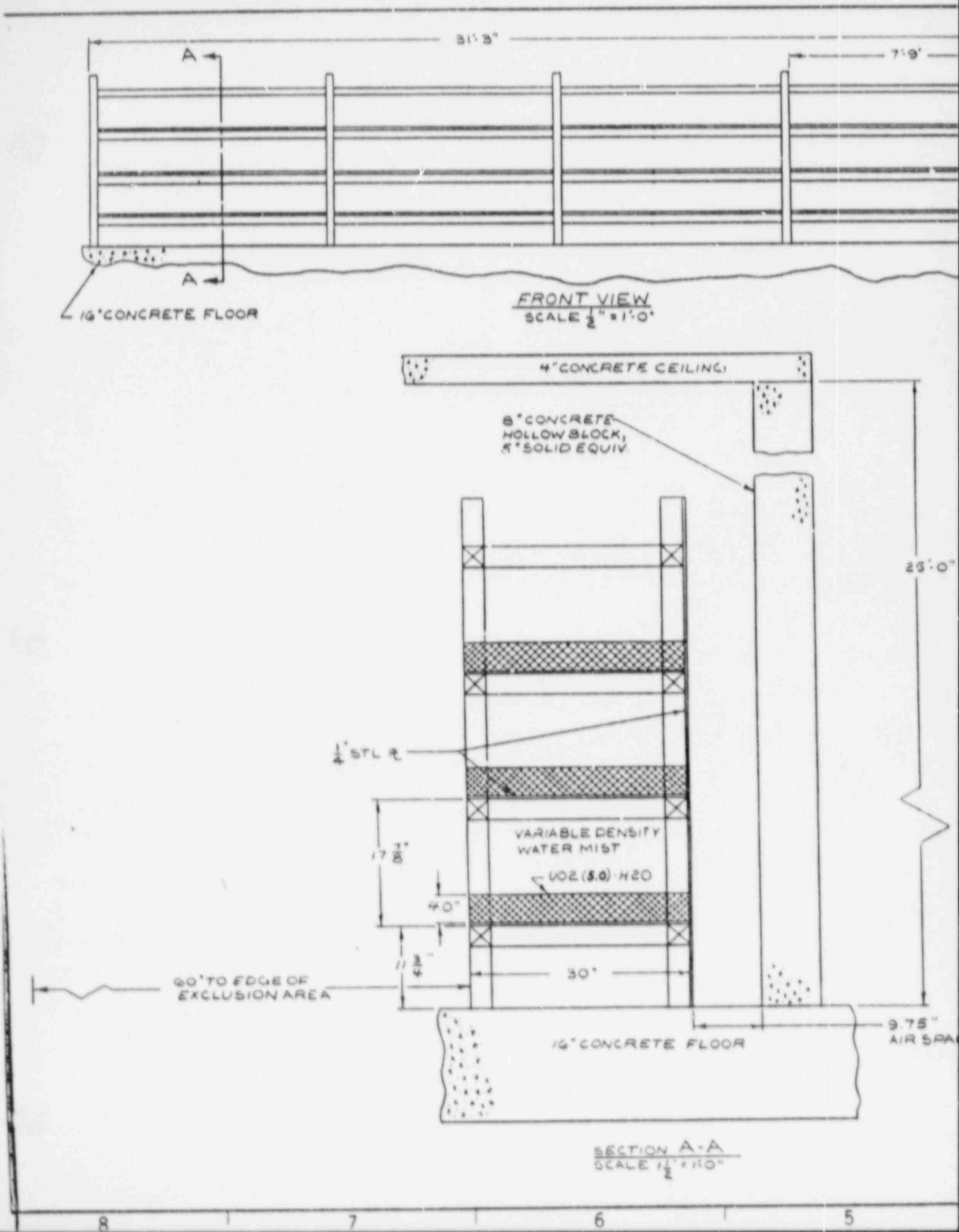

31'-3"
7'-9"
A
A
16" CONCRETE FLOOR
FRONT VIEW
SCALE 1/2" = 1'-0"
4" CONCRETE CEILING
8" CONCRETE HOLLOW BLOCK, 5" SOLID EQUIV.
25'-0"
1/4" STL PL
VARIABLE DENSITY WATER MIST
17 7/8"
UO2 (5.0) H2O
4.0"
11 3/4"
30"
60' TO EDGE OF EXCLUSION AREA
16" CONCRETE FLOOR
9.75" AIR SPA
SECTION A-A
SCALE 1 1/2" = 1'-0"
8
7
6
5

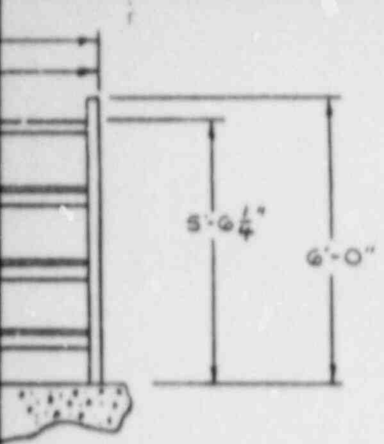


FIGURE 8.6
PELLET STORAGE SHELVES

4 3 2 1

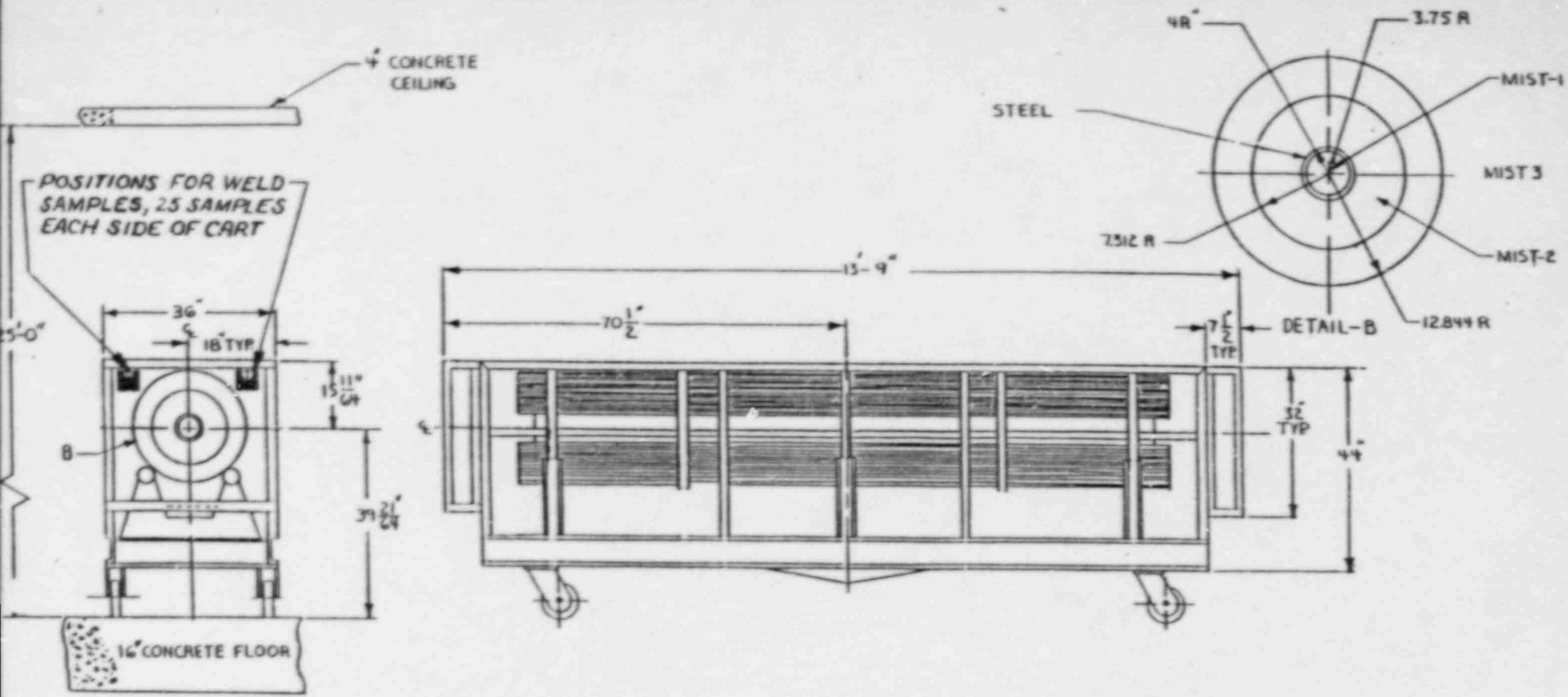
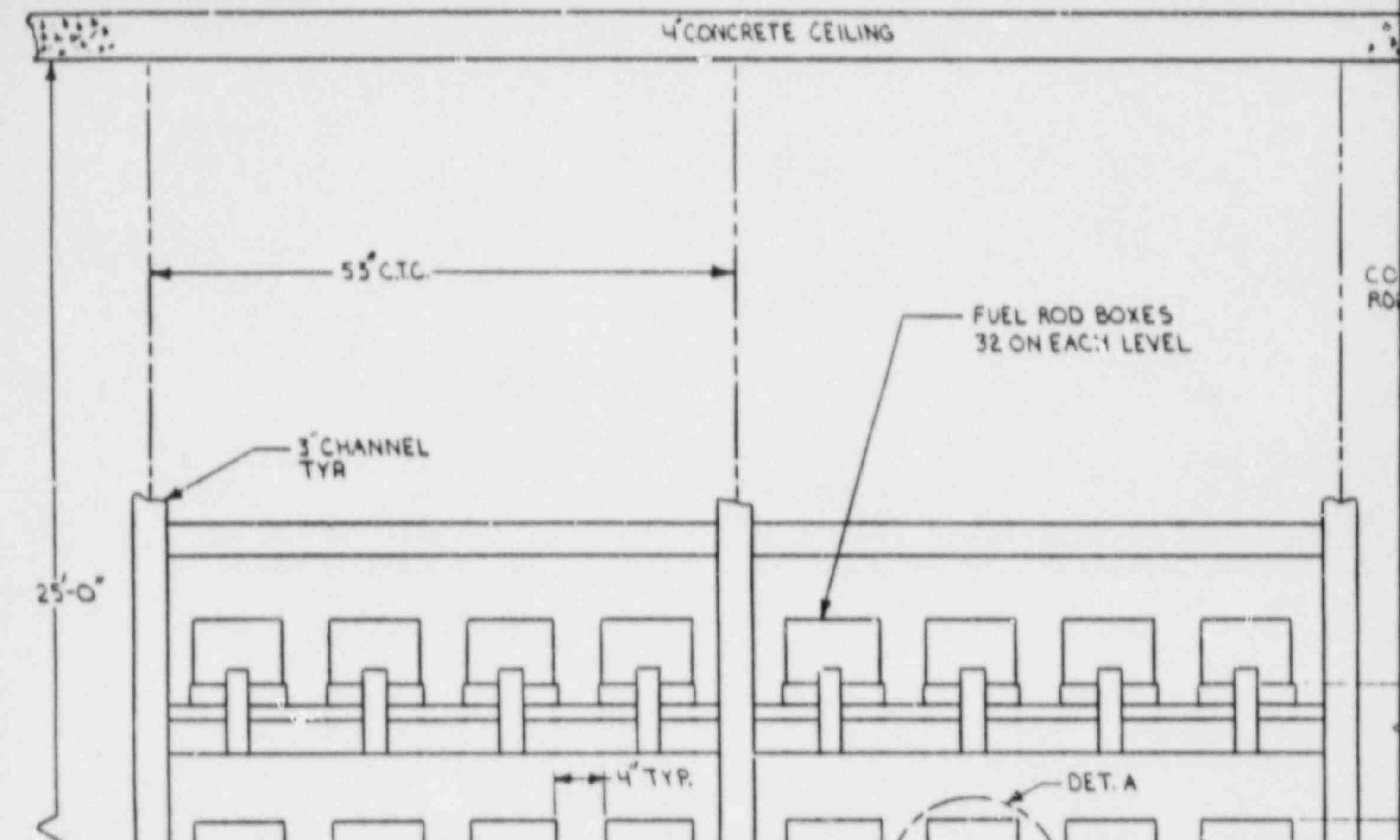


FIGURE 8.7

FUEL TRANS. CART ASSEMBLY

SCALE: $\frac{3}{4}"=1'$



ROD BOX STORAGE AREA

SCALE: 1/8" = 1'

8 7 6 5

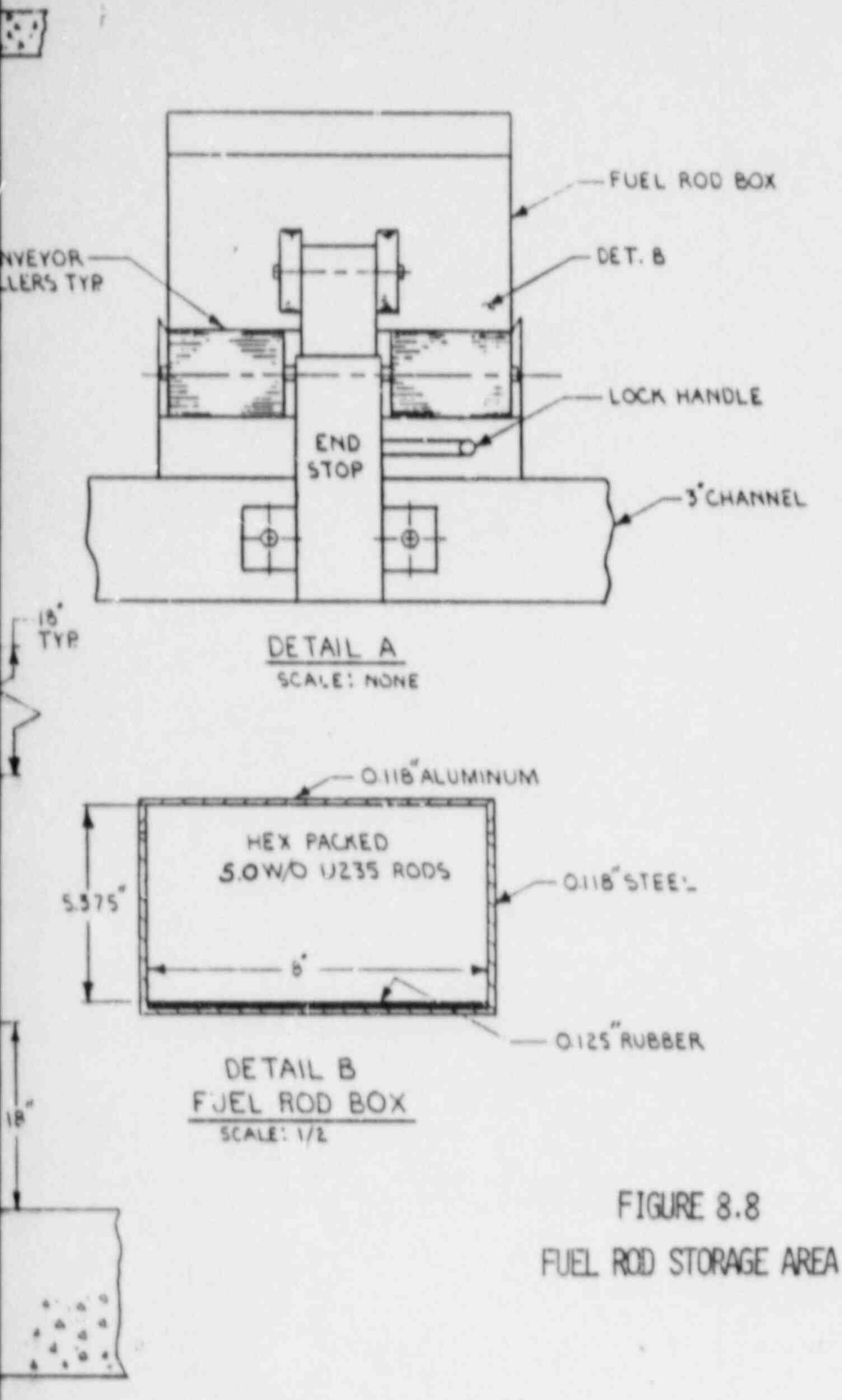


FIGURE 8.8

FUEL ROD STORAGE AREA

SI
APERTURE
CARD

Also Available On
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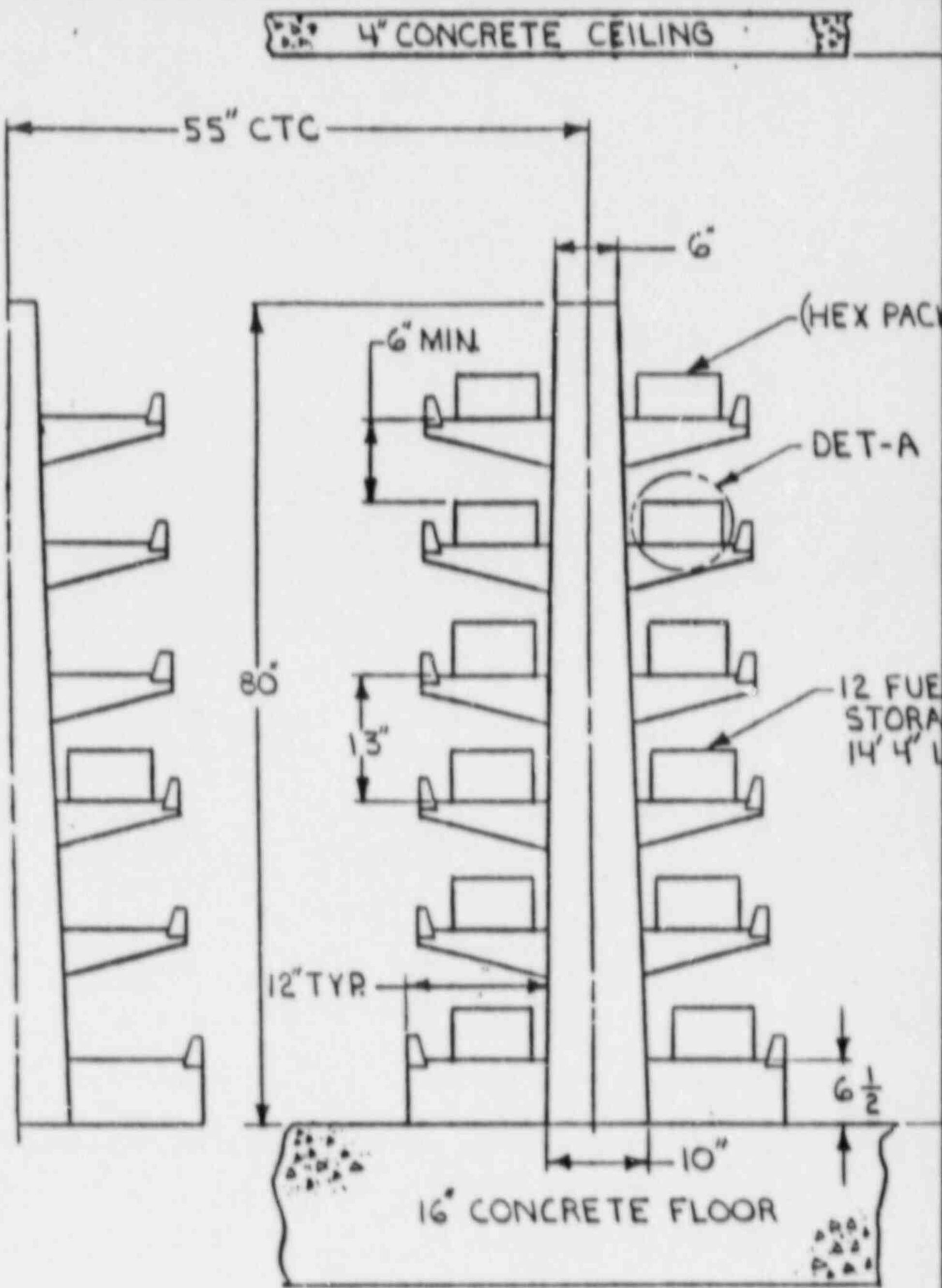

ROD STORAGE RACKS

SCALE: 1" = 1'

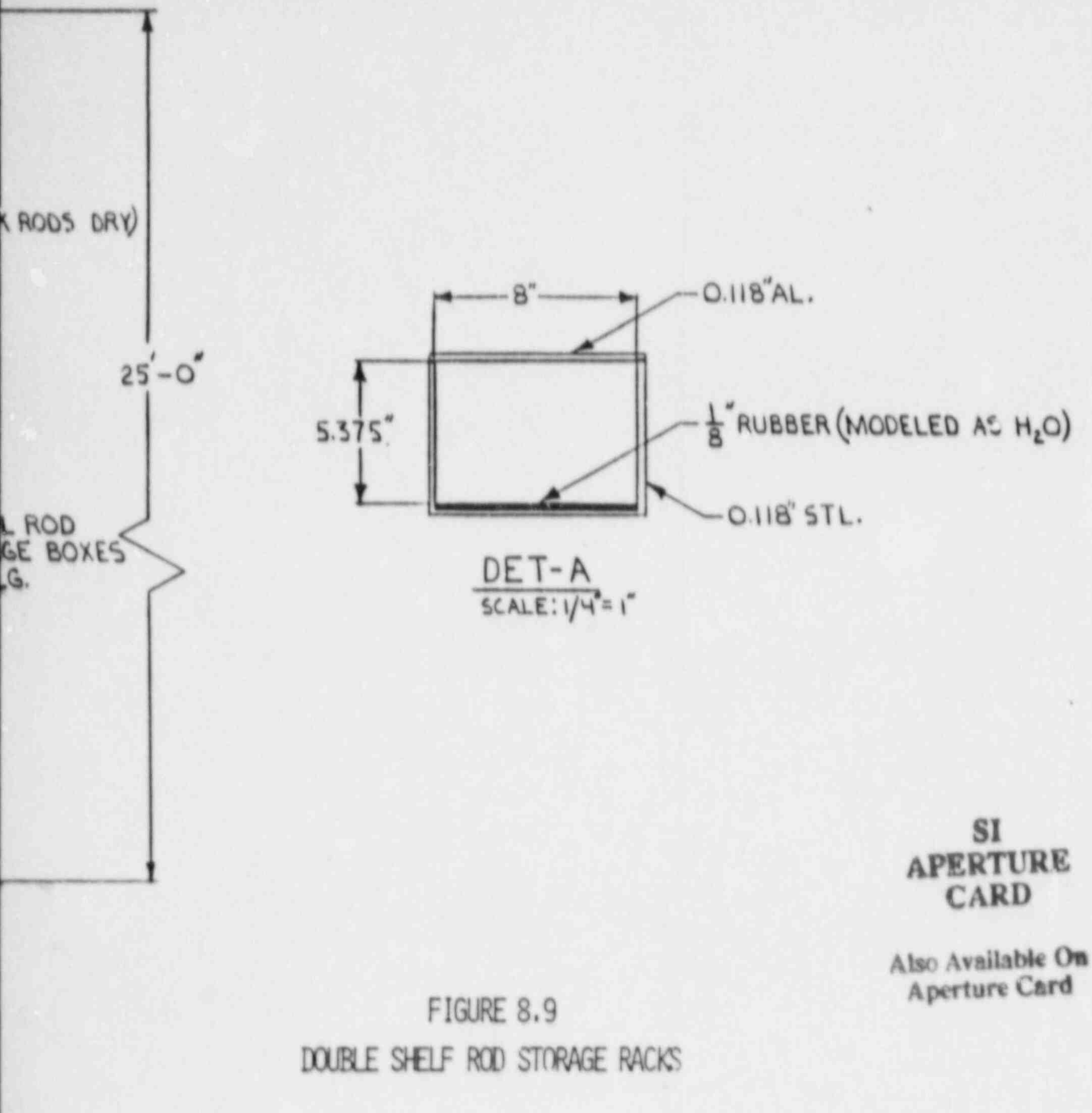

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FIGURE 8.9
DOUBLE SHELF ROD STORAGE RACKS

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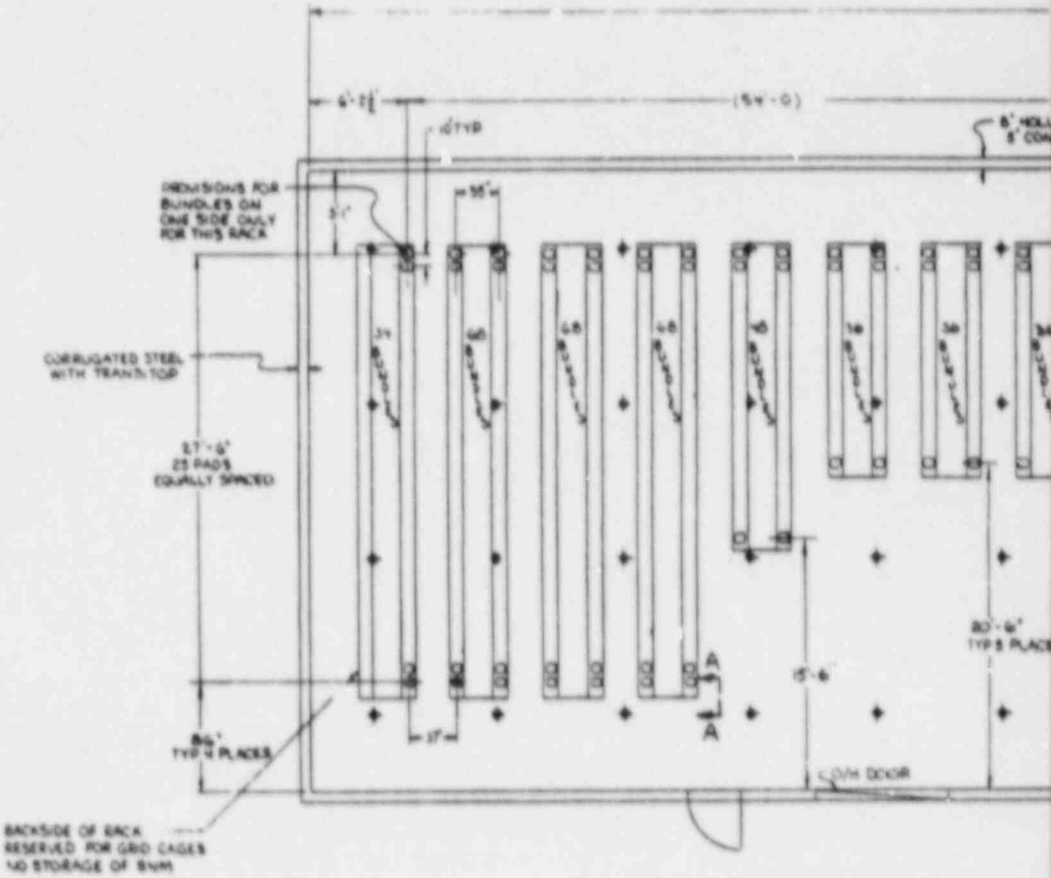
Figure 8.10
Design Parameters of Fuel Assemblies

Fuel Assembly		
Fuel Rod Array per Assembly	14 x 14	16 x 16
Total No. Fuel Rod Positions per Assembly	176	236
Fuel Assembly Pitch, in.	8.180	8.116
Fuel Rod Pitch, in	0.580	0.506
Fuel Rod		
Clad Material	Zr-4	Zr-4
Clad O.D., in.	0.440	0.382
Clad Thickness, in.	0.028	0.025
Diametrical Gap, in.	0.0075	0.0070
Active Length, in.	136.7	150.0
Total Length, in.	146.963	161.5
Fuel Pellet		
Material	UO2	UO2
Dish Depth, in.	0.015	0.019
Diameter, in.	0.03765	0.325
Length, in.	0.450	0.390
Density, g/cc/% Theoretical	10.412/95.0	10.41/95.0
Density Stacked, g/cc/% Theoretical	10.03/91.5	10.03/91.5
Spacer Grid		
Material	Zr-4	Zr-4
No. per Assembly	8	11
		Inconel
		1
K_{eff}	0.90	0.90



FIGURE

CITICALITY

FUEL ASSE

STORAGE R

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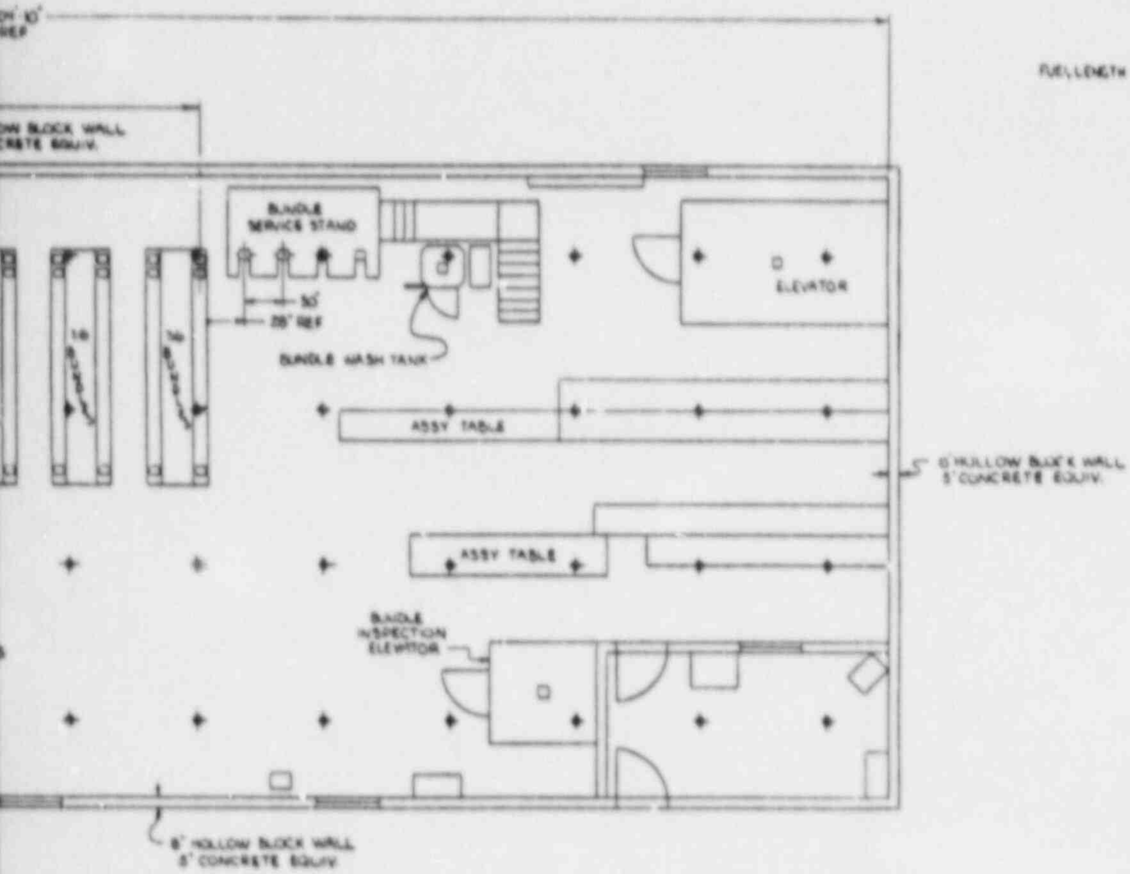

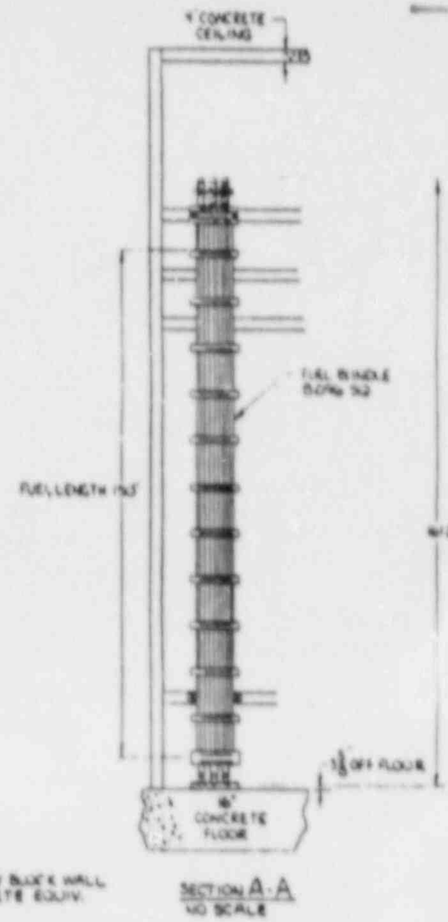

B.11

MODEL

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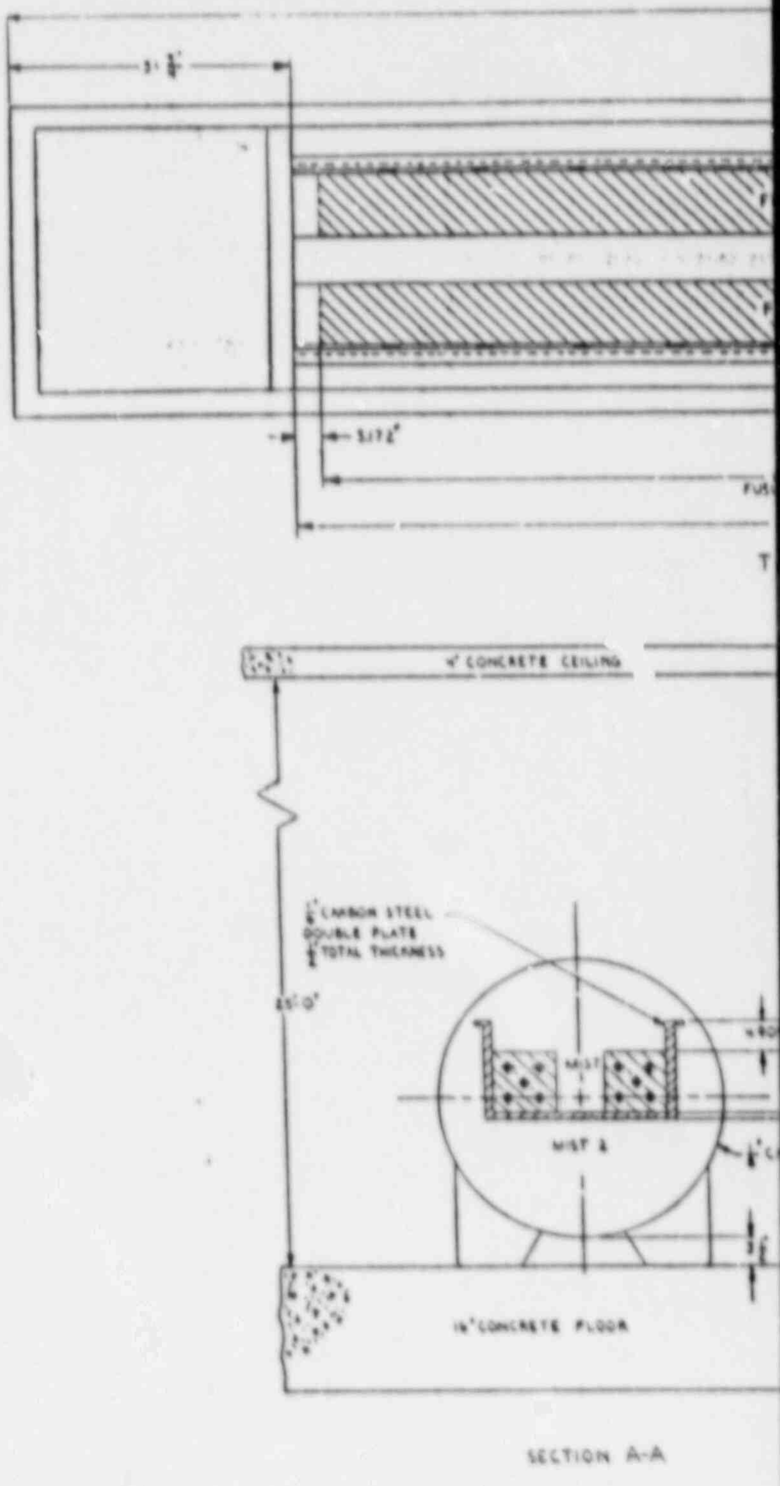

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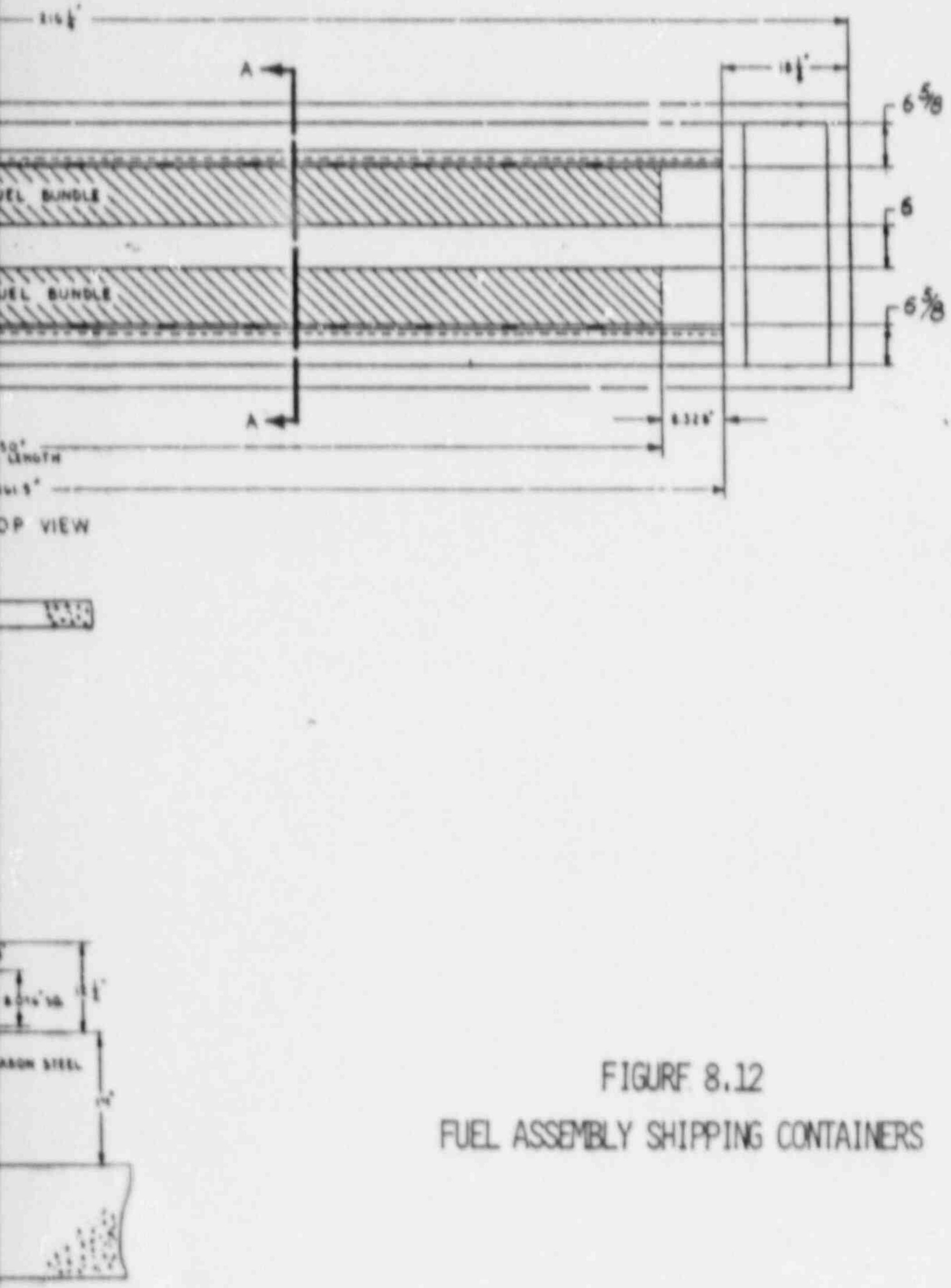

FIGURE 8.12

FUEL ASSEMBLY SHIPPING CONTAINERS

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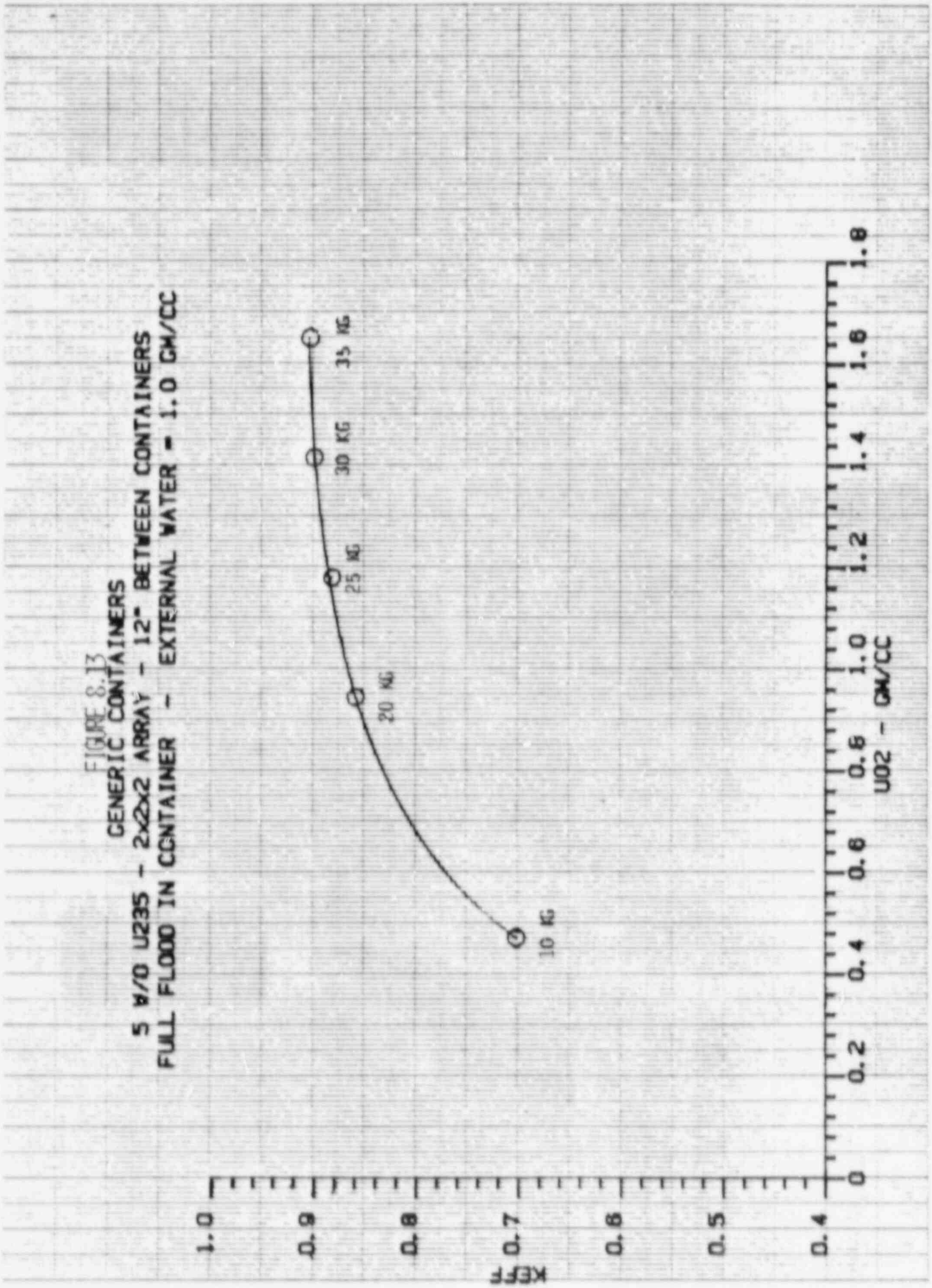
FIGURE 8.13
GENERIC CONTAINERS
5 W/O U235 - 2x2x2 ARRAY - 12" BETWEEN CONTAINERS
FULL FLOOD IN CONTAINER - EXTERNAL WATER - 1.0 GM/CC
10 KG
20 KG
25 KG
30 KG
35 KG
KEFF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
UO2 - GM/CC
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8