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4410-88-L-0110/0381P

US Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Dear Sirs:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Criticality Safety Assessment for Use of the Plasma Arc Torch to Cut the Upper Core Support Assembly Baffle Plates and the Core Support Shield

Attached for NRC review and approval is the Criticality Safety Assessment for Use of the Plasma Arc Torch to Cut the Upper Core Support Assembly Baffle Plates and the Core Support Shield. This safety assessment demonstrates that the maximum allowable drainable volume for the plasma arc torch system can be safely increased from 3.0 gallons to 3.5 gallons. The current limit (i.e., 3.0 gallons) was analyzed by GPU Nuclear letter 4410-87-L-0139 dated November 30, 1987, and approved by NRC Letter dated April 1, 1988. When the plasma arc torch is positioned to cut at or near the top of the baffle plates, the length of the cooling water supply hose below the Reactor Vessel water level will be shorter than was assumed in the referenced GPU Nuclear letter. Consequently, the amount of unborated water that can drain into the RV is potentially greater than 3.0 gallons.

Sincerely,

F. R. Standerfer
Director, TMI-2

RDW/emf

Attachment

A001 1/1

cc: Senior Resident Inspector, TMI - R. J. Conte
Regional Administrator, Region 1 - W. T. Russell
Director, Plant Directorate IV - J. F. Stolz
Systems Engineer, TMI Site - L. H. Thonus

SAFETY ANALYSIS

SA No. 4710-3221-88-02

Rev. No. 0

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TITLE

CRITICALITY SAFETY ASSESSMENT FOR
USE OF THE PLASMA ARC TORCH TO CUT THE
UPPER CORE SUPPORT ASSEMBLY BAFFLE PLATES AND
THE CORE SUPPORT SHIELD

Originator [signature] Date 8/1/88

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APPROVAL

Mgr
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Director [signature] (ACTING) Date 08/08/88

FORM 4000-ENG-7310.09-1 (12/87)

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Rev.	SUMMARY OF CHANGE	Approval	Date
0	Initial submittal via GPU Nuclear letter 4410-88-L-0110.	[signature]	8/88

FORM 4000-ENG-7310.06-2 (11/83)

PURPOSE

Future anticipated uses of the plasma arc torch include cutting the Upper Core Support Assembly (UCSA) (e.g., baffle plates, core formers, and Core Support Shield [see Figures 1, 2, and 3]). Cutting the baffle plates will enable access to the core debris located behind the baffle plates in the core formers. The following evaluation addresses the criticality safety aspects of using the plasma arc torch to cut the UCSA.

Cutting of the Core Support Shield with the plasma arc torch will eventually enable access to the core debris located in the Reactor Coolant System cold-leg piping. Currently, there is no core debris identified in the immediate vicinity where cutting of the Core Support Shield is planned; thus, use of the plasma arc torch for this activity is bounded by the following evaluation.

BACKGROUND

Reference 1 submitted to the NRC a criticality safety assessment for use of the plasma arc torch to cut the Lower Core Support Assembly (LCSA). This assessment concluded that use of the plasma arc torch to cut the LCSA does not pose a criticality safety concern provided that the plasma arc torch coolant system is configured to limit the maximum amount of unborated water that can drain into the Reactor Vessel to less than three (3) gallons. To support the analysis provided in Reference 1, draindown tests were conducted to determine the maximum water leakage from the plasma arc torch cooling system. The tests demonstrated that approximately 3.5 gallons drained when the system hoses were suspended in air. To determine the approximate amount of leakage that would have occurred with the plasma torch operating the Reactor Vessel, credit was taken for the reduction in leakage that would have occurred since a portion of the cooling system inventory would have been immersed in the Reactor Vessel water. This reduction was equivalent to the volume contained in the immersed hoses which was calculated to be approximately 0.5 gallons. Consequently, the maximum leakage considered in the Reference 1 analysis was 3.0 gallons.

The NRC approved the use of the plasma arc torch system (Reference 2) based on the analyses in Reference 1 and based on the response to NRC comments on this subject (Reference 3).

INTRODUCTION

The following evaluation addresses criticality safety during use of the plasma arc torch to cut the baffle plates in the UCSA and gain access to the core debris resting behind the baffle plates on the core formers. In this evaluation, the unborated cooling water from the plasma arc torch is assumed to leak into the core debris located behind the baffle plates (see cross-hatched sections of Figure 3). When the plasma torch is positioned to cut at or near the top of the baffle plates, the length of the cooling water supply hose immersed in the Reactor Vessel water will be less than was assumed in Reference 1. Consequently, the amount of cooling water that could drain into the vessel is potentially greater than the 3.0 gallons used in the analyses presented in Reference 1. The volume of unborated water available to leak from the plasma arc coolant system is a key parameter of the criticality safety analysis; increased leakage results in an increased neutron multiplication K_{eff}, provided all other modeling parameters remain unchanged. Thus, it is important to ensure that the amount of leakage used in this analysis (i.e., 3.5 gallons) bounds all potential operating conditions. To provide an upper bound on the leakage, it was conservatively assumed that none of the cooling systems hose inventory will be immersed during baffle plate cutting. The following analysis demonstrates that the maximum drainable volume for the plasma torch system can be increased to 3.5 gallons for baffle plate cutting without posing a criticality safety concern.

The criticality safety analysis performed to support this safety evaluation report is very similar to the analysis reported in Reference 1. Due to this similarity, only a brief descriptive summary of the criticality analysis performed for use of the plasma torch in the UCSA is presented in this evaluation. Reference 1 provides a more detailed description of the plasma torch system along with the background information describing the basic logic employed to assess the criticality safety implications of unborated water entering the RV. Reference 1 also provides a more detailed technical discussion of the analytical approach used to perform the criticality safety analysis.

MODELING

The model used in the criticality safety analysis for this scenario is shown in Figure 4. The drained unborated water was assumed to mix with fuel in the inner cylinder of the model. The volume of this inner cylinder (i.e., 1122 cubic inches) was determined by combining the 3.5 gallons of unborated water with an optimum quantity of fuel (fuel volume fraction = 0.28). The height and radius of this cylinder were varied, while keeping the volume constant, until a maximum K_{eff} was determined. This approach neglects the physical constraints imposed by the core barrel and baffle plates.

The inner fuel cylinder was surrounded by another cylinder having the same height and containing a mixture of fuel and 4950 ppm borated water. This region was used to represent the fuel remaining behind the baffle plates that did not become mixed with the unborated water. To avoid imposing limits on the quantity of fuel that could remain behind the baffle plates, the radius of the outer fuel region was set to a large value (i.e., 150 inches). The top and bottom of these two cylinders were covered with a 4950 ppm borated water reflector. Figure 3 provides a view of the fuel cylinders superimposed onto the region of the vessel in which the unborated water was assumed to leak. The dimensions of the cylinder in this figure correspond to the dimensions resulting in the maximum value of K_{eff}.

A cylindrical model was used in the analysis which facilitated the use of more realistic reflective boundary conditions. That is, a borated water reflector, used to represent the large Reactor Vessel water inventory, could be applied on the ends of the fuel cylinders, while a borated water/fuel mixture, representing the remaining fuel behind the baffle plates, could be placed outside the curved surfaces of the unborated cylinder.

As with the Reference 1 analyses, the fuel was represented as a homogeneous medium for which neutronic data corresponds to a dodecahedral lattice structure of spherically shaped fuel pellets. The composition of the fuel corresponds to TMI-2 core average fuel (i.e., the homogeneous mix of the three fuel enrichments). Incorporation of burnup effects resulted in a net U^{235} enrichment of 2.24%. The equivalent of standard size fuel pellets was used as the particle size in all fuel regions. Additionally, no credit was taken for any impurities that exist in the fuel debris (e.g., control rod and structural materials).

This model is appropriate because the region between the baffle plates and core barrel forms an irregular annulus. This annular like region with its large diameter may be represented by an essentially infinite slab because the sides are neutronically isolated. Further, a large diameter cylinder in the same plane may be used in lieu of a slab to simplify the model, along with an inner cylinder to represent the unborated water/fuel mixture.

It is recognized that localized regions of fuel debris behind the baffle plates may have an average enrichment that is greater than that used in the criticality safety model. However, based on the current defueling data and considering the mechanisms that could have transported the fuel to a location behind the baffle plates, it is concluded that no significant agglomerations of Batch 3 fuel are credible in the annular region behind the baffle plates. Consequently, it is concluded that the use of an average enrichment is appropriate for this evaluation.

<u>Conservatisms</u>

In the development of this criticality safety model, conservative assumptions were utilized. These conservatisms include:

- o No credit for large amounts of structural or solid poison materials existing in debris

- o Optimized fuel/moderator ratio in all fuel regions

- o No credit for mixing of unborated cooling water with borated vessel water

- o The height of the cylindrical fuel model was varied until a maximum neutron multiplication was determined, thus, neglecting the physical constraints imposed by the core barrel and the baffle plates.

- o Minimum allowable boron concentration of 4950 ppm is assumed in borated regions of model

- o Unborated water region is placed in the center of the fuel model

The conservatisms discussed above assure that the geometry model used for this evaluation bounds credible geometries, including the distortion of the baffle plates, that may exist during the cutting of the baffle plates with the plasma arc torch. Thus, it is considered appropriate to use this model for the criticality safety evaluation to assess usage of the plasma arc torch to dismantle the UCSA.

RESULTS/CONCLUSIONS

The results of the criticality safety analysis completed by Oak Ridge National Laboratory (Reference 4) are provided in Table 1. As can be seen from this table, the maximum calculated neutron multiplication, including an uncertainty bias of 2.5% Δk was 0.928. This value of K_{eff} occurs with an inner fuel cylinder height of 23.0 inches. A cylinder of this size cannot fit (i.e., somewhat large) in the region in which the unborated water is assumed to leak (see Figure 3). Consequently, it is concluded that 0.928 is a conservative value for the neutron multiplication as a result of the unborated water inleakage that can be postulated to occur during the cutting of the baffle plates with the plasma arc torch. As this K_{eff} is significantly less than the licensing basis of $K_{eff} \leq 0.99$, it is concluded that the plasma arc torch can be used to cut the baffle plates without presenting a criticality safety concern.

Operational Limitations

The above conclusion is based on the following operational limitation and the applicable limitations in References 1, 2, and 3:

- o A system configuration such that a maximum of 3.5 gallons can drain following a line rupture or torch tip blowout with the torch operating in the Reactor Vessel.

- o Following the loss of coolant inventory, the torch must be removed and repaired before refilling the torch cooling system.

- o If in-vessel flushing of the torch is being performed, no load handling operations (heavy or light) are permitted in or above the Reactor Vessel.

- o Flushing of the plasma arc torch coolant system with the torch within the vessel can only occur if there are no known leaks in the coolant system and the torch is at least 1 foot from the baffle plates or core formers. Otherwise, the torch must be removed from the vessel prior to connection of the flushing tie-in.

- o The maximum inventory of unborated water permitted in the flush system storage tank is 15 gallons.

- o Operating Procedure 4210-OPS-3255.29, "Automated Cutting Equipment System Operation," includes a signed verification by the on-duty Fuel Handling Senior Reactor Operator that the 15 gallon tank has been disconnected from the HE-200 unit prior to system operation and prior to filling the 15 gallon tank.

- o The plasma arc torch shall be positioned greater than one (1) foot from fuel bearing areas, external to the region between the baffle plates and core barrel, which contain greater than or equal to 10 kg of fuel. This restriction does not apply to fuel bearing areas in the Lower Core Support Assembly/Lower Head region (e.g., fuel assembly R-6) which is bounded by the criticality safety assessment in Reference 1.

10 CFR 50.59 EVALUATION

10 CFR 50, Paragraph 50.59, permits the holder of an operating license 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.

10 CFR 50, Paragraph 50.59, states a proposed change involves an unreviewed safety question if:

a. The probability of occurrence or the consequence 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.

Has the probability of occurrence or the consequence of an accident or malfunction of equipment important to safety previously evaluated been increased?

The TMI-2 Reactor Coolant System is borated between 4350-6000 ppm, as required by the Technical Specifications, which ensures subcriticality under all credible conditions. The plasma arc torch utilizes unborated water; thus, the safety concern with use of this system is to ensure that a leakage of unborated water from the plasma arc torch system will not result in a criticality event. To provide an adequate operating margin, TMI-2 has established an administrative limit of 4950 ppm as the minimum operational RCS boron concentration which is utilized in this analysis and in Reference 1.

Reference 1 demonstrated that use of the plasma arc torch system for cutting the Lower Core Support Assembly does not pose a criticality concern provided that the maximum drainable volume of unborated water is limited to 3.0 gallons. However, the plasma arc torch will be utilized at a higher elevation in the Reactor Vessel during cutting of the baffle plates. Thus, a criticality safety evaluation was performed which does not take credit for the water remaining in the plasma arc torch hoses (i.e., approximately 0.5 gallons) when they are submerged in the Reactor Vessel. This evaluation demonstrates that increasing the maximum drainable volume of unborated water to 3.5 gallons for plasma arc cutting of the baffle plates will still maintain the maximum $K_{eff} \leq 0.99$ as was previously analyzed in Reference 1. Thus, use of the plasma arc torch to cut the baffle plates does not pose a criticality safety concern. Additionally, since there has currently not been any core debris identified in the immediate vicinity where cutting of the Core Support shield is planned, the use of the plasma arc torch for this activity does not pose a criticality safety concern. Consequently, this activity does not increase the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety.

Has the possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report been created?

This evaluation demonstrates that use of the plasma arc torch to cut the UCSA does not pose a criticality safety concern. Thus, this activity does not create the possibility for an accident or malfunction of a different type than any evaluated.

Has the margin of safety, as defined in the basis for any technical specification, been reduced?

TMI-2 Technical Specification 3.1.1, "Boration Control and Borated Cooling Water Injection," requires the boron concentration in all filled portions of the Reactor Coolant System to be maintained between 4350-6000 ppm. The basis for this specification states, "The limitation for minimum boron concentration ensures that the core will remain subcritical under all credible conditions which exist during the long-term cooling mode."

This evaluation demonstrates that a limit of 3.5 gallons of unborated water that can drain from the plasma arc torch coolant system ensures that the core will remain subcritical during plasma arc cutting of the USCA. Thus, this activity does not reduce the margin of safety defined in a Technical Specification basis.

Based on the above evaluation, GPU Nuclear concludes that this activity does not constitute an unreviewed safety question pursuant to 10 CFR 50.59.

REFERENCES

1. GPU Nuclear letter 4410-87-L-0139 dated November 30, 1987, "Criticality Safety Assessment for Use of the Plasma Arc Torch to Cut the Lower Core Support Assembly."

2. NRC Letter dated April 1, 1988, J. F. Stolz to F. R. Standerfer, "Lower Core Support Assembly Defueling."

3. GPU Nuclear letter 4410-88-L-0026 dated February 26, 1988, response to NRC comments on "Criticality Safety Assessment for Use of the Plasma Arc Torch to Cut the Lower Core Support Assembly."

4. Letter, C. V. Parks (ORNL) to D. S. Williams, dated April 5, 1988.

5. Criticality Report for the Reactor Coolant System, Revision 0, 15737-2-N09-001, October 1984.

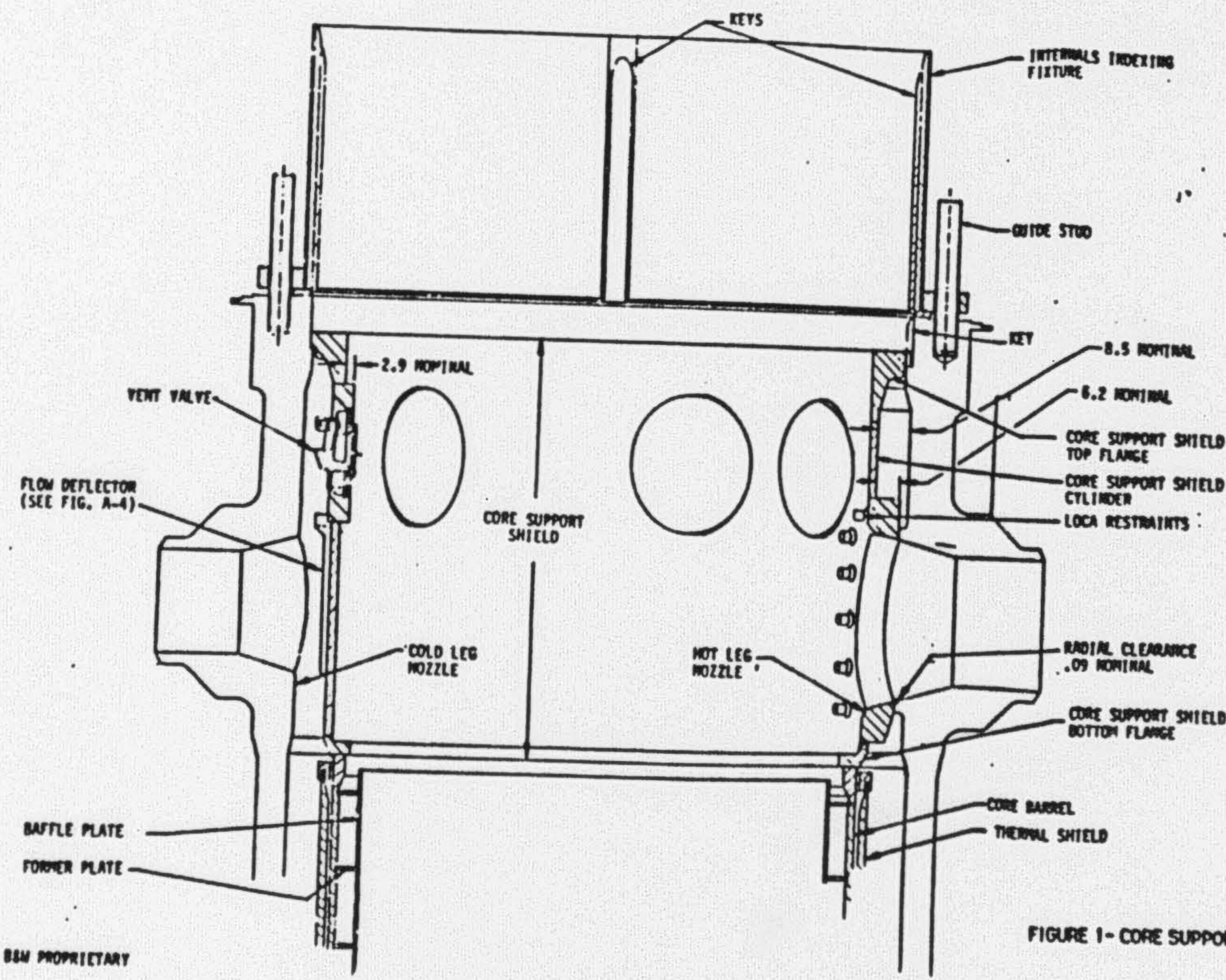


FIGURE 1- CORE SUPPORT ASSEMBLY DIAGRAM

B&W PROPRIETARY

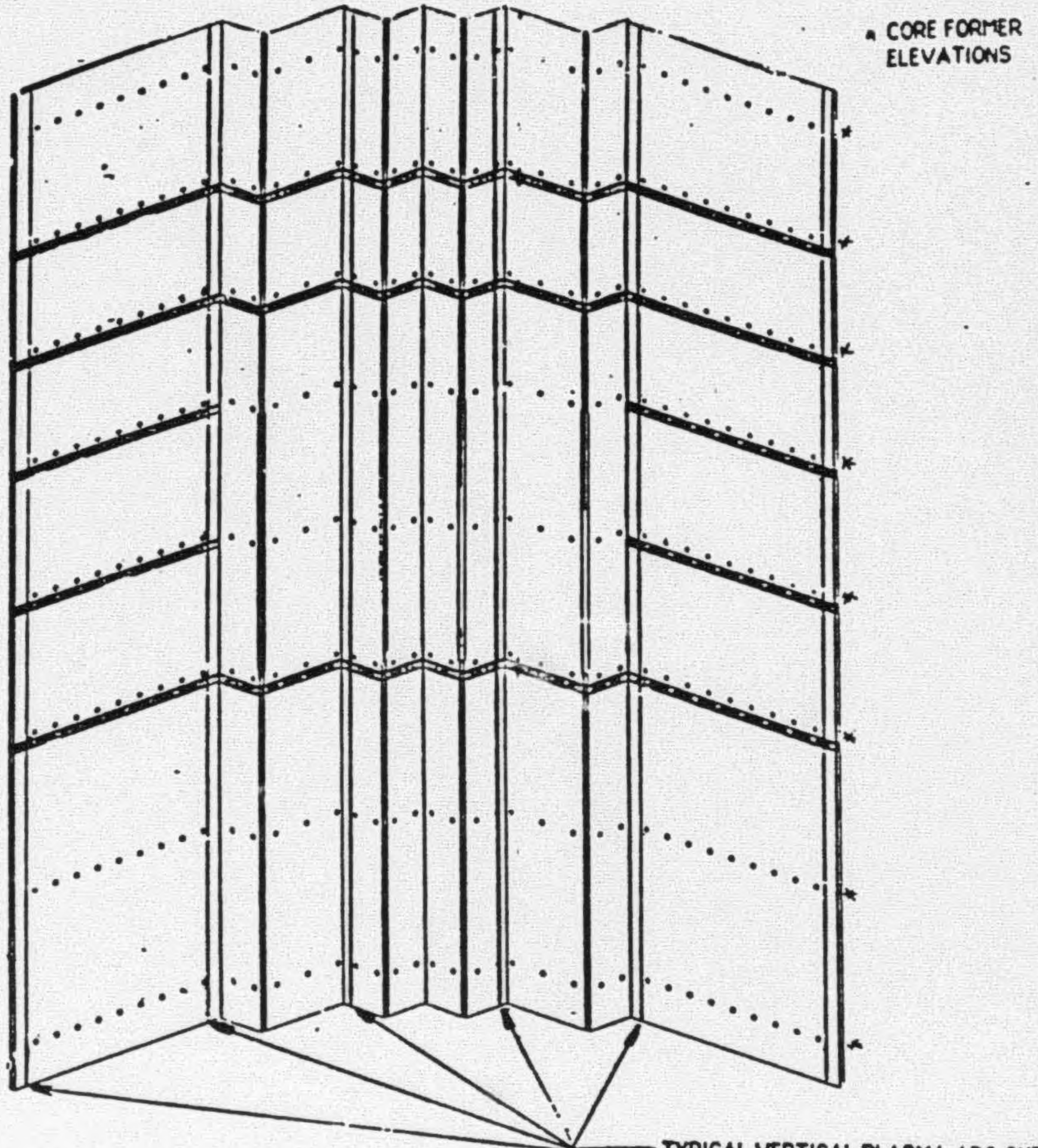


FIGURE 2- BAFFLE PLATE ACCESS OPENINGS

NOTE: HORIZONTAL BLACK BARS DO NOT REPRESENT ANY STRUCTURE, THEY ARE NECESSARY FOR THE CADD SYSTEM TO DEPICT HOLES IN A FLAT PLATE.

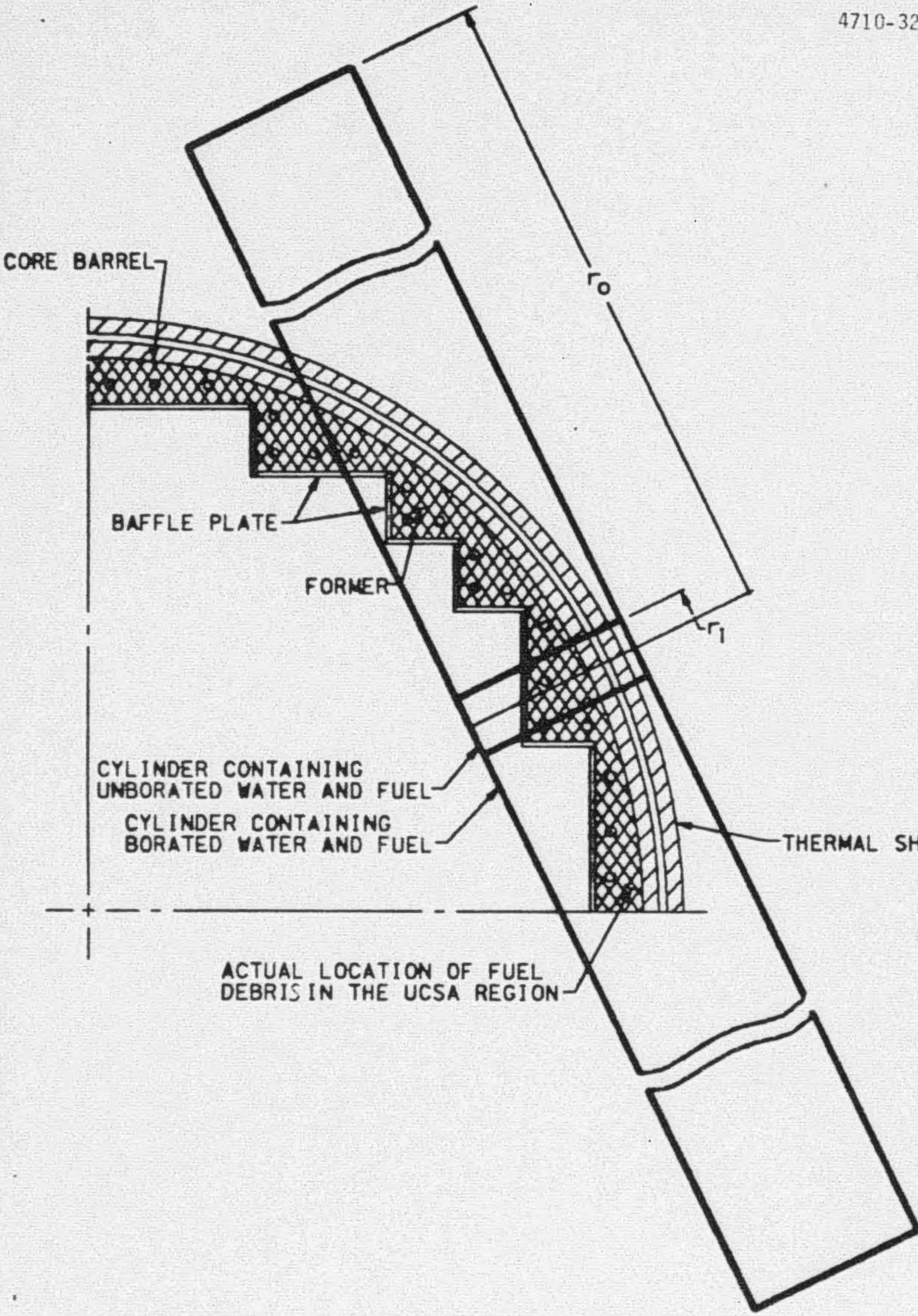
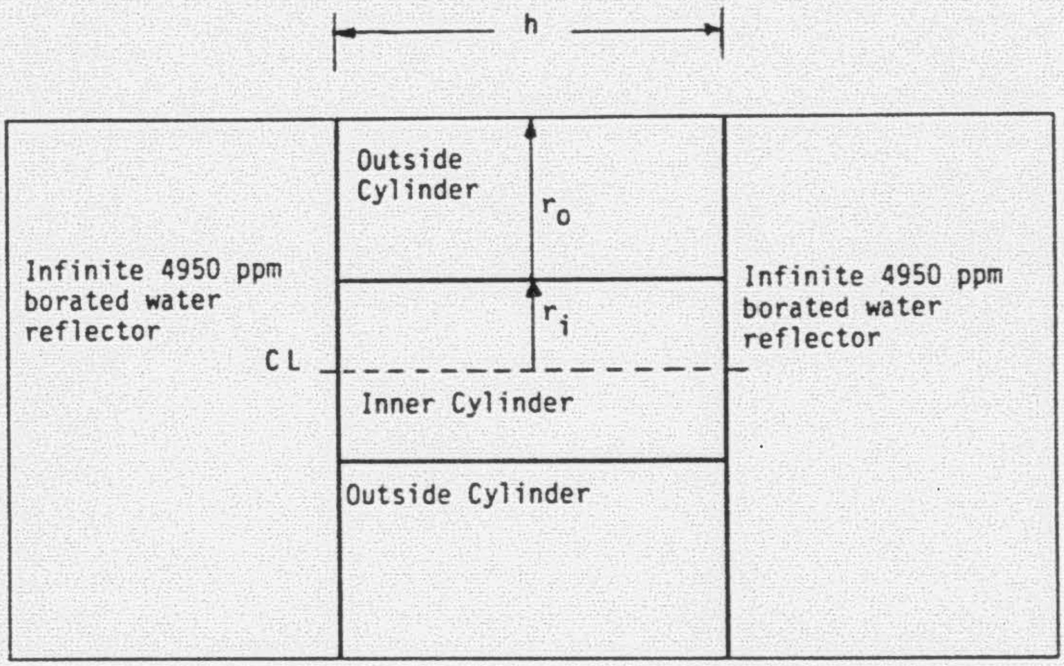


FIGURE 3 - FORMER/BAFFLE PLATE LAYOUT



Criteria for Inner Cylinder Region

- o 3.5 gallons Unborated Water
- o Core Average Fuel with Burnup
- o Standard Pellet Size Fuel Particles
- o Optimum Fuel/Water Mixture

Criteria for Outside Cylinder Region

- o 4950 Borated Water Mixture
- o Core Average Fuel Burnup
- o Standard Pellet Size Fuel Particles

* Note: For maximum k_{eff} case h=23 inches, r_i = 3.94 inches, r_o=150 inches

Figure 4: Model Geometry

TABLE 1

Inner Cylinder Height (in.)	Inner Cylinder Radius (in.)	Keff *
9.01	6.30	0.833
11.26	5.63	0.873
13.56	5.12	0.898
19.06	4.33	0.916
20.00	4.23	0.927
21.00	4.13	0.923
22.00	4.03	0.926
23.00	3.94	0.928
24.00	3.86	0.921
25.00	3.78	0.924

*Results include 2.5% Δk bias for KENO V.a uncertainty (Reference 5).

NOTE: All results were provided by Reference 4.