GENERAL ATOMIC COMPANY

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TITLE: SAFETY ANALYSIS REPORT -- FSV Region Constraint Devices

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ISSUE SUMMARY

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Issue	Date	Prepared by	Approval: Engineering	Approval: QA	Approval: Project	Purpose of Issue/ Sections Changed
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GENERAL ATOMIC COMPANY
FORT ST. VRAIN NUCLEAR GENERATING STATION
SAFETY ANALYSIS REPORT

1. INITIATING DOCUMENT: FSV-SD-0067

		YES	NO		
2.	CATEGORY: PLANT CHANGE	X		DOCUMENT CHANGE ONLY	☐
	CLASS I	X		MAINTENANCE	☐
	SAFE SHUTDOWN COOLING		X		
3.	FAILURE MODES AFFECTED		X	TEST	☐
4.	SAFETY RELATED COMPONENT, SYSTEM OR STRUCTURE CHANGE	X		STATE IN ITEM 10 THE BASIS FOR THE BOXES CHECKED	
5.	SAFETY SIGNIFICANT CHANGE		X		
6.	UNREVIEWED SAFETY QUESTION		X		
7.	TECH SPECIFICATION CHANGE		X		
8.	FSAR CHANGE		X		

9. APPLICABLE FSAR OR TECH SPEC SECTIONS REVIEWED:
FSV FSAR Chapter XIV

10. BASIS FOR SAFETY EVALUATION: (Add additional Sheets if Required):

See attached report for details of this SAR.

11. IS SAN DIEGO SAFETY ANALYSIS/LICENSING REVIEW REQUIRED? YES [X] NO [ ]

12. HAS SAN DIEGO SAFETY ANALYSIS/LICENSING REVIEW BEEN PERFORMED? YES [X] NO [ ]

13. Richard J Meyer 1/9/79 — INITIATOR/DATE
O. J. Kennedy 1/11/79 — LICENSING/DATE

14. GAC ENGR. REVIEW/DISPOSITION: This SAR has been reviewed and is correct. The addition of RCD'S to FSV does not affect FSAR safety analysis or introduce any unreviewed safety questions.

ENG'R DATE [illegible] 1/10/79

FORM: SAR 4/77

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SAFETY ANALYSIS REPORT

FSV REGION CONSTRAINT DEVICE

1. INTRODUCTION

This Safety Analysis Report (SAR) presents an evaluation of the installation of 84 Region Constraint Devices (RCDs) into the core of the Fort St. Vrain Nuclear Generating Station. The RCDs will mechanically interlock fuel regions across the top layer of the core and prevent accumulation of bypass flow gaps at region boundaries. The constraint devices will stabilize external region gaps at their nominal values and will limit changes in gap flows and minimize pressure differences across regions. Based on observed data, it has been postulated that changes in gap widths, flows, and pressure distributions contribute to observed temperature fluctuations in the primary coolant system.

This report describes the mechanical design of the Region Constraint Devices and summarizes the structural and other engineering analyses which substantiate the design adequacy of the devices. The potential effects on core performance and fuel handling operations are evaluated, as is the potential impact on postulated accident sequences described in the Fort St. Vrain Final Safety Analysis Report (FSAR). The potential for introducing new safety concerns is also discussed.

2. PLANNED MODIFICATION

The proposed modification is to add 84 Region Constraint Devices to the top layer of hexagonal elements (keyed plenum elements). These mechanical links are placed at locations in the core where 3 regions intersect (Figure 1) with each of the 3 pins inserted into the handling hole of a keyed plenum element. The addition of the RCDs results in a more fully constrained keyed top core layer. The present keying configuration is that top layer elements within each fuel region are keyed to each other but not to elements in adjacent regions. The RCDs provide inter-region keying and preclude the accumulation of gaps between regions that might result if several regions are displaced in the same direction.

3. OBJECTIVES AND PERFORMANCE CRITERIA

The primary objective of installing the Region Constraint Devices in the core is to provide a permanent solution to the core temperature fluctuations that have occurred at the Fort St. Vrain plant. Core flow and pressure distribution analyses have shown that static pressure differences occur when gaps change within the core array. Small pressure differences acting over the large surface area of a region can result in forces large enough to displace regions and/or reflector columns. Subsequent flow redistributions may cause thermal

distortions in side reflector columns of sufficient magnitude to change the gaps again. Movements of columns and regions, accompanied by local periodic changes in bypass flow best explain the observed temperature fluctuations. The Region Constraint Devices will stabilize gap flow areas at the top of the core to near nominal values. The triangular pitch of the three pins is chosen to prevent any cross core stack-up of gaps without changing the normal position of plenum elements within each region. During operation, the pressure drop across the flow control valve creates a radially inward pressure difference across the top plenum elements in a region and therefore causes them to group around the valve. In this position, the keyed elements in a region rest against each other on the raised contact pads (Figures 2 and 3). With the RCDs installed, plenum elements will still move to the normal grouped position but the region itself will be constrained from "leaning" as a unit. The primary performance criteria of the RCDs is that, once installed, they provide a mechanical inter-region linking function without interfering with normal plenum grouping around the orifice valve. Structural criteria which dictated the design of individual RCDs are based on expected loads during normal and abnormal operating conditions. Specific design criteria are as follows:

1. With the RCDs installed, the stresses in involved core components will be less than yield under normal operating conditions and during an Operating Basis Earthquake (OBE).

2. In the event of a .10g Design Basis Earthquake (DBE), the stresses in all components will not reach the ultimate strength of the material.

3. The RCDs will remain intact and in place until removed by the fuel handling machine.

4. Overall reactor performance is not affected by the presence of the RCDs.

5. The RCDs will maintain nearly uniform gap flow areas across the core inlet.

6. Materials are compatible with the reactor environment and with existing interfacing hardware (keyed plenum elements).

7. The RCDs will be compatible with fuel handling equipment after minor changes are made to the grapple head.

8. Since each RCD contacts a plenum element from 3 different regions, each RCD can be removed or installed from any one of the three respective reference penetrations, i.e., normal refueling operations are simplified if an RCD can be installed through one penetration and removed through another if desired.

4. DESIGN DESCRIPTION

4.1 Mechanical Features

The Region Constraint Device (RCD) consists of a central triangular plate of 5 inch thick SA-515 Gr 70 carbon steel (1020 boilerplate) with an Inconel 718 pin bolted to each corner of the triangle (Figure 4). The pins fit into the fuel handling pick-up holes of 3 adjacent keyed plenum elements at the intersection of three regions (Figure 5). Three dowels and a fuel element pick-up hole are provided at the top of the RCD to provide for orientation, indexing and insertion/removal, respectively, by the fuel handling machine. Lead-in chamfering at the end of each pin and on the plenum handling hole ensures that the pins will engage three plenum elements simultaneously, requiring only the 200 lb. dead weight of the RCD for full insertion. Pin chamfering is sufficient to allow insertion under conditions where elements are separated by up to a 1.0 in. gap. Each pin extends 6.88 in. into the pick-up hole of a keyed element plenum element to allow for expected 30 year variations in column heights. The pins are cut to a nearly half-round cross section to allow for passage of the RCD through a 17 in. diameter sleeve inside the refueling penetration and fuel handling machine. A chromium carbide flame spray coating and dry film lubricant are applied to the pins to reduce friction and wear during insertion and when in contact with the inside surface of the plenum element pick-up holes. Locking pins are included on all bolt heads. Threaded connections used to attach the dowels and the handling hole tube are fillet welded after assembly. Choice of material for the pins and bolts was dictated by structural considerations discussed in Section 5.3. Critical dimensions specifying size, weight, pin spacing, etc., were chosen based on performance criteria and interface requirements with existing components.

4.2 Insertion and Removal Handling

The Region Constraint Devices can be inserted into the reactor and removed using the existing fuel handling equipment with minor modifications that do not compromise normal fuel element handling. These modifications include: 1) Modification of the fuel storage rack extension rails to allow for storage of RCDs, 2) Azimuthal drive mechanical stop replacement to allow for increased azimuthal rotation, 3) Addition of two dowel holes to the grapple head to accomodate the dowel pattern on the RCDs. An RCD may be inserted through one refueling penetration and removed through an adjacent penetration. The devices can be stored for transport to storage inside the handling machine above the storage rack used for standard fuel elements. The weight of about 200 lb. is within the range of weights normally handled by the fuel handling machine.

5. PERFORMANCE EVALUATION - Normal Operation

5.1 Overall Reactor Performance

As described earlier, the principal objective of the Region Constraint Devices (RCDs) is to limit the maximum value of the inter-region gaps at the top of the core. The impact of these devices on core performance is discussed below.

5.1.1 Nuclear Design: The installation of the RCDs will have no impact on the nuclear design or projected nuclear performance of the core except as their utilization affects fuel and graphite temperatures. As discussed below, the changes in temperature are negligible. No changes in radial or axial power distribution, control rod worths, shutdown margins, or kinetics parameters will result from the use of these devices. With the currently installed neutron sources, the RCDs will reduce the count rate of the start-up detectors by about 25%. However, count rates will be adequate and within tech. spec. requirements through cycle 2. Installation of replacement sources is planned for subsequent cycles. The strength of these new sources will reflect the presence of RCD's.

5.1.2 Thermal/Hydraulic Performance: The installation of the Region Constraint Devices will result in a limiting of the maximum gap width between fuel regions and therefore flow between two regions. This will have a beneficial effect on fuel temperatures and performance since the amount of bypass flow will, if changed, be reduced. The effect is not large, however, and no credit is taken for it in thermal/hydraulic analyses.

The RCDs will slightly increase the flow resistance of the core by covering 33% of the gap flow entry area at the top of the plenum elements. The resulting redistribution of flow to increase in mass flow rate in the coolant holes causes a small increase in core pressure drop of less than 1.5%.

Thermal effects on the core due to crossflow resulting from RCDs covering gaps are negligible. The large chamfers on the edges of the plenum elements enable flow to enter gaps directly under the RCDs. The localized disturbance of gap flow around the RCDs does not alter crossflow paths in the core and the small decrease (1.2% maximum) in total gap flow is not great enough to cause significant thermal effects on core elements. The RCDs will produce no flow disturbances in the upper plenum that would have an adverse effect on flow control valve performance. Hence, the thermal/hydraulic analyses described in Chapter XIV and Appendix D of the FSAR remain appropriate for normal operation and accident analyses.

5.1.3 Fuel Performance and Fission Product Release: Because no adverse impact on fuel or graphite temperature is anticipated when the RCDs are installed, and since the core will be operated within limits prescribed in the plant technical specifications, the expected fuel performance and fission product release values will remain at their present levels. Accordingly, the design fission product inventories presented in Section 3.7 of the FSAR will not be exceeded and are appropriate as source terms in accident analyses.

5.1.4 Core Operation: The use of RCDs will not require special operating procedures or revisions to the plant technical specifications except for descriptions of plant components.

5.2 Gap Flow and Pressure Distribution

The effect on gap flow and pressure distribution of installing constraint devices on top of the metallic plenum elements was evaluated using the SPIFFS code (Reference 1) with a gap flow network model. The results from this study showed the following fluid system performance at 100% power and 3.5×10^6 lbm/hr of circulator flow.

a) For a given core configuration, the installation of constraint devices will keep the bypass flow to a minimum possible value by preventing large gaps from opening up at the top of the core.

b) The maximum pressure difference between gaps across a fuel region at any axial level is predicted to be 0.6 psi with the RCDs installed. This ΔP occurs across regions adjacent to the side reflector with the resulting force acting toward the center of the core. Significant changes in the radial pressure distribution due to variation in gaps within the tolerances between the constraint devices and the fuel handling hole of the metallic plenum elements are not expected.

c) The constraint devices constrain gap dimensions between the plenum elements (between pads) of adjacent regions in the range of 0 inches to 0.15 inches, thereby preventing large pressure differences from developing in the core. The constraint devices therefore will significantly reduce the potential for large inter-region static pressure differences.

5.3 Structural Evaluation

The structural evaluation of the core with Region Constraint Devices (RCDs) indicates substantial margin of safety for all components under normal operating conditions. The components with the highest stresses are the reflector block keys, RCD bolts and RCD pins. The RCDs transfer the loads from the fuel regions to the hex reflector columns. The load then passes through the hex reflector block keys into the permanent side reflector blocks and then to the core barrel through the top reflector keys.

The normal operating loads include loads due to pressure gradients across regions and loads required to move regions to unfavored positions. The "favored position" of a region refers to the slight leaning of columns that occurs due to the stack up of normal tolerances and to irradiation shrinkage. The maximum normal operating loads occur at the boundary of the core. Here, both the pressure gradients and the cumulative cross-core gaps can be at maximum. The larger cross-core gap increases the likelihood that an RCD will be required to pull a region to an unfavored position. Furthermore, the loads from the five-fuel column regions (Regions 20, 23, 26, 29 and 32, and 35 in Figure 1) are transferred to the hex reflector columns by RCDs which are also required to carry the loads from the adjacent seven-fuel-column regions. In the center of the core, the pressure gradients across regions are much less than those at the boundary. The maximum cumulative cross-core gap is half of the maximum at the boundary. In addition, the RCDs in the core interior are positioned symmetrically about each region which allows all of the loads to be transferred directly to the boundary.

The pressure gradients across the outer fuel regions produce forces which tend to push these regions towards the center of the core. The RCDs restrict this movement and transfer the loads to the hex reflector block keys. For the seven-fuel-column regions, this load is assumed to be carried by two RCDs to the hex reflector blocks, producing a load of 174 lb. per pin. The pressure load from the five-fuel-column region is carried by the two adjacent

RCDs, which also carry loads from the adjacent seven-fuel-column regions. The maximum pin load (348 lb.) is the sum of pressure loads due to the five- and seven-fuel-column regions.

After several years of radiation exposure, some of the columns will be subjected to uneven irradiation shrinkage causing the columns to lean in various directions. The RCDs will then be required to hold these columns to an unfavored vertical position. The RCD pin force required to hold a rigid column in a tipped position is 117 lb. when the column is subjected to a 9.0 psi vertical pressure drop. The top of the column can deflect elastically 0.24 in. before the RCD pin load reaches 117 lb. If it is assumed that all of the columns in two regions near the boundary lean in the same direction and that this load is carried by two pins, then the maximum load to move these regions to an unfavored position is 819 lb. Combining this load with the pressure load (348 lb.) yields a maximum normal operating load of 1167 lb. for hex reflector block keys and RCDs at the core boundary. In the interior of the core, two regions can both move elastically toward each other, therefore, the assumption is made that two RCDs hold one interior region in an unfavored position resulting in a maximum load of 410 lb. per pin for RCDs located in the interior of the core. Since relatively uniform gaps are expected to be maintained with the RCDs in place, pin loads due to pressure gradients are not predicted in the center of the core. Therefore, the maximum normal operating load is 410 lb. per pin.

The failure mode for the reflector block keys is shearing of the threads of the screws which attach the key to the block. Failure occurs when the screw shears out the internal threads in the plenum element. The maximum shear stress in the threads under normal operating conditions is calculated to be 2290 psi. The shear yield stress at 760°F for the plenum element threads (SA-387 GR 22) is 16,000 psi.

The bending stresses in the RCD pins and the loads in the RCD bolts are dependent on the vertical offset between columns. Analysis shows that irradiation shrinkage can produce vertical offsets between new and old columns of 2.40 in. for regions at the core boundary and 4.62 inches for regions in the interior of the core. This produces RCD pin bending stresses of 36,700 psi for pins at the boundary and 24,200 psi for pins in the core interior. The yield stress of the pins (Inconel 718) is 134,000 psi at 760°F. The RCD bolts have tensile stresses of 6,550 psi at the boundary and 2,920 psi in the core interior. This compares to a yield stress of 80,200 psi (SA-453-660) at 760°F. The above loads and yield stresses are summarized in Table 1. The radiation exposure of the RCDs is the same as the keyed plenum elements and no significant effect on material properties is preducted.

The addition of the RCDs adds a maximum of 1500 lb. to the weight of a fuel region (a tall region will support the weight of six RCDs). This additional weight reduces the safety factor for the core support posts and the life of the core support blocks; however, adequate margins are still maintained. The safety factor for the fuel region support posts is reduced from 7.46 to 7.06 where a factor of 3.0 is required. The allowable depth of burnoff in the coolant channels is reduced from 0.61 to 0.59 inch which does not significantly reduce the expected core support block life.

6. SAFETY ANALYSIS

The addition of the RCDs to the core was evaluated for potential effects on plant safety from two standpoints: (1) to determine if their presence in any way invalidates the assumptions, analyses, probabilities of events, or conclusions of the safety analysis presented in Chapter XIV of the FSAR; and (2) to determine if their presence introduces any new events which might pose a threat to the health and safety of the public. It is concluded that the addition of the RCDs of the design described in this report. does not affect the FSAR safety analysis nor introduce any unreviewed safety issues.

6.1 Consideration of Potential Impact on FSAR Chapter XIV Events

The safety and transient analyses of Chapter XIV were systematically reviewed for potential impact of the RCDs on assumptions, initial conditions, consequences and conclusions. As summarized in Table 2, this review showed that the RCDs afford no significant effect on those events for reasons discussed below.

Of the events initiated by Environmental Disturbances (Section 14.11), all disturbances listed, except earthquakes. directly affect only components external to the core. As described in Section 6.3, the RCD design is consistent with the seismic design criteria for the plant. Therefore, the discussion regarding adequacy of structures, instrumentation and core to seismic loading of Section 14.11 is not affected by the presence of the RCDs.

Reactivity Accidents and Transient Response (Section 14.2) discussed in the FSAR are likewise not affected by the RCDs because, as discussed in Section 5.1.1, above, the RCDs do not change power distributions, control rod worths, shutdown margins, or kinetic parameters. Therefore, analysis of the limiting rod withdrawal accident remains valid. The RCDs also do not affect potential reactivity anomalies described in the FSAR except as described in Section 6.2 where the failure of one or more RCDs may introduce an additional source of negative reactivity and power distribution perturbation.

For those events described in FSAR Section 14.3, Incidents, none are adversely affected by the RCDs. In fact, the evaluations regarding column deflection and misalignment as referenced in Section 14.3 from FSAR Sections 3.3 and 3.8 are enhanced by the use of RCDs. Other incidents addressed in Section 14.3 do not involve the reactor core so the RCDs have no potential effect.

The events described in FSAR Section 14.4, Loss of Normal Shutdown Cooling and Section 14.5, Secondary Coolant System Leakage, would not be affected by the RCD since, as discussed in Sections 5.1.1 and 5.1.2, the nuclear and thermal/hydraulic performance of the core are not significantly changed by the RCDs.

Events described in FSAR Sections 14.7, Primary Coolant Leakage, 14.8. Maximum Credible Accident, and 14.10, Permanent Loss of Forced Circulation, are not affected by the RCD. The consequences described in Section 14.7 and 14.8 stem from circulating and plateout radioactivity. As described in Section 5.1.3, the design basis inventories presented in FSAR Section 3.7

will not be exceeded with the RCDs in the core and remain valid as accident source terms. As noted in Section 5.1.2, the RCDs do not create flow disturbances which would invalidate the analysis of the core heatup described in FSAR Section 14.10 and Appendix D.

Finally, the discussion of the Rapid Depressurization/Blowdown discussed in FSAR Section 14.11 would not be invalidated by the presence of RCDs. The RCDs cannot be lifted and become internal missiles by the pressure differential and flow forces developed during the design basis depressurization event described in Section 14.11. As discussed above, the pre accident circulating activity is unaffected by the RCDs so event consequences remain as in the FSAR.

Therefore, the introduction of RCDs does not invalidate the accident analyses described in the FSAR.

6.2 Consideration of Potential New Concerns Introduced by RCDs

The RCDs described herein have been considered for potential of initiating safety concerns which have not been addressed and resolved in the FSAR. These hypothesized failure modes are discussed below. It is concluded that there are no new safety issues introduced by the employment of the RCDs.

Though considered incredible, one proposed failure mode is the break-off of a lower pin of an RCD. This could lead to a pin falling through the plenum and reflector handling holes and being inserted into a first row fuel element handling hole. While this would constitute a negative reactivity insertion, the resulting local power depression in the fuel element is less than 1% of the power produced by the element. This effect is not a safety concern and is within the range of events considered in the FSAR.

This same failure mode could lead to difficulty in fuel handling since the pin in the handling hole would prevent insertion of the normal grapple. In this event, normal fuel handling would be interrupted and the use of special fuel handling machine attachments would be required either to remove the broken pin or pick up the element with a tool designed to pick up blocks with damaged handling holes. No increase of risk to the public is associated with any abnormal fuel handling operations. The use of special attachments to the fuel handling machine would result in some additional personnel radiation exposure due to increased time spent fitting this equipment to the handling machine and increased fuel handling operations.

Another failure mode which may be postulated is the migration of an RCD after being left uninserted at installation or somehow working its way up out of the plenum elements. It is noted, however, that neither event appears credible.

First, the procedure for inserting the RCDs will be computer controlled in the same manner as fuel handling and includes appropriate limit switches and controls to preclude improper positioning and insertion of the RCDs. Because of space limitations between the top surface of plenum elements and the core cavity roof, the fuel handling grapple head cannot be disconnected from an RCD unless it is well inserted into the plenum elements. Hence,

there is little chance of initiating reactor operation with an uninserted RCD on top of the core.

Second, the pins of the RCDs were designed to have maximum length, compatible with handling requirements, as well as dry film lubricated surfaces. This was done to avoid the possibility of their ratcheting out during normal operation.

6.3 Abnormal Conditions Structural Evaluation

Seismic evaluation of the core with RCDs was performed for a .05 g Operating Basis Earthquake (OBE) and a .10 g Design Basis Earthquake (DBE). The OBE produces in-core accelerations of .19 g, and the DBE produces in-core accelerations of .26 g (Reference 2). The seismic loads were combined with the normal operating loads to determine the structural integrity of the core under abnormal conditions. The analysis shows that the core with RCDs will not sustain any damage nor require replacement of any components following an OBE. In the event of a DBE, the analysis shows that all equipment remains capable of performing its safety function and that no component will be loaded to failure.

The addition of the RCDs alters the seismic load path through the top plenum elements such that some of the load is transferred by the RCDs through the hex reflector block keys to the core boundary. This increases the loads in the hex reflector block keys and produces additional loads in the RCDs. The addition of the RCDs does not alter the seismic loads computed in Reference 2 for the core blocks, dowels or core support system since they do not alter the basic assumptions on which these loads were computed.

The load paths through the top plenum elements were established using a 1/10 scale two-dimensional plastic model on which pertinent sizes and gaps were scaled. The model indicates that when the core is accelerated in a horizontal direction, the RCDs restrict horizontal translation and cause the fuel regions to pivot about the RCD pins. This pivoting closes the gaps between the fuel regions and causes the loads between the regions to be carried by compressive forces between the blocks to the boundary. The loads from the fuel regions in the interior of core are carried primarily by compressive forces between fuel regions.

The maximum seismic loads in the RCDs and side reflector block keys were shown to occur when the direction of the seismic acceleration passes through the center of the core and a five-fuel-column region. In this case, six RCDs carry the loads from one five-fuel-column region and the three adjacent seven-fuel-column regions (Figure 1, shaded). The maximum seismic RCD load is 2.0 times the average distributed load based on the assumption that all 6 RCDs will not pickup the load simultaneously but that all 6 will be effective in carrying the total seismic loading. The maximum seismic load in the hex reflector block keys is equal to the seismic load in the RCDs plus the seismic load from a hex reflector column. The seismic load carried by the RCDs and hex reflector block keys is computed based on half the mass of the hex reflector block columns and fuel regions. The remaining load is carried through the core support floor. The maximum RCD seismic loads were computed to be 2,390 lb. for OBE and 3,270 lb. for DBE. Combining these

loads with the normal operating loads from Section 5.3 yields 3,557 lb. for OBE and 4,437 lb. for DBE. The maximum reflector block key seismic loads were computed to be 2,690 lb. for OBE and 3,680 lb. for DBE. Combining these loads with the normal operating loads yields 3,857 lb. for OBE and 4,847 lb. for DBE.

The model indicates that the loads in the interior of the core are transferred primarily by compressive forces between fuel regions. The RCD seismic loads in the interior of the core were computed by conservatively assuming that one pin acting perpendicular to the seismic acceleration vector prevents the region from rotating about its bottom corner. This assumption produces a maximum RCD seismic load of 1,520 lb. for OBE and 2,070 lb. for DBE. Combining these loads with the normal operating loads yields 1,930 lb. for OBE and 2,480 lb. for DBE.

The loads and stresses for these conditions are summarized in Table 1. The results show that the stresses are substantially below yield for both the reflector block key screw threads and RCD bolts. The RCD pin bending stresses are also shown to be below yield for OBE. For DBE, the results show that the outer pin fibers reach yield. However, the pin will not fail until all of the fibers in a cross section reach yield (i.e., until the hinge moment is exceeded). The hinge moment for the RCD pins is 19,500 in-lb. The maximum SSE pin moment is 11,200 in-lb at the boundary and 11,800 in-lb in the core interior. This indicates a minimum margin of safety of 39 percent before the pins will fail.

Conclusion

The structural, safety and plant performance analyses summarized in this Safety Analysis Report lead to the conclusion that the employment of the Region Constraint Devices in the Fort St. Vrain plant does not adversely affect the safety of the plant or risk to the health and safety of the public.

Table 1

SUMMARY OF MAXIMUM LOADS AND STRESSES

Component		Normal Operation		OBE		DBE		Yield Stress (psi) @ 760°F
		Applied Load (lb)	Max. Stress (psi)	Applied Load (lb)	Max. Stress (psi)	Applied Load (lb)	Max. Stress (psi)	
Reflector Block Keys (shear in screw threads)		1,167	2,290	3,857	7,570	4,847	9,510	16,100 (SA-387 G22)
RCD Bolts (tension)	Interior	410	2,920	1,930	13,700	2,480	17,700	80,200 (SA-453-660)
	Boundary	1,167	6,550	3,557	20,000	4,437	24,900	
RCD Pins (bending)	Interior	410	24,200	1,930	114,000	2,480	134,000 *	134,000 (Inconel 718)
	Boundary	1,167	36,700	3,557	111,000	4,437	134,000 *	

*For these conditions, the outer fibers reach yield. The maximum moment the pin can carry before all of the fibers reach yield is 19,500 in-lb (hinge moment). The maximum DBE moment is 11,200 in-lb at the boundary and 11,800 in-lb in the interior.

Table 2

POTENTIAL EFFECTS OF REGION CONSTRAINT DEVICES (RCD) ON FSV FSAR ACCIDENT PENETRATIONS

FSAR Chapter XIV Event	Potential Effects on Event Analysis Due to RCDs in Core
14.1 Environmental Disturbances	
Earthquake	No effect on FSAR analysis; RCD design compatible with plant seismic criteria.
Wind effects Flood Fire Landslides Snow and Ice	No effect from RCD presence.
14.2 Reactivity Accidents and Transient Response	
Summary of Reactivity Sources	
Excessive removal of control poison Loss of fission product poisons	No effect from RCD presence.
Rearrangement of core components Introduction of steam into the core	No effect on assumptions of FSAR treatment.
Sudden decrease in reactor temperature Rod withdrawal accidents	No effect from RCD presence.
14.3 Incidents	
Incidents Involving the Reactor Core	
Column deflection and misalignment Fuel element malfunctions	Cross references Ch. 3, RCD should Improve evaluation.
Misplaced fuel element Blocking of coolant channel	No effect from RCD presence.

TABLE 2 (Continued)

	FSAR Chapter XIV Event	Potential Effects on Event Analysis Due to RCDs in Core
	Control rod malfunctions	No effect from RCD presence.
	Orifice malfunctions	No effect from RCD presence.
	Core support floor loss of cooling	No effect from RCD presence.
	Incidents involving the primary coolant system	
	Incidents involving the control and instrumentation system	
	Incidents involving the PCRV	
	Incidents involving the secondary coolant and power conversion system	No effect from RCD presence.
	Incidents involving the electrical system	
	Malfunctions of the helium purification system	
	Malfunctions of the helium storage system	
	Malfunction of the nitrogen system	
14.4	Loss of Normal Shutdown Cooling	No effect from RCD presence.
14.5	Secondary Coolant System Leakage	
	Steam leaks outside the primary coolant system	
	Leaks inside the primary coolant system (moisture inleakage)	No effect from RCD presence.
	Steam generator leakage accident consequences	

TABLE 2 (Continued)

FSAR Chapter XIV Event	Potential Effects on Event Analysis Due to RCDs in Core
14.6 Auxiliary System Leakage	
Failures involving the helium purification system	
Loss of both purification trains	No effect from RCD presence.
Failure of regeneration line w/simultaneous valve failure and operational error	
Accidents involving the gas waste system	
Fuel handling and storage accidents	No effect or consequences of event analyzed in FSAR. Possibility of loose parts increases the probability of interference with fuel removal from core.
Fuel handling accidents	
Fuel storage accidents	
14.7 Primary Coolant Leakage	No effect from RCD presence.
14.8 Maximum Credible Accident	No effect from RCD presence.
14.9 Maximum Hypothetical Accident (See 14.11)	
14.10 Design Basis Accident No. 1 "Permanent Loss of Forced Circulation (LOFC)"	No effect from RCD presence.
14.11 Design Basis Accident No. 2 "Rapid Depressurization/Blowdown (DBDA)"	No effect from RCD presence (i.e., Orifice plenum element does not levitate and RCD is less likely to levitate.)

References

1. H. D. Chiger and B. E. Boyack, "Verification of the SPIFFS Computer Program," GA-A13074, July 1974.

2. "Structural Analysis of PSC Reactor Internals," GADR-16, 1972.

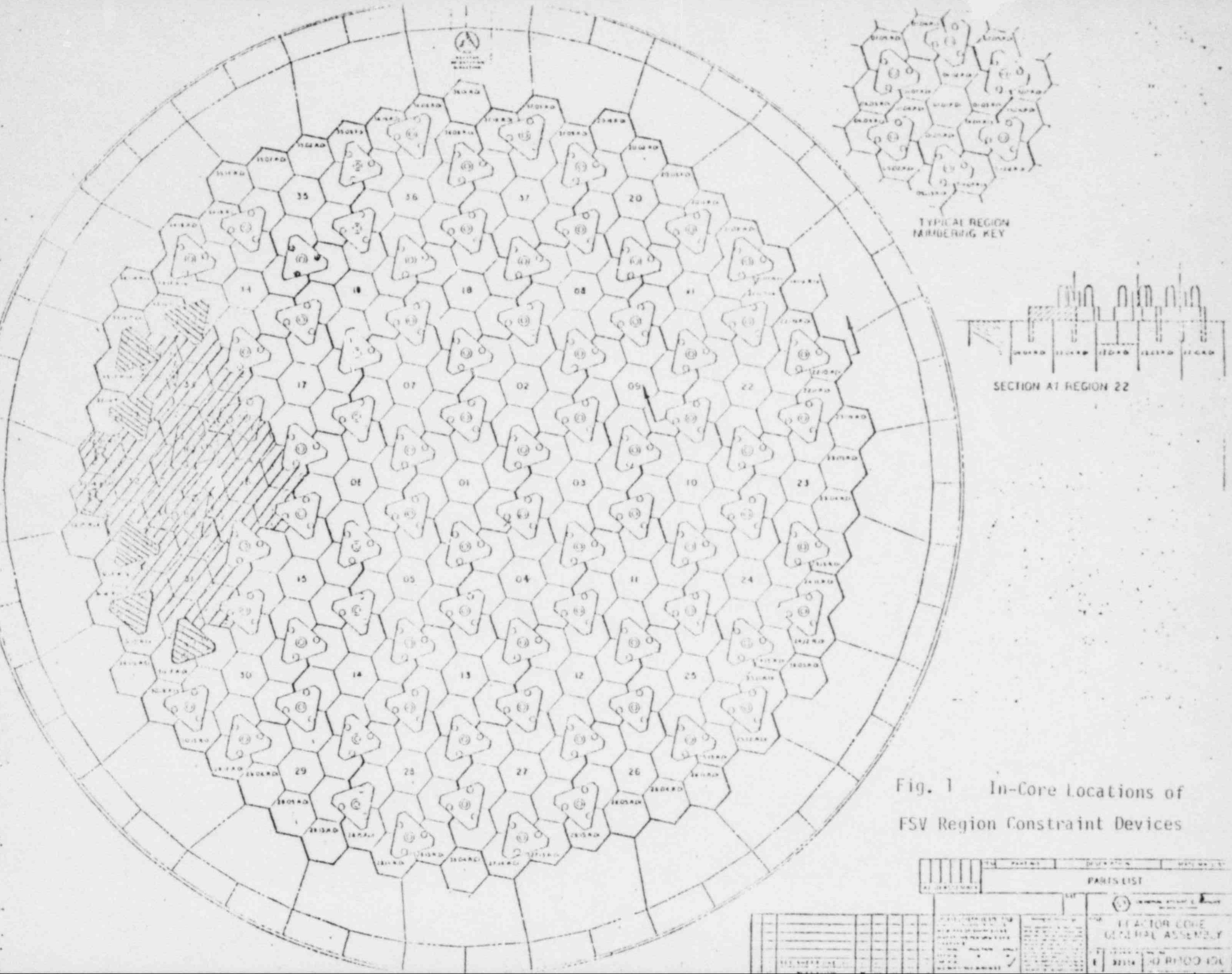

Fig. 1 In-Core Locations of FSV Region Constraint Devices

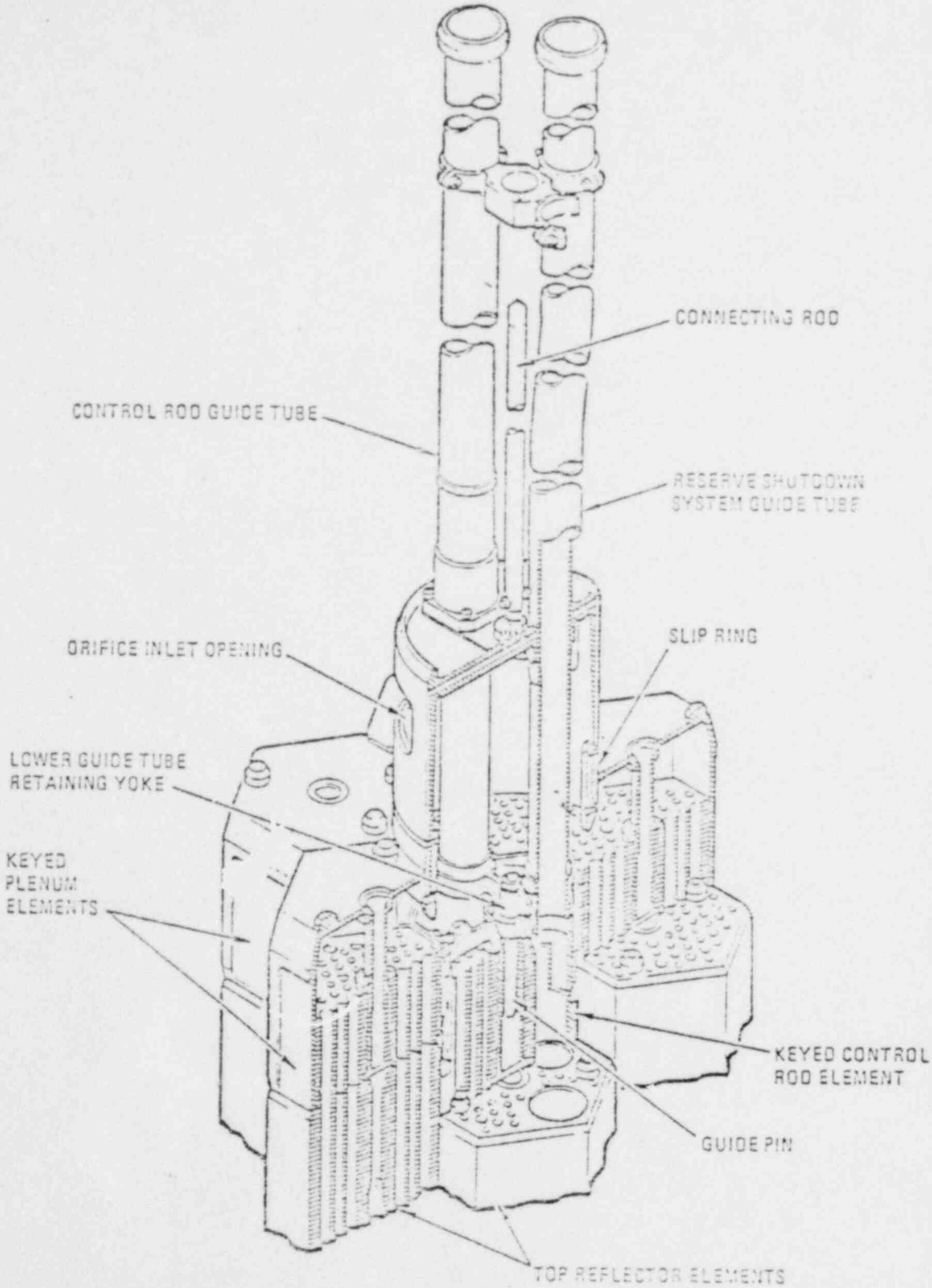

Fig. 2 Top plenum and orifice valve arrangement

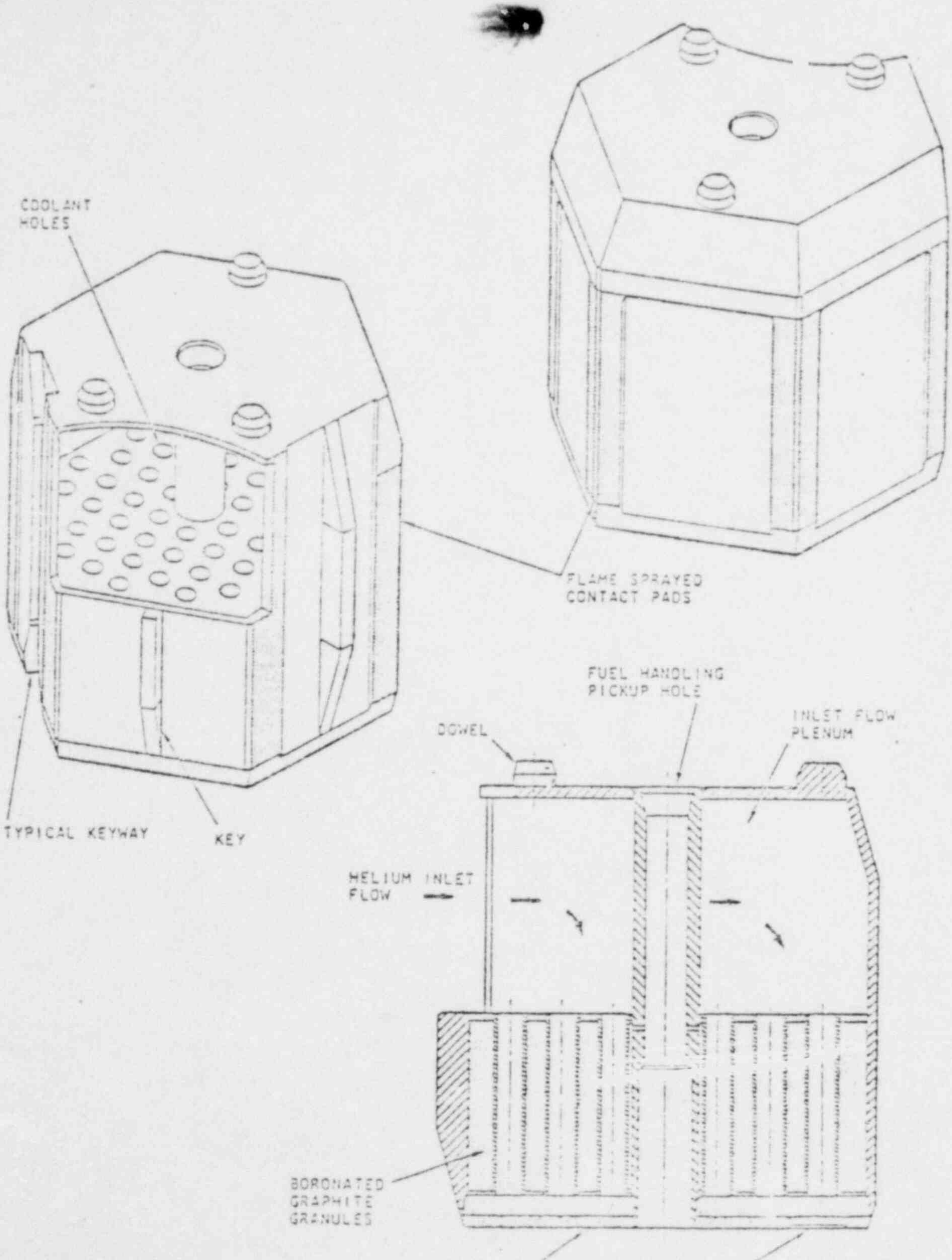

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Fig. 3 Top reflector orifice plenum

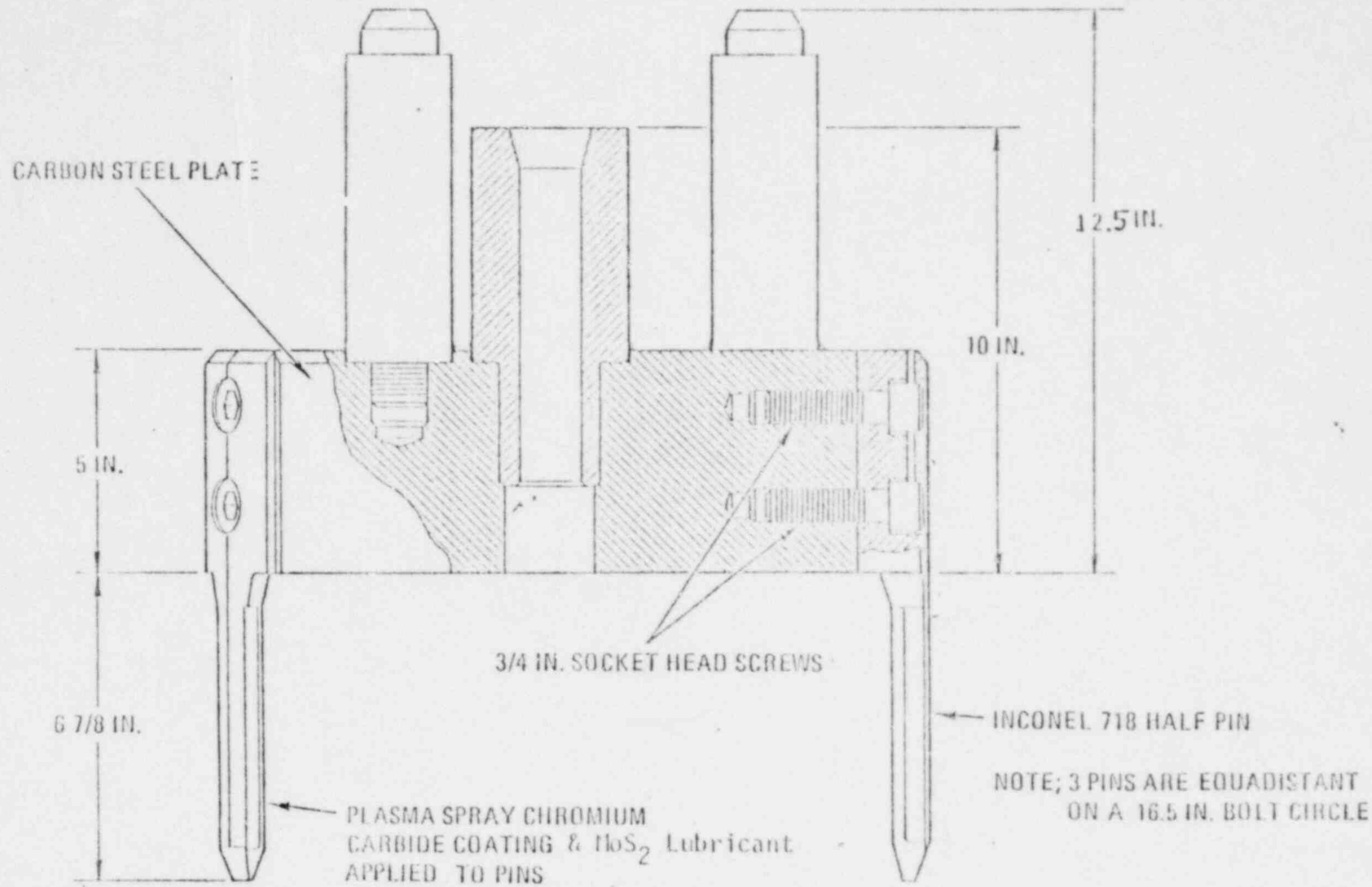
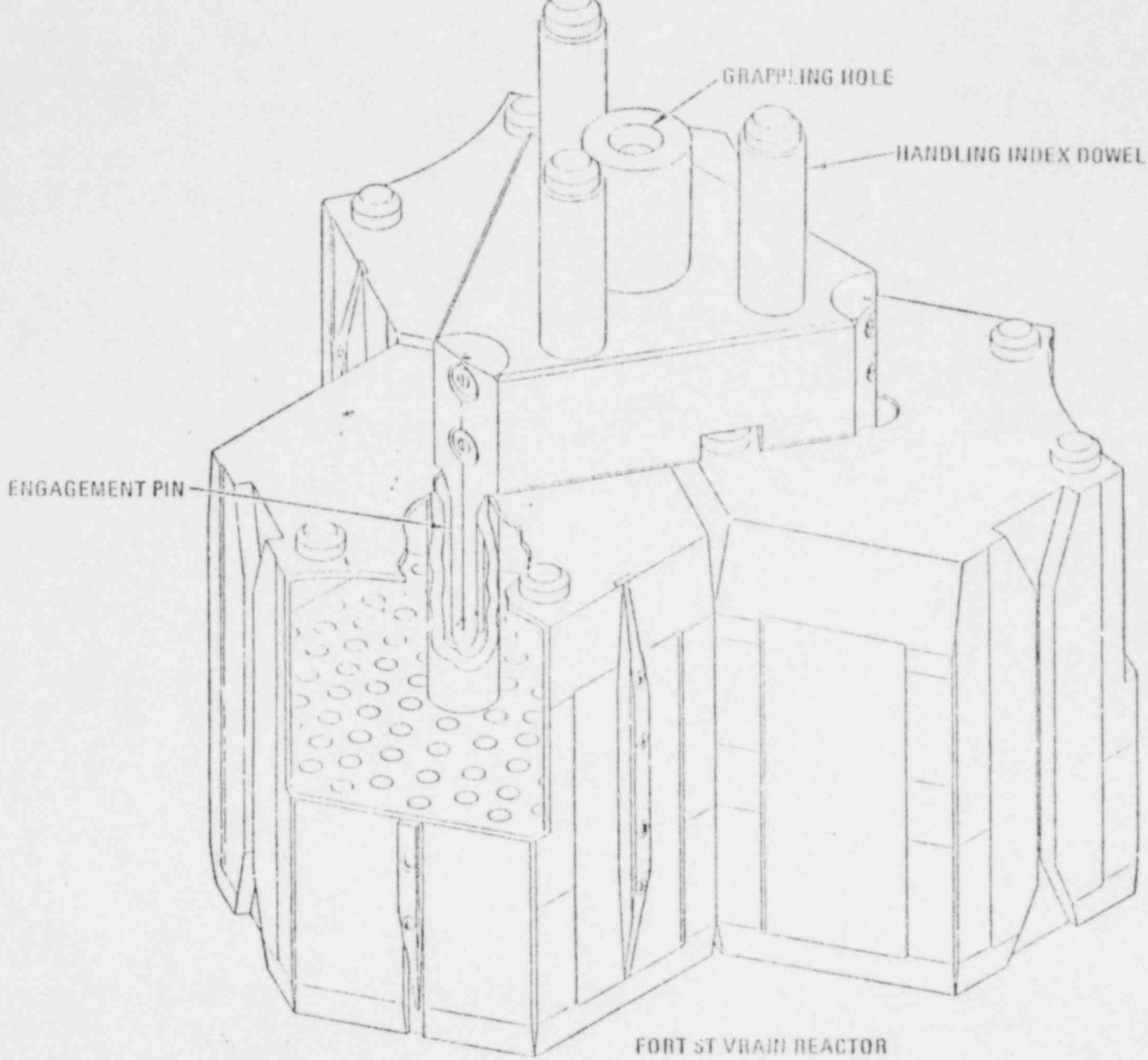


Fig. 4 FSV Region Constraint Device - Elevation View



FORT ST VRAIN REACTOR

REGION CONSTRAINT DEVICE
INSTALLATION

Fig. 5