Nuclear

GPU Nuclear Corporation
Post Office Box 480
Route 441 South
Middletown, Pennsylvania 17057-0191
717 944-7621
TELEX 84-2386
Writer's Direct Dial Number:

(717) 948-8461

4410-86-L-0086
Document ID 0429A

May 29, 1986

TMI-2 Cleanup Project Directorate
Attn: Dr. W. D. Travers
Director
US Nuclear Regulatory Commission
c/o Three Mile Island Nuclear Station
Middletown, PA 17057

Dear Dr. Travers:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Annual Update of the Fuel Canister Storage
Racks Technical Evaluation Report

Pursuant to your letter of February 4, 1982, attached is the annual update to the Technical Evaluation Report for the Fuel Canister Storage Racks. This revision corrects the height-weight restrictions imposed for load handling over the fuel canister storage racks and reflects the final design report of the fuel canister storage racks.

The correction to the load handling guidelines is significant in that it generally reduced the allowable lift height for loads less than 3355 pounds. Movement of loads weighing greater than 3355 pounds are prohibited over the fuel canister storage racks; consequently they are unaffected by the revision. Because of the reduction in allowable lift heights, GPU Nuclear performed a review in accordance with 10 CFR Part 21 to determine if a substantial safety hazard was created. This review determined that any offsite release resulting from a load drop would constitute a small fraction (i.e., less than 5%) of the 10 CFR Part 100 limits. Therefore, a substantial safety hazard was not created and this deviation is not reportable pursuant to 10 CFR Part 21.

Sincerely,

F. R. Standerfer
Vice President/Director, TMI-2

D009
1/1

FRS/RDW/eml

Attachment

GPU Nuclear

TER 3253-012 15737-2-G03-113 REV. 1

ISSUE DATE January 29, 1985

☐ ITS
☒ NSR
☐ NITS

TMI-2
DIVISION
TECHNICAL EVALUATION REPORT
FOR

Fuel Canister Storage Racks

COG ENG C. L. Rid DATE 1/29/85
RTR E. T. Smith DATE 1/29/85
COG ENG MGR. C. L. Rid for R. L. Rider DATE 1/29/85

NO	DATE	REVISIONS	BY	CHECKED	GROUP SUPERVISOR	MGR DESIGN ENGINEERING
1	5/2/86	Revised to Perform General Update	[illegible]	[illegible]	ETS	CR
0	1/29/85	Issued For Use	[illegible]	[illegible]	ETS	CR
				CHIEF ENGINEER		

8606030131 860529
PDR ADOCK 05000320
P PDR

EPD-33812 10/84

Rev.	SUMMARY OF CHANGE
0	Issued For Use
1	Updated to reflect final design report for the fuel canister storage racks and to correct the load handling guidelines in section 3.2.

SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.	SHEET	LATEST REV.
1	1												
2	1												
3	1												
4	1												
5	1												
6	1												
7	1												
8	1												
9	1												
10	1												
11	1												
12	1												
13	1												
14	1												
15	1												
16	1												
17	1												
18	1												
19	1												
20	1												

GPD-33000-T 10/83

BECHTEL

REVISION STATUS SHEET

DOCUMENT TITLE: Technical Evaluation Report for Fuel Canister Storage Racks

JOB 15737

SPEC NO 3253-012 15737-2-G03-113

REV. 1

Table of Contents

1.0 INTRODUCTION

1.1 General/Purpose

The Fuel Canister Storage Racks (FCSR) are utilized to provide storage for the three different types of canisters (fuel, filter and knockout) which are filled with materials from the TMI Unit 2 reactor core. Storage for a total of 263 canisters is available in the racks which are located in spent fuel pool A and the deep end of the fuel transfer canal (FTC). The purpose of this Technical Evaluation Report (TER) is to evaluate the FCSR to assure they do not create an undue risk to the health and safety of the public.

1.2 Scope

The scope of this TER includes the design of the FCSR and the activities associated with the installation and use of the racks during defueling. Also included, is a discussion of structural and seismic concerns related to the FCSR.

The criticality analyses for the FCSR are not within the scope of this TER. These analyses are addressed in the TER for Defueling Canisters, Reference 1.

2.0 RACK DESCRIPTION

2.1 Codes and Standards

The FCSR are designed in accordance with the following:

A. ASME Code, Section III, Subsection NF, 1983 Edition.

B. USNRC Regulatory Guide 1.92, "Combination of Modes and Spatial Components in Seismic Response Analysis," Rev. 1, February 1976.

C. USNRC Standard Review Plan (SRP), 9.1.2, "Spent Fuel Storage," July 1981.

D. USNRC "Position Paper for Review and Acceptance of Spent Fuel Storage and Handling Applications," April 14, 1978 and Supplement, January 18, 1979.

E. AISC, Manual of Steel Construction, Eighth Edition, 1980.

F. AISI, Stainless Steel Cold-Formed Structural Design Manual, 1974 Edition.

G. USNRC SRP 3.8.4 - "Other Category I Structures," July 1981.

H. USNRC Regulatory Guide 1.61 "Damping Values for Seismic Design of Nuclear Power Plants," October 1973.

2.2 Rack Locations

Racks for storing the three types of defueling canisters are installed at two locations in TMI-2, these locations are:

1. The deep end of the fuel transfer canal, within the containment, contains 11 canister storage cells. The materials for these racks was taken through the containment personnel air lock and assembled inside the containment. The rack arrangement is shown in Figure 1.

2. Fuel pool "A" in the Fuel Handling Building (FHB) contains an additional 252 fuel canister storage cells. These racks are modular and were transported to fuel pool 'A' as 4, 9 x 7 assemblies. The rack arrangement is shown in Figure 2.

2.2.1 Fuel Transfer Canal

The FCSR in the deep end of the FTC are layed out in a C-shaped array, with 11 storage locations and are seismically designed in order to protect the FCSR should long term storage of canisters become necessary. The racks are constructed of 14.4 inch square ID cells connected by means of tie plates welded intermittently along their entire heights. The cells are made of 0.12-inch thick 304L stainless steel sheets and are assembled in an 18.5-inch center to center spacing in the east-west direction, and 18-inch center to center spacing in the north-south direction. The rack includes a bottom support plate and swiveling, adjustable pads to contact the canal floor. The rack is designed to resist lateral loads by means of 10 support points that interlock the rack with the existing structural embedment bracket near the top of the south wall of the deep end of the fuel transfer canal. The overall height of the cells is 167.25 inches with an internal height of 150 inches, the tops of the canisters will be flush with the tops of the cells. Figure 3 shows a schematic drawing of the rack array. These racks are classified as Nuclear Safety Related (NSR).

2.2.2 Spent Fuel Pool

The FHB FCSR are comprised of four free-standing 9 x 7 modules and are seismically designed in order to protect the FCSR should long term storage of canisters become necessary. The racks are constructed from Type 304L stainless steel cells, 18.0-inch square nominal OD by 0.090-inch walls. The cells are connected by tie angles to form a continuous honeycomb structure which is rigid and dimensionally stable. The cell center to center spacing is maintained at a nominal 18.0 inches. The canisters are laterally supported at top and bottom by guide collars that are flared to facilitate insertion. Each storage chamber has an interior height of 150 inches to ensure that the tops of the cells are flush with the tops of canisters when the canisters are fully inserted. The bottom of each storage cell sits on and is welded to the rack base plate. The rack base plate has swiveling, adjustable support pads to contact the pool floor. Sufficient space is provided between adjacent racks and between racks and pool structures and walls to preclude impact/collision in the event that the rack assemblies slide on the fuel pool floor during a seismic event. Figure 4 shows a schematic of a 9 x 7 rack. These racks are classified as NSR.

3.0 TECHNICAL EVALUATION

The technical evaluation for the FCSR includes five separate areas: structural and seismic, load drops, criticality, occupational exposure and thermal loads. Each of these areas is addressed individually.

3.1 Structural and Seismic

Both structural and seismic analyses of the TMI-2 FCSR were performed to verify the adequacy of the design to withstand the loadings encountered during handling, shipping, installation, normal operation, severe and extreme environmental conditions of Safe Shutdown Earthquake (SSE), Operating Basis Earthquake (OBE, herein equated to 1/2 SSE), and impact loadings resulting from a dropped canister.

The following is a summary of the results of the structural and seismic analyses:

1) The results of the seismic and structural analyses indicate that the stresses in the rack structure resulting from the specified load cases are within allowable stress limits.

2) Sloshing of pool water during a seismic event has insignificant effects on the fuel storage racks.

3) The maximum rack cell displacement for the free standing 9 x 7 modular rack (rack sliding plus cell top deflection) is less than the 8-inch minimum clearance provided between the pool walls and racks, and less than the 3.5-inch minimum clearance provided between adjacent racks. Therefore, it has been concluded that even if adjacent racks simultaneously slide and deflect toward each other the gaps provided are sufficient to preclude any collision during an SSE.

3.1.1 Load Conditions

The following load conditions are considered in the analysis of the canister storage racks.

3.1.1.1 Load Definitions

A. Normal Loads

D = Dead load of racks and supporting framing
L = Live load due to weight of fuel canister
T_o = Thermal effects and loads during normal operating and shutdown conditions ($T=54^oF$)

B. Severe Environmental Loads

E = Loads generated by the OBE (including loads generated by wave action, i.e., sloshing)

C. Extreme Environmental Loads

E' = Loads generated by the safe shutdown earthquake (SSE) (to include loads generated by wave action, i.e., sloshing)

D. Abnormal Loads

T_a = Thermal effects and loads generated by maximum pool temperature differential
P_f = 6000 lb maximum upward load applied at any point on the racks
P_d = Fully loaded canister load drop onto the racks

3.1.1.2 Load Combinations

The fuel canister storage racks are proportioned to maintain elastic behavior. When subjected to various combinations of gravity, thermal, and accident loads, elastic behavior is considered limited by the yield stress (Sy) of the effective load-carrying structural members. Yield stresses for stainless steel are the values of "Sy" at the temperatures as outlined in ASME Section III, Subsection NF.

The following load combinations are satisfied:

A. For Elastic Analysis	Acceptance Limit
1) D + L	Normal limits of NF 3231.1a
2) D + L + T_o	Normal limits of NF 3231.1a

3) $D + L + T_o + E$ — Normal limits of NF 3231.1a

4) $D + L + T_a + E$ — Sy

5) $D + P_f$ — Sy

6) $D + L + T_a + E'$ — Faulted condition, Limits of NF 3231.1c

7) $D + L + F_d$ — The overall structural integrity of the racks shall be demonstrated

B. For Limit Analysis

The following load combinations will be subjected to the limits of ASME Code Section III, Appendix XVII Paragraph 4000:

1) $1.7 (D + L)$

2) $1.7 (D + L + E)$

3) $1.3 (D + L + T_o)$

4) $1.3 (D + L + E + T_o)$

5) $1.1 (D + L + T_a + E')$

The fuel canister storage racks are designed to withstand the impact energy of a postulated defueling canister drop. The design drop height from the canister transfer shield (CTS) is a total of 6'-1.5" in air and 6'-6" in water. Damage to the FCSR caused by such an accidental drop is limited to the area of impact and does not cause a reduction in the spacing between canisters to less than the 17.3 inches used in criticality analyses for the defueling canisters. Additionally, damage to the liner does not result as the FCSR absorbs the energy from the impact of the dropped canister and transmits that energy to the liner plates via the support pads. In addition, the storage racks are designed to preclude a canister from falling between canister positions. The design of the rack includes provisions to prevent a canister which is dropped outside of the rack from leaning against the rack or rolling against the rack so that the side of the dropped canister is less than 4 inches from the side of the nearest canister in the rack.

3.1.2 Stress Analysis

The analyses of the FCSR subjected to the specified static and dynamic loading conditions have been performed by means of linear elastic and non-linear methods implemented through finite element techniques. The impact effects of the canisters striking against the storage cells have been considered. For the fuel pool rack modules which are "free standing" in design (modules are free to slide on the pool floor), non-linear time history dynamic analyses have been performed to evaluate sliding, tipping, maximum friction and fall back reaction load of the canister storage rack during a seismic event. Partially loaded, fully loaded and empty rack conditions have been considered in the non-linear time history dynamic analysis. Non-linear analysis and energy balance techniques have been used to evaluate structural damage due to canister drop accident event. For the specified loading conditions, the maximum stresses and deflections of the rack structure have been calculated and shown to be less than the allowable values.

3.1.2.1 Method of Analysis

The basic rack seismic stress analysis steps are outlined below.

A. Detailed finite element models of all rack module types were developed using beam and plate elements for computer analysis using the ANSYS computer code.

B. Modal analysis was performed to determine maximum seismic response for the 3 and 4-cell FTC rack modules.

C. Three dimensional beam type non-linear models of the combined rack and contained canisters were developed using data from the detailed finite element models for the 9 x 7 modules.

D. Sliding analyses were performed on the non-linear models of step C assuming fully loaded, partially loaded, and empty 9 x 7 racks to determine pool floor loads and maximum rack displacement.

3.1.2.2 Detailed Finite Element Models

Detailed three dimensional finite element models of the racks were used to provide the dynamic characteristics used in the non-linear models and for the detailed stress evaluation. In the vertical direction the nodes are spaced closer together to allow more detail in the higher stress areas.

3.1.2.3 Results of Stress Analysis

The racks are designed to ensure that the stresses resulting from the specified load cases are maintained within allowable stress limits defined in section 3.1.1.2 above.

The analyses of the accidental load drops indicate acceptable local structural damage to the storage cells with no buckling or collapse, and thus no significant effect on the cell spacing.

3.1.3 Sliding Analysis

The sliding and stability analysis for the 9 x 7 rack module uses the 3-dimensional non-linear time-history analysis method described below. For the Reactor Building storage racks, the computations are based on energy principles utilizing the results of the modal analysis.

3.1.3.1 Method of Analysis

Detailed simultaneous, three directional non-linear time history seismic analyses were performed to evaluate the maximum sliding and tipping motions of the 9 x 7 canister racks and to determine the maximum frictional resistance load transmitted by the racks to the pool floor liner plate during an SSE.

In order to perform the non-linear time history seismic analysis of the canister spent fuel assembly/storage cell structure, a 9 x 7 spent fuel rack and the stored fuel assemblies were represented by a three dimensional beam type finite element model. Using computer analysis, the effects of impact, friction, and hydro-dynamic coupling are included in the step by step procedure of the code.

In order to account for canister impact, adjacent masses of the canister beam and the spent fuel rack beam are laterally coupled by means of non-linear spring/gap elements. The non-linear spring/gap elements permit the adjacent masses to impact each other whenever the gap closes during a seismic event. The stiffness of the non-linear spring is taken as the local stiffness value of the canister/cell impact surface. An initial gap reflecting the lateral gap between the canister and the storage cell wall is provided. The non-linear spring/gap elements are effective for canister impact on either side of the storage cell.

The combined model representing the storage cells and the canisters are attached to the pool floor by means of the non-linear sliding element to best represent the rack standing freely on the pool floor. The sliding of the rack is initiated when the lateral force in the sliding element exceeds the frictional resistance force which is equal to the coefficient of friction times the vertical weight of the rack.

3.1.3.2 Sliding Analysis

The non-linear time history seismic analysis of the Three Mile Island 2 free-standing fuel canister storage racks was performed using the ANSYS computer program.

Two extreme cases of coefficient of friction between the rack and the pool have been postulated; 0.2 and 0.8. Each of the two cases of partially full and completely full rack has been analyzed for these two friction coefficients. The empty rack condition has been analyzed only for the low coefficient of friction. The lower coefficient gives the maximum sliding distances, while the higher coefficient gives maximum tipping and shear forces transferred to the pool floor.

The maximum rack cell displacment (rack sliding plus cell top deflection) is limited to less than the 8-inch minimum clearance provided between the pool walls and racks, and less than the 3.5-inch minimum clearance provided between adjacent racks.

3.2 Load Drops

The FCSR are designed to withstand the impact energy of a postulated defueling canister drop. The maximum design drop height from the CTS is a total of 6'-1.5" in air and 6'-6" in water for a drop in the FTC and for a drop in the fuel pool. Damage caused by such an accidental drop is local in nature and does not cause a reduction in the spacing between canisters to less than the 17.3 inches used in criticality analyses for the defueling canisters. The dropping of the CTS is not considered a credible event as the CTS is an integral part of the canister handling bridge (CHB).

The FCSR and the CTS are configured in such a way as to prevent a canister falling from the transfer shield to drop horizontally on top of the FCSR. In addition, the storage racks are designed to preclude a canister from falling between canister positions. The design of the rack includes provisions to prevent a canister which is dropped outside of the rack from leaning against the rack or rolling against the rack so that the side of the dropped canister is less than 4 inches from the side of the nearest canister in the rack.

The dropping of heavy loads on the FCSR without canisters present (in either the fuel pool or the FTC) poses no safety concern as there is no opportunity for a criticality event, radiation release or uncovering of fuel. Furthermore, the FCSR are constructed in such a way that should damage occur, the damaged FCSR section could be removed and repaired or replaced.

During the installation or replacement of sections of the FCSR the potential exists for dropping a section due to a load handling accident. In order to avoid creating any potential safety concerns due to a load handling accident the sections of the FCSR to be installed in containment will be handled within the limits set forth in Reference 2.

The handling of loads other than canisters over the FCSR in the fuel pool or deep end of the FTC, when canisters are in the racks, will be restricted to loads less than the design load drop for the FCSR (3355 pounds). In addition, the loads lift height will be limited such that the potential energy will be less than that of a suspended fuel canister. The following equations will be used to determine the maximum plant elevation (h, maximum plant elevation in feet) to which a given weight (W, where W is in pounds and less than 3355 lbs.) can be raised over the FCSR in the FHB or containment. Two equations are presented as the canister lift heights for the containment and FHB are different.

$$h_{FHB} = \frac{37,000}{W} + 321$$

$$h_{CONT} = \frac{37,000}{W} + 322$$

3.3 Criticality

This TER addresses only the design, including FCSR response to structural and seismic loads, and assembly of the FCSR. Criticality is not addressed in this TER. Criticality concerns with defueling canisters in the FCSR will be addressed in the TER for the Defueling Canisters, Reference 1.

3.4 Occupational Exposure

The occupational exposure attributable to the fuel racks would be that dose accumulated during their installation in and removal from the containment and FHB. In order to calculate the man-rem associated with the installation and removal a general area dose rate of 35 mR/hr will be used for in-containment man-hours. This dose rate is based on the man-millirem per man-hour for in-containment work. A dose rate of 0.3 mR/hr is assumed in the man-rem estimates for the installation and removal of the FCSR in the FHB. This dose rate is based upon the FHB being decontaminated prior to the FCSR installation and the FCSR being decontaminated prior to their removal if required. The following table provides an estimate of the man-hours and man-rem associated with the installation and removal (man-hours for removal are estimated to be equal to 50% of those required for installation) of the in-containment and FHB FCSR. These estimates are based upon man-hour projections for the in-containment work.

IN CONTAINMENT

Activity	Man-Hours	Dose Rate (mR/hr)	Man-Rem
Installation	100	35	3.50
Removal	50	35	1.75

FUEL HANDLING BUILDING

Activity	Man-Hours	Dose Rate (mR/hr)	Man-Rem
Installation	300	.3	.09
Removal	150	.3	.05

The total man-rem attributable to the installation and removal of the FCSR is expected to be between 4.5 and 8.5 man-rem. This estimate is based upon a total of 5.4 man-rem from the above, increased by 20% for Health Physics coverage and allowing $\pm$ 30% due to uncertainties.

3.5 Thermal Loads

The loaded defueling canisters when standing in the FCSR are cooled by the fuel pool water. The decay heat produced by the fuel in each canister is approximately 60 watts (this is based upon a decay heat load of 15KW being distributed amongst 250 canisters) and the surface area of the defueling canister exposed to the fuel pool water is approximately 46 ft^2. The canister support plate contains the necessary openings for adequate cooling flow past the canisters.

4.0 10CFR50.59 EVALUATION

10CFR50, Paragraph 50.59, permits the holder of an operating licensing to make changes to the facility or perform a test or experiment, provided the change, test, or experiment is determined not to be an unreviewed safety question and does not involve a modification of the plant technical specifications.

A proposed change involves an unreviewed safety question if:

a) The possibility of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report may be increased; or

b) The possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report may be created; or

c) The margin of safety, as defined in the basis for any technical specification, is reduced.

The activities associated with the design, installation and use of the FCSR do not increase the probability of occurrence of the consequences of an accident or malfunction of equipment important to safety previously evaluated. The FCSR are designed and used in accordance with this TER and its references in order to prevent an inadvertent criticality. In addition, the racks are seismically designed in order to prevent an inadvertent criticality during a seismic event.

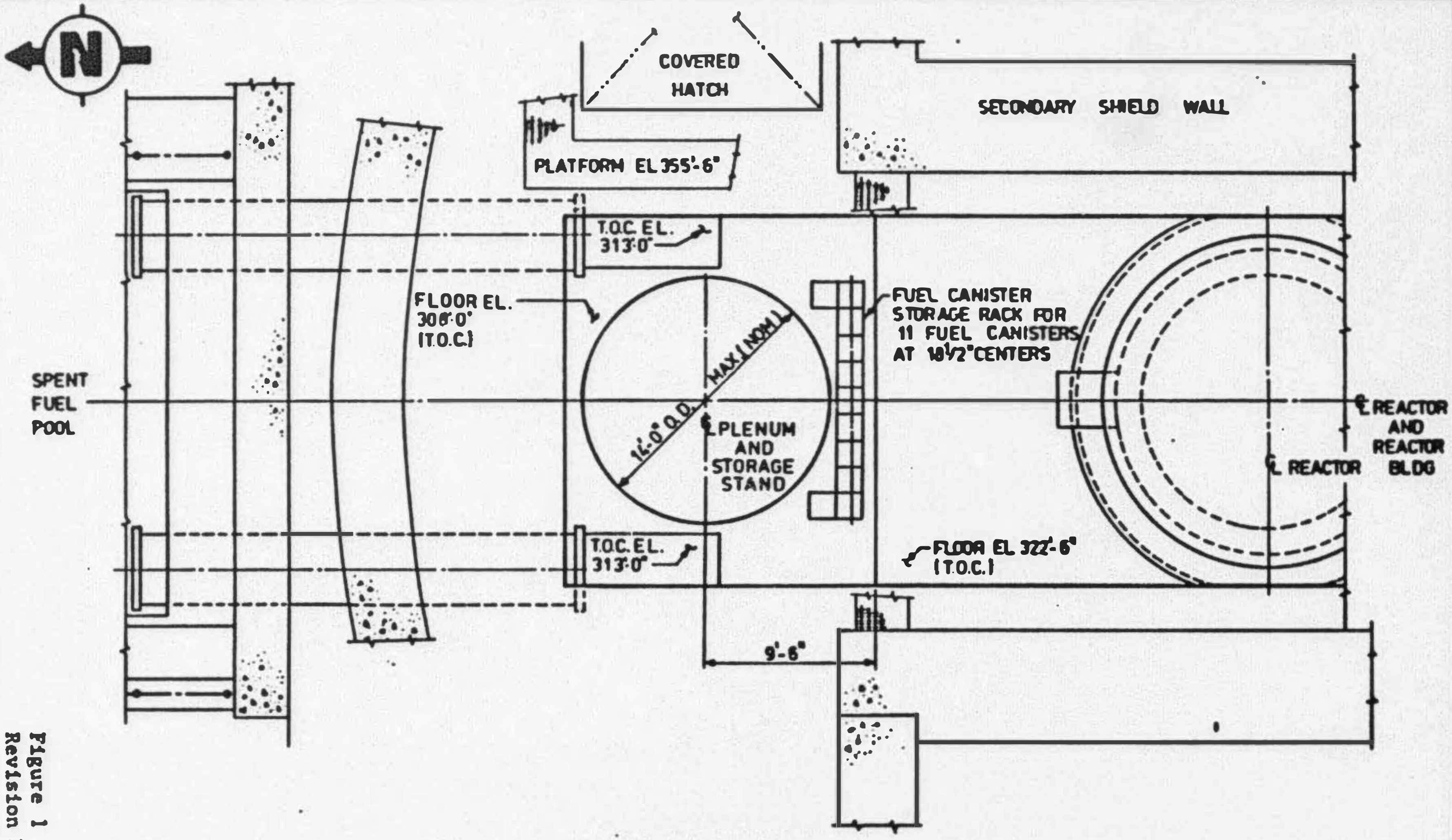
Additionally, there were no safety concerns associated with the installation of the FCSR, if a section of the racks were dropped during their installation in the FTC/fuel pool which resulted in damage to the liner plate, the liner plate could have been repaired prior to the commencement of defueling. The planned activities do not create the possibility of an accident or malfunction of a different type than any evaluated previously and have been shown not to be an unreviewed safety question. Since the operation of systems and equipment are in accordance with approved procedures to ensure compliance to technical specifications, the tasks included in this TER will not reduce the margin of safety as defined in the basis for any technical specification.

Therefore, it is concluded that the fuel canister storage racks do not involve any unreviewed safety question as defined in 10CFR Part 50, Paragraph 50.59.

5.0 REFERENCES

1. "Technical Evaluation Report for Defueling Canisters," Revision 2, 15737-2-G03-114.

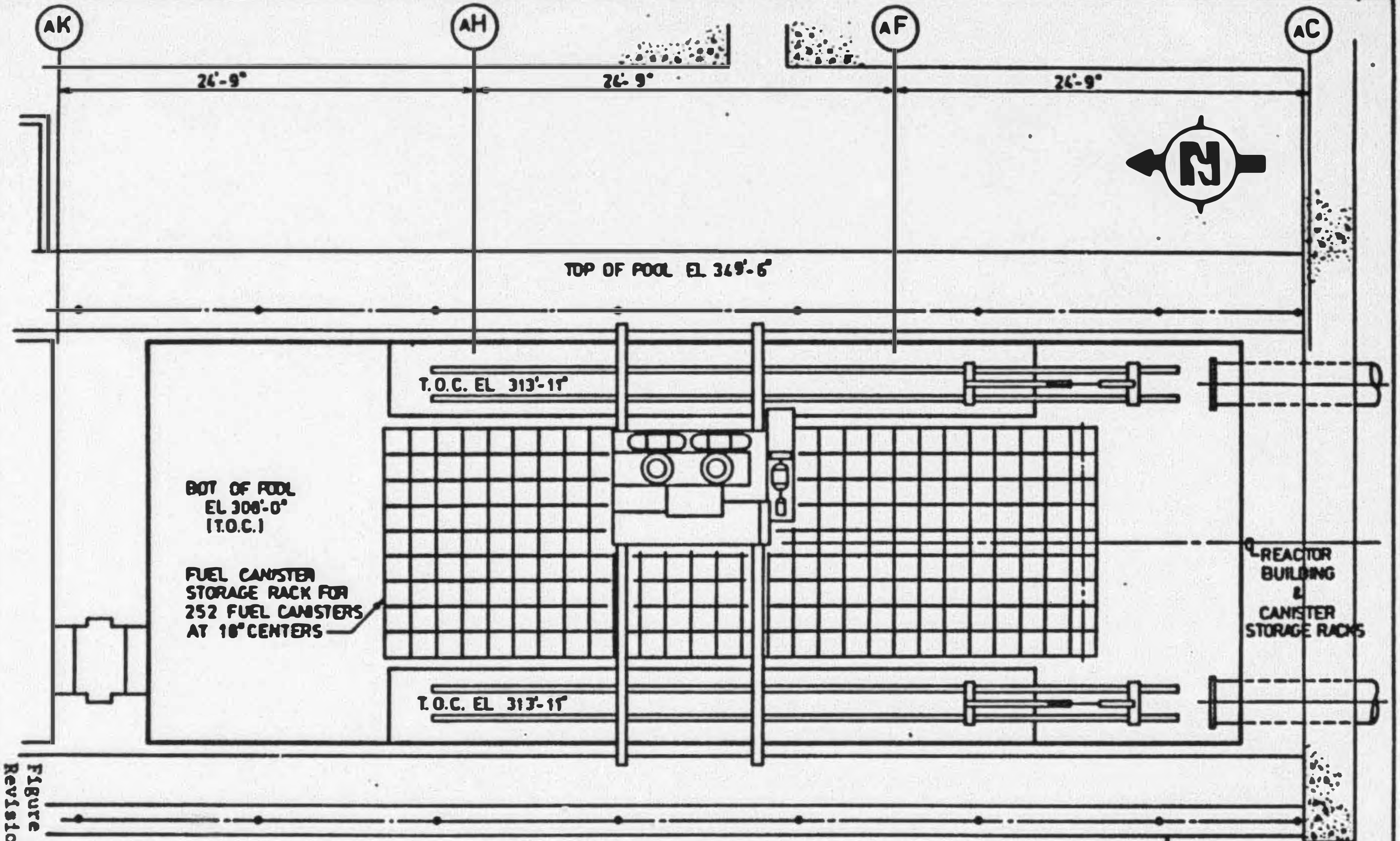
2. "Safety Evaluation Report for Heavy Load Handling Inside Containment," Revision 2, 15737-2-G07-105.



FUEL TRANSFER CANAL

PLAN

Figure 1
Revision 1

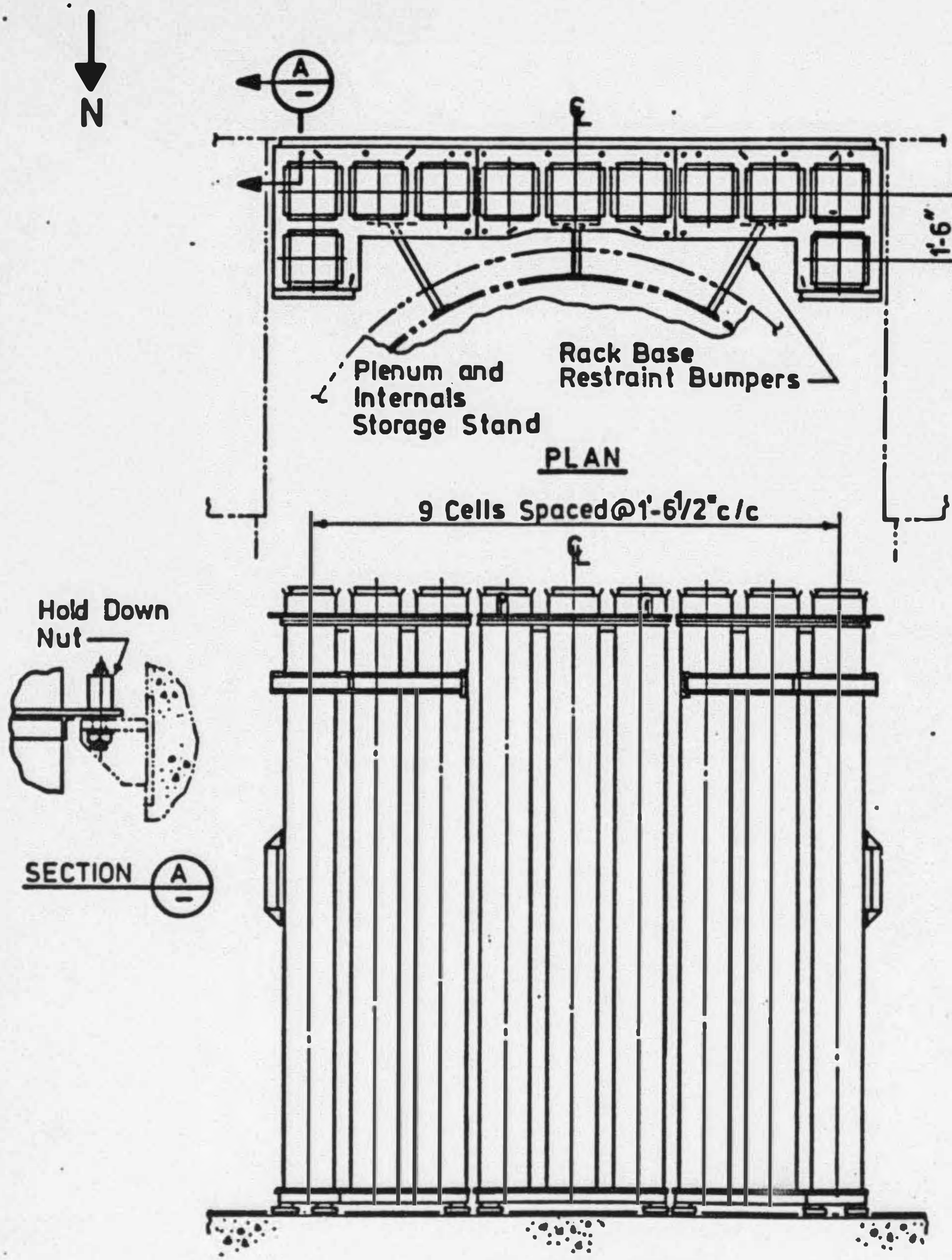


SPENT FUEL POOL "A"

PLAN

FIGURE 1

Figure 2
Revision 1

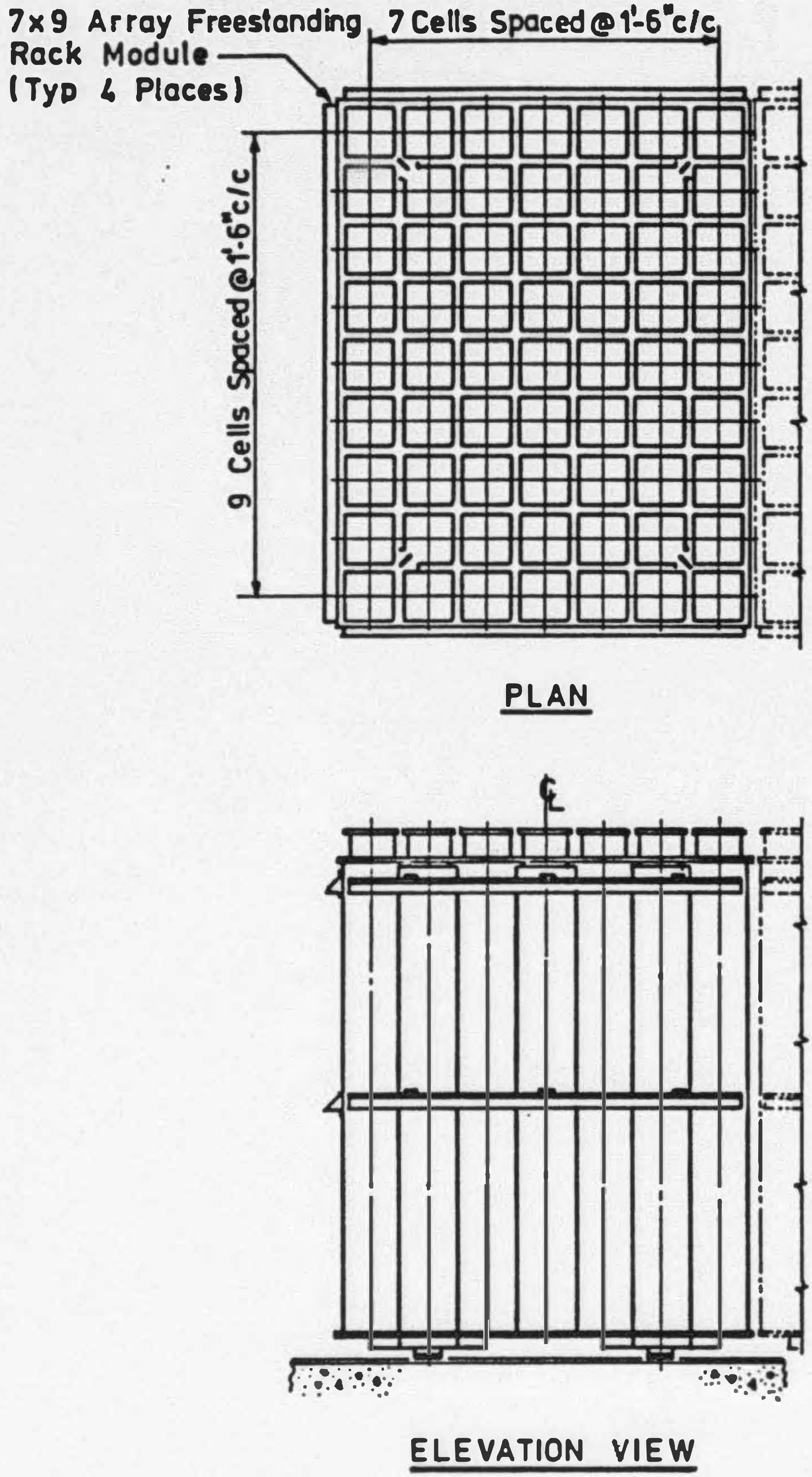


ELEVATION VIEW

(REACTOR BUILDING)

FUEL CANISTER STORAGE RACKS

Figure 3
Revision 1



(FUEL HANDLING BUILDING)

FUEL CANISTER STORAGE RACKS

Figure 4
Revision 1