ENCLOSURE 2

APP-GW-GLE-016 NS

Revision 0

"Impact of In-core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package (IHP)"

(Public Version)

Redacted version of Enclosure 1 with sensitive unclassified non-safeguards information related to the physical protection of an AP1000 Nuclear Plant withheld from public disclosure pursuant to 10 CFR 2.390(d)

F-AP-3.2-1 Rev 4

AP1000 DOCUMENT COVER SHEET

TDC:________ Permanent File:________

AP1000 DOCUMENT NO.	REVISION	PAGE	ASSIGNED TO	OPEN ITEMS (Y/N)
APP-GW-GLE-016-NS	0	1 of ~~64~~ 93 JW 6/30/08	D. E. Ekeroth	N

ALTERNATE DOCUMENT NUMBER: None WORK BREAKDOWN #: 1.6.4.5.2

ORIGINATING ORGANIZATION: Westinghouse Electric Company

TITLE: **Impact of In-core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package (IHP)**

ATTACHMENTS: None	DCP #/REV. INCORPORATED IN THIS DOCUMENT REVISION: APP-GW-GEE-411 Rev. 1(redacted)
CALCULATION/ANALYSIS REFERENCE: None	

ELECTRONIC FILENAME	ELECTRONIC FILE FORMAT	ELECTRONIC FILE DESCRIPTION
APP-GW-GLE-0016_R0	Microsoft Word	text

LEGAL REVIEW ~~T. J. White~~ Lisa Campagna	SIGNATURE / DATE Lisa A Campagna 7/1/08
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****Plant Applicability:** ☒ All AP1000 plants except: No Exceptions
☐ Only the following plants:

APPLICABILITY REVIEWER** J. A. Speer	SIGNATURE / DATE [signature] 6/30/08
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* Approval of the responsible manager signifies that the document and all required reviews are complete, the appropriate proprietary class has been assigned, electronic file has been provided to the EDMS, and the document is released for use.

APP-GW-GLE-016-NS
Revision 0

June 2008

AP1000 DCD Impact Document

Impact of In-Core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package (IHP)

Revision 0

Public (redacted) Version with sensitive unclassified non-safeguards information relative to the physical protection of an AP1000 nuclear plant withheld under 10 CFR 2.390(d).

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Document Number: APP-GW-GLE-016-NS **Revision Number:** 0

Title: **Impact of In-core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package**

Brief Description of the Impact (what is being changed and why):

Components of the upper internals are being changed to allow the activated portion of the in-core instrumentation thimble tubes (IITAs) to remain underwater at all times during the refueling outage. This eliminates the 42 in-core instrumentation guide tubes penetration in the reactor vessel head and replaces them with eight Quickloc penetrations. The IHP storage stand and water tank are replaced with a conventional reactor vessel headstand. These changes will enhance safety; facilitate reactor vessel head inspection and lower Occupational Radiation Exposure (ORE) during refueling outages. Because the activated portion of the IITAs are kept underwater, the shielding on the IHP can be significantly reduced and the IITA thimble handling rig eliminated. This reduces the size and weight of the IHP lifting rig. It also allows the four CRDM cooling fans to be directly mounted to the IHP. This eliminates the removable CH-40 platform. The seven inch thick seismic support/shielding plate is replaced by a thinner plate. The seismic support function of this plate is replaced by a seismic support system used in the Westinghouse operating fleet. This system uses the Digital Rod Position Indicator Plates, which act as the lateral support for the CRDM via interaction with a grid work of spacer plates and a seismic support platform.

SRP Section Impacted:
Impacts Sections 3.7.2, 3.8.3, 3.9.4 and 3.9.5 of the Standard Review Plan (SRP).

This evaluation is prepared to document the following Design Control Document (DCD) changes:

<u>Tier 1</u>

- Figure 2.1.3-3 Reactor Vessel Arrangement
- Figure 3.3-1 Nuclear Island Section A-A
- Figure 3.3-7 Nuclear Island Plan View at EL 117'-6"
- Figure 3.3-8 Nuclear Island Plan View at EL 135'-3"

<u>Tier 2</u>

- Subsection 1.2.1.2.1 Reactor Design
- Subsection 3.9.5.1.2 Upper Core Support Assembly
- Subsection 5.3.1.2, Safety Description
- Subsection 3.9.7 Integrated Head Package
- Subsection 4.4.6.1 In-core Instrumentation
- Subsection 4.6.1 Information for Control Rod Drive System
- Subsection 12.2.1.2 Sources for Shutdown
- Subsection 12.2.1.2.5 In-core Flux Thimbles
- Subsection 15.4.8.1.1.6 Effect of Rod Travel Housing Circumferential Failure
- Figure 1.2-8 Nuclear Island General Arrangement Plan at Elevation 117'-6" & 130'-0"
- Figure 1.2-9 Nuclear Island General Arrangement Plan at Elevation 117'-6" with Equipment

- Figure 1.2-10 NI General Arrangement Plan at EL 135'-3"
- Figure 1.2-11 Nuclear Island General Arrangement Plan at Elevation 153'-0" & 160'-6"
- Figure 1.2-13 Nuclear Island General Arrangement Section A-A
- Figure 1.2-14 Nuclear Island General Arrangement Section A-A with Equipment (Tripod added during operation)
- Figure 1.2-16 Nuclear Island General Arrangement Section B-B with Equipment (Tripod added during operation)
- Table 3.2-3 (Sheet 33 of 65) AP1000 Classification of Mechanical and Fluid Systems, Components and Equipment
- Figure 3H.5-1 (Sheet 3 of 3) Nuclear Island Critical Sections Section A-A
- Figure 3.7.2-12 (Sheet 5 of 12) Nuclear Island Key Structural Dimensions Plan at EL. 153'-0" & 160'-6"
- Figure 3.7.2-12 (Sheet 6 of 12) Nuclear Island Key Structural Dimensions Plan at EL. 153'-0" & 160'-6"
- Figure 3.9-6 Upper Core Support Structure
- Figure 3.9-7 Integrated Head Package
- Figure 3.9-8 Reactor Internals Interface Arrangement
- Table 5.2-1 (Sheet 1 of 5) Reactor Coolant Pressure Boundary Materials Specifications
- Figure 5.3-1 Reactor Vessel
- Figure 5.3-6 Reactor Vessel Key Dimensions, Side View
- Figure 6.2.4-9 Hydrogen Igniter Locations Plan View Elevation 118'-6"
- Figure 6.2.4-10 Hydrogen Igniter Locations Plan View Elevation 135'-3"
- Figure 6.2.4-11 Hydrogen Igniter Locations Plan View Elevation 162'-0"
- Figure 9A-1 (Sheet 6 of 16) Nuclear Island Fire Area Plan at Elevation 117'-6"
- Figure 9A-1 (Sheet 7 of 16) NI Fire Area Operating Deck EL 135'-3"
- Figure 9A-1 (Sheet 8 of 16) Nuclear Island Fire Area Plan at Elevation 153'-0" & 160'-6"
- Figure 9A-1 (Sheet 10 of 16) Nuclear Island Fire Area Section A-A
- Figure 12.3-1 (Sheet 7 of 16) Radiation Zones, Normal Operation/Shutdown Nuclear Island, Elevation 117'-6"
- Figure 12.3-1 (Sheet 8 of 16) Radiation Zones Normal Operation/Shutdown EL 135'-3"
- Figure 12.3-1 (Sheet 9 of 16) Radiation Zones, Normal Operation/Shutdown Nuclear Island, Elevation 153'-0" & 160'-0"
- Figure 12.3-2 (Sheet 7 of 15) Radiation Zones, Post-Accident Nuclear Island, Elevation 117'-6"
- Figure 12.3-2 (Sheet 8 of 15) Radiation Zones Post-Accident EL 135'-3"
- Figure 12.3-2 (Sheet 9 of 15) Radiation Zones, Post-Accident Nuclear Island, Elevation 153'-0" & 160'-6"
- Figure 12.3-3 (Sheet 7 of 16) Radiological Access Control, Normal Operation/Shutdown Nuclear Island, Elevation 117'-6"
- Figure 12.3-3 (Sheet 8 of 16) Radiological Access Control Normal Operation/Shutdown EL 135'-3"

- Figure 12.3-3 (Sheet 9 of 16) Radiological Access Control, Normal Operation/Shutdown Nuclear Island, Elevation 153'-0" & 160'-6"

These changes are intended to be included in revision 17 of the DCD.

I. TECHNICAL DESCRIPTION

An instrument grid assembly is added to the reactor vessel upper internals package. This instrument grid assembly positions and supports the 42 instrumentation guide tubes. The IITAs fit inside the instrumentation guide tubes. They do not move from the instrumentation guide tubes until they have to be replaced. Six instrumentation guide tubes are ganged together to form an individual Quickloc stalk. The Quickloc stalks penetrate the reactor vessel head at eight Quickloc penetrations. A Quickloc is the primarily coolant pressure boundary for up to six IITAs. This is shown in Figure 1 Reactor Vessel (DCD Figure 3.9-8 Reactor Internals Interface Arrangement).

Since the activated portions of the IITAs are always underwater, the shielding of the IHP has been reduced. The IHP shroud still provides excellent shielding for the lower radioactive source term associated with the reactor vessel head and CRDMs within the IHP. The thimble rig is eliminated and the lower weight of the IHP allows for a smaller more compact lifting rig. Since the lifting rig is much smaller it remains on the IHP at all times during operation and refueling. The lower weight of the IHP allows the four CRDM cooling fans to be mounted directly on the IHP shroud structure. This eliminates the large plenums and ductwork as well as the CH-40 module that held the plenum, ductwork and four CRDM cooking fans.

The seven inch thick seismic support plate is replaced with a thinner plate. The seismic support function of this plate is replaced by a seismic support system of the type used in the Westinghouse operating fleet. This system uses the Digital Rod Position Indicator Plates, which act as the lateral support for the CRDM via interaction with a grid work of spacer plates and a seismic support platform.

Since the IITAs remain underwater and are stored in the upper internals stand in the flooded reactor refueling cavity, a conventional head stands is used during refueling outages. This eliminates the large IHP head stand/water tank.

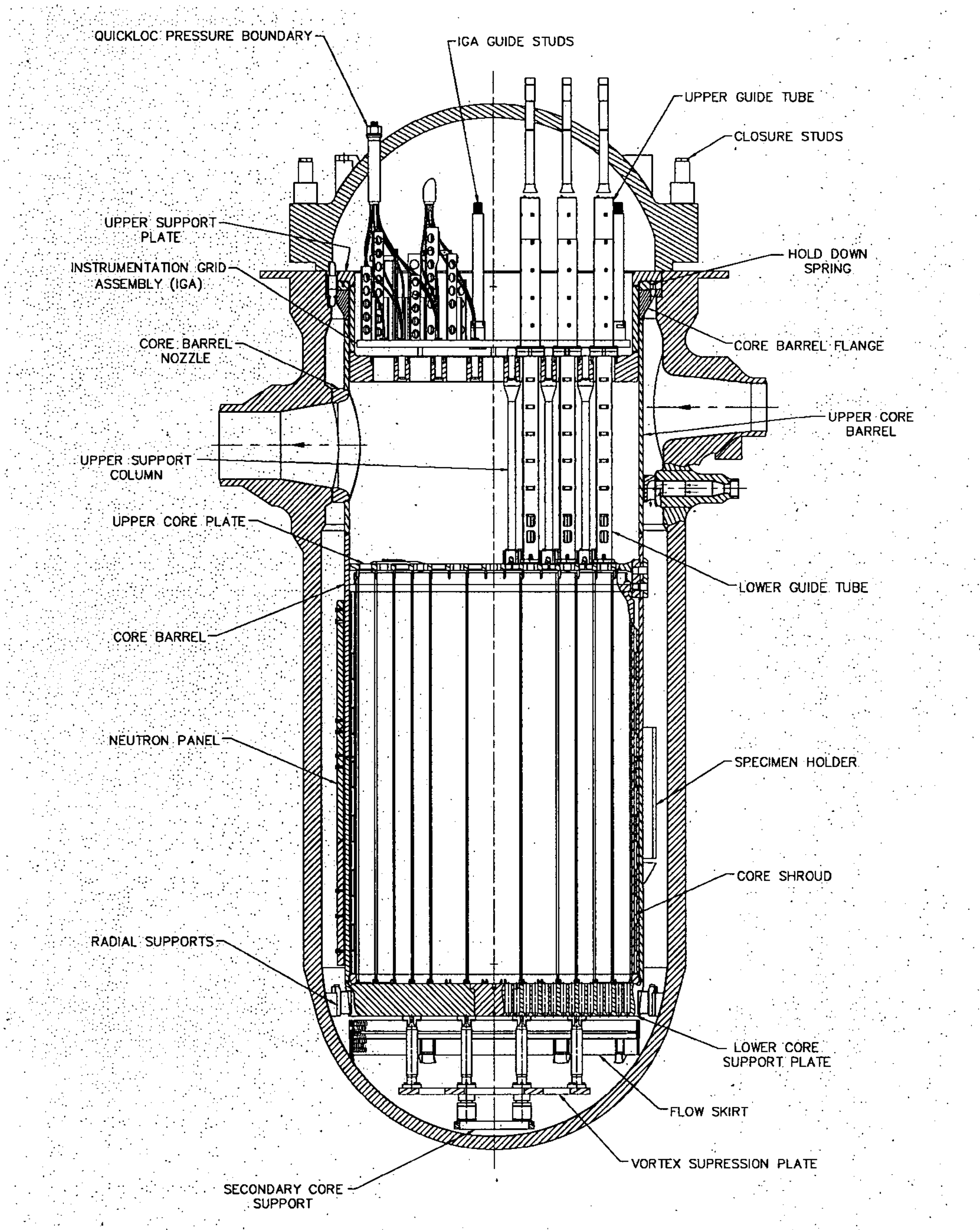

Figure 1 Reactor Internals Interface Arrangement

II. CHANGE JUSTIFICATION

As noted in the description, the goal of this change is to enhance safety, facilitate reactor vessel head inspection and reduce ORE during refueling outages. The 42 twenty-five foot long in-core instrumentation guide tubes are eliminated and are replaced with eight Quickloc nozzles. Quicklocs are proven technology and approved by the NRC. Similar Quickloc nozzles are in operation at the Waterford 3, Calvert Cliffs 1&2 and St. Lucie 1&2 units. This reduces the number of penetrations in the reactor vessel head. Only eight Quickloc nozzles are connected to the reactor vessel head. This greatly reduces the amount of handling time. The highly activated portions of the IITAs are underwater at all times and are moved remotely with the rest of the upper internals package all at one time by the internals lift rig. There is a minimum of 10 feet of water above the activated portion of the IITAs and over 20 feet of water when the upper internals are in the upper internals head stand. Movement of the upper internals is an administratively-controlled heavy lift. In the certified design, the IITAs were manually lifted and lowered one at a time. There were two raise/lower cycles during each refueling outage. This change eliminates manual mishandling events with the IITAs.

Eliminating the in-core instrumentation guide tubes allows more room between CRDMs for visual examination of the reactor vessel head. It also allows for easier access to the Digital Rod Position Indicator (DRPI) connectors at the top of the CRDMs.

The IHP now rests on a conventional head stand less than five feet high on the containment operating deck. In the certified design, the IHP was place over a large water shield tank and special track ways were needed to mount the inspection equipment over the headstand water tank.

The CRDM cooling fans are now mounted directly on the IHP and there is no need to uncouple them from the ductwork/plenums. The large CH-40 module is eliminated so two polar crane picks of this potentially contaminated structure are eliminated.

The highly activated IITAs are no longer are pulled into the IHP shroud and this greatly reduces both the radiation dose and number of personnel needed to service the IHP. Cumulative radiation exposure to the CRDM coil stacks, cables and connectors within the shroud is greatly reduced.

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III. REGULATORY IMPACT

A. EVALUATION OF DEPARTURE FROM TIER 2 INFORMATION (Check correct response and provide justification for that determination under each response)

10 CFR Part 52, Appendix D, Section VIII.B.5.a. provides that an applicant for a combined licensee who references the AP1000 design certification may depart from Tier 2 information, without prior NRC approval, if it does not require a license amendment under paragraph B.5.b. The questions below address the criteria of B.5.b.

1. Does the proposed departure result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the plant-specific DCD? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not alter accident precursors or the design function of the in-core instrumentation.

2. Does the proposed departure result in more than a minimal increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety and previously evaluated in the plant-specific DCD? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not increase the likelihood of an occurrence of a malfunction of a structure, system, or component important to safety. The addition of instrument grid assembly, Quicklocs and change to the integrated head package do not affect accident precursors.

3. Does the proposed departure result in more than a minimal increase in the consequences of an accident previously evaluated in the plant-specific DCD? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not alter the design function of the stack or increase the consequences of an accident previously evaluated in the plant-specific DCD.

4. Does the proposed departure result in more than a minimal increase in the consequences of a malfunction of an SSC important to safety previously evaluated in the plant-specific DCD? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not increase the consequences of a malfunction of an SSC important to safety previously evaluated in the plant-specific DCD.

5. Does the proposed departure create a possibility for an accident of a different type than any evaluated previously in the plant-specific DCD? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not alter the design function of the in-core instrumentation. The addition of the instrument grid assembly, Quicklocs and change to the integrated head package changes do not add or modify accident precursors.

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6. Does the proposed departure create a possibility for a malfunction of an SSC important to safety with a different result than any evaluated previously in the plant-specific DCD? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not alter operating conditions or design functions of SSCs important to safety. Therefore there is no new malfunction.

7. Does the proposed departure result in a design basis limit for a fission product barrier as described in the plant-specific DCD being exceeded or altered? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not alter the pressure boundary integrity design function of the reactor coolant system or other SSCs important to safety.

8. Does the proposed departure result in a departure from a method of evaluation described in the plant-specific DCD used in establishing the design bases or in the safety analyses? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package do not alter the methodology of the evaluation of the pressure boundary integrity of the safety analysis.

B. IMPACT ON RESOLUTION OF A SEVERE ACCIDENT ISSUE

   10 CFR Part 52, Appendix D, Section VIII. B.5.a. provides that an applicant for a combined licensee who references the AP1000 design certification may depart from Tier 2 information, without prior NRC approval, if it does not require a license amendment under paragraph B.5.c. The questions below address the criteria of B.5.c.

1. Does the proposed activity result in an impact to features that mitigate severe accidents. If the answer is Yes answer Questions 2 and 3 below. ☐ YES ☒ NO

   There is no change to the response of safety systems used to mitigate severe accidents due to the addition of the instrument grid assembly, Quicklocs and change to the integrated head package.

2. Is there is a substantial increase in the probability of a severe accident such that a particular severe accident previously reviewed and determined to be not credible could become credible? ☐ YES ☐ NO ☒ N/A

3. Is there is a substantial increase in the consequences to the public of a particular severe accident previously reviewed? ☐ YES ☐ NO ☒ N/A

C. SECURITY ASSESSMENT

1. Does the proposed change have an adverse impact on the security assessment of the AP1000? ☐ YES ☒ NO

   The addition of the instrument grid assembly, Quicklocs and change to the integrated head package will not alter barriers or alarms that control access to protected areas of the plant. The addition of instrument grid assembly, Quicklocs and change to the integrated head package will not alter requirements for security personnel.

D. OTHER REGULATORY CRITERIA

   N/A

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IV. DCD MARK-UP

Changes are shown with deletions shown with strikeout and additions underlined. Note DCD subsection 15.4.8.1.1.6, Effect of Rod Travel Housing Circumferential Failures has been deleted. A discussion of potential gross failure of a control rod drive housing is presented in DCD subsection 3.5.1.2.1, Missile Selection. The following revisions will be incorporated in Revision 17 of the DCD:

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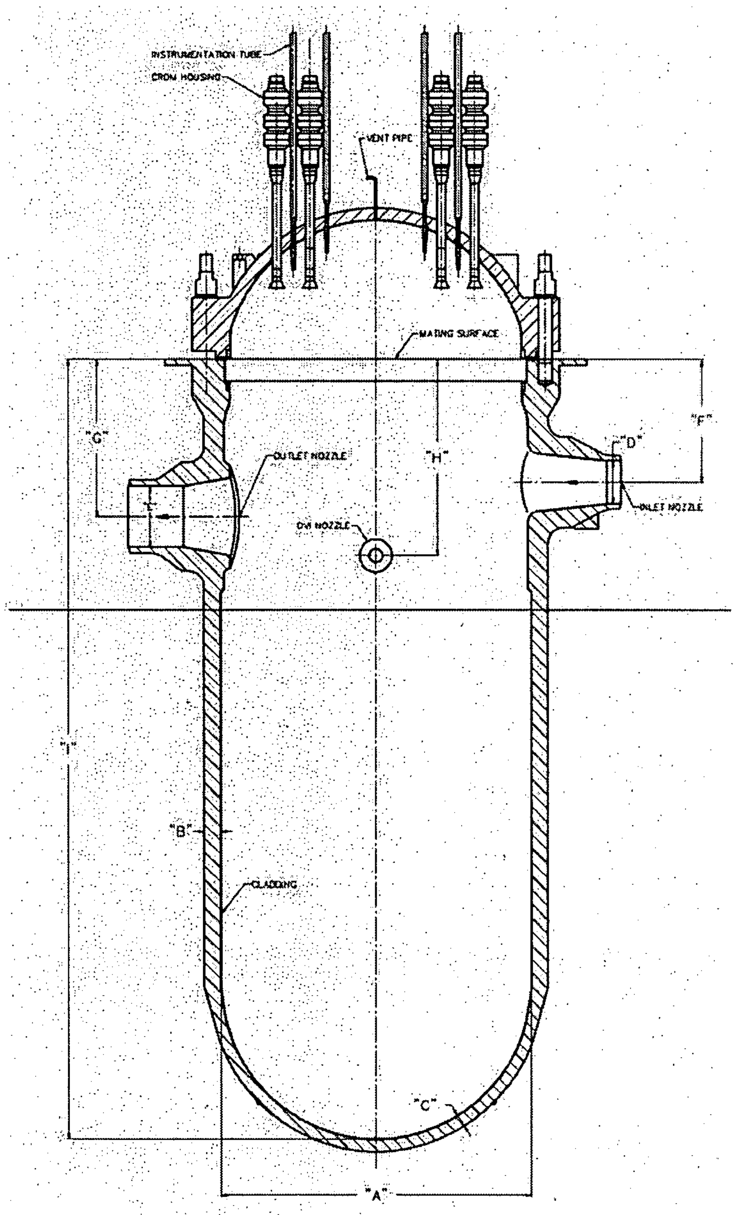

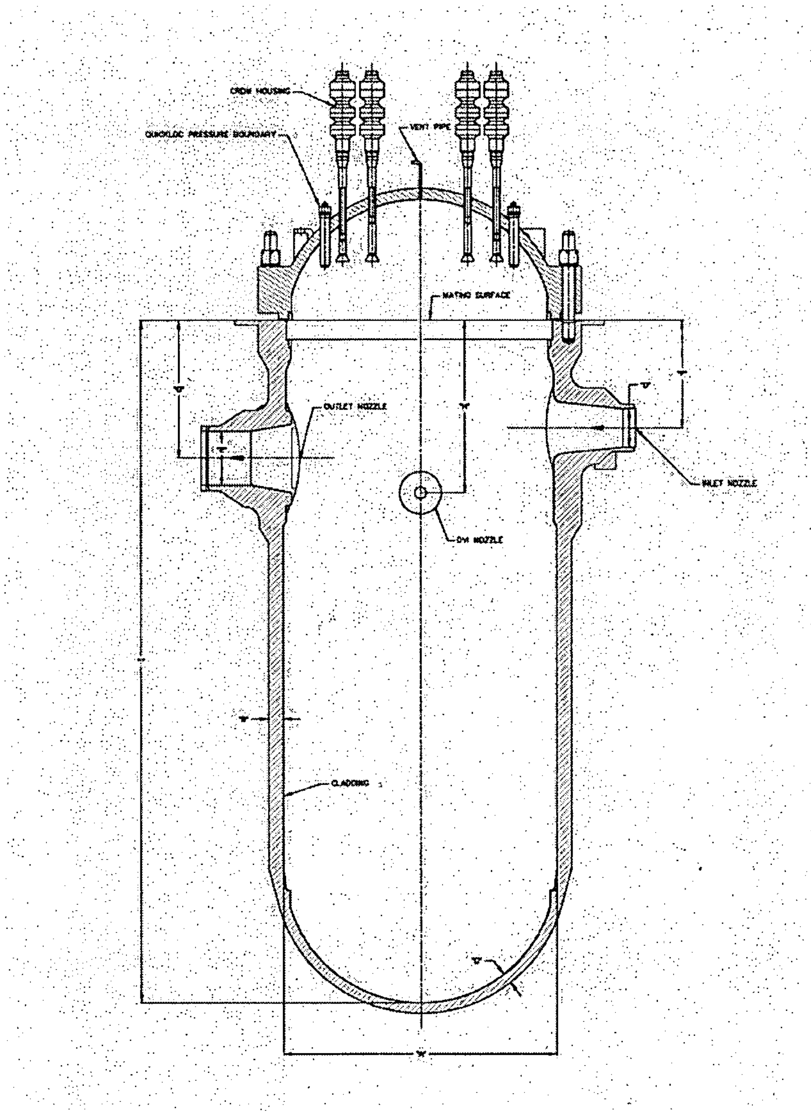

Figure 2.1.3-3
Reactor Vessel Arrangement

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 3.3-1

Nuclear Island Section A-A

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 3.3-7

Nuclear Island Plan View at Elevation 117'-6"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 3.3-8

Nuclear Island Plan View at Elevation 135'-3"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 1.2-8

Nuclear Island General Arrangement
Plan at Elevation 117'-6" & 130'-0"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 1.2-9

Nuclear Island General Arrangement
Plan at Elevation 117'-6" with Equipment

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 1.2-10

Nuclear Island General Arrangement
Plan at El. 135'-3"

Security-Related Information. Withhold Under 10 CFR 2.390d

Figure 1.2-11

Nuclear Island General Arrangement
Plan at Elevation 153'-0" & 160'-6"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 1.2-13

Nuclear Island General Arrangement
Section A-A

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 1.2-14

Nuclear Island General Arrangement
Section A-A with Equipment

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 1.2-16

Nuclear Island General Arrangement
Section B-B with Equipment

TABLE 3.2-3 (SHEET 33 OF 65)

AP1000 CLASSIFICATION OF MECHANICAL AND FLUID SYSTEMS, COMPONENTS, AND EQUIPMENT

Tag Number	Description	AP1000 Class	Seismic Category	Principal Construction Code	Comments
Reactor System (Continued)					
RXS-MI-01	Reactor Upper Internals	C	I	ASME III, CS	
RXS-MI-02	Reactor Lower Internals	C	I	ASME III, CS	
RXS-MI-10	Non-Threaded Fasteners	D	NS	ASME III, CS	
RXS-MI-11	Threaded Structural Fasteners	C	I	ASME III, CS	
RXS-MI-20	Lower Core Support Plate	C	I	ASME III, CS	
RXS-MI-22	Vortex Suppression Plate	D	II	ASME III, CS	
RXS-MI-23	Core Shroud Assembly	C	II	ASME III, CS	
RXS-MI-24	Radial Supports [4]	C	I	ASME III, CS	
RXS-MI-25	Core Barrel	C	I	ASME III, CS	
RXS-MI-26	Core Barrel Nozzle	C	I	ASME III, CS	
RXS-MI-27	Head and Vessel Pins	D	II	ASME III, CS	
RXS-MI-28	Lower Support Plate Fuel Alignment Pins	C	I	ASME III, CS	
RXS-MI-29	Core Barrel Hold Down Spring	C	I	ASME III, CS	
RXS-MI-50	Upper Support	C	I	ASME III, CS	
RXS-MI-51	Upper Core Plate	C	I	ASME III, CS	
RXS-MI-52	Support Columns [42]	C	I	ASME III, CS	
RXS-MI-53	Guide Tube Assemblies [69]	C	I	ASME III, CS	
RXS-MI-54	Upper Support Plate Fuel Alignment Pins	C	I	ASME III, CS	
RXS-MI-55	Upper Core Plate Inserts	C	I	ASME III, CS	
RXS-MI-56	Safety Injection Deflector	D	II	ANSI B31.1	
RXS-MI-57	Irradiation Specimen Guide Tubes	D	II	ANSI B31.1	
RXS-MI-58	Head Cooling Nozzles	D	II	ANSI B31.1	
RXS-MV-10	Reactor Integrated Head Package	C	I	AISC-690	
RXS-MV-10A	Integrated Head Package Shroud	C	I	ASME-NF	
RXS-MV-10B	Integrated Head Package Seismic Support ~~Plate~~System	C	I	ASME-NF	
RXS-MV-11B06	Control Rod Drive Mechanism Position B6	D	NS	Manufacturer Std.	

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 3.7.2-12 (Sheet 5 of 12)

[Nuclear Island Key Structural Dimensions Plan at El. 135'-3"]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 3.7.2-12 (Sheet 6 of 12)

[Nuclear Island Key Structural Dimensions Plan at El. 153'-0" & 160'-6"]

3.9.5.1.2 Upper Core Support Assembly

The AP1000 upper core support assembly consists of the upper support, the upper core plate, the support columns, and the guide tube assemblies. Figure 3.9-6 shows the upper core support assembly.

The support ~~columns~~ grid assembly establish the spacing between the upper support and the upper core plate. The support columns are fastened at the top and bottom to these plates. The support columns transmit the mechanical loadings between the two plates and some serve the supplementary function of supporting the tubes that house the fixed in-core detectors. The instrument grid assembly housing the in-core detectors provide a protective path for the detectors during installation, reactor operation, and removal at refueling outages.

The guide tube assemblies sheath and guide the control rod drive shafts and control rods. The guide tubes are fastened to the upper support and are restrained by pins in the upper core plate for proper orientation and support. The upper core support assembly is positioned in its proper orientation, with respect to the lower core support assembly, by flat-sided pins in the core barrel. Four equally spaced flat-sided pins are located at an elevation in the core barrel where the upper core plate is positioned. Four mating sets of inserts are located in the upper core plate at the same positions. As the upper support assembly is lowered into the lower support assembly, the inserts engage the flat-sided pins in the axial direction. Lateral displacement of the plate and of the upper support assembly is restricted by this design.

3.9.7 Integrated Head Package

The integrated head package (IHP) combines several components in one assembly to simplify refueling the reactor. Figure 3.9-7 illustrates the integrated head package. The integrated head package includes a lifting rig, seismic restraints for control rod drive mechanisms, support for reactor head vent piping, power cables, cables ~~and guide tubes~~ for in-core instrumentation, cable supports and shroud assembly.

The integrated head package provides the ability to rapidly disconnect cables, including the CRDM power cables, digital rod position indication cables, and in-core instrument cables from the components. The integrated head package also provides the ability to rapidly disconnect the reactor head vent system.

The integrated head package provides the ability to move these components as an assembly to permit their lifting and removal with the reactor vessel head. In addition, the integrated head package provides support for the vessel head stud tensioner/detensioner during refueling.

The lifting rig function is discussed in subsection 9.1.5. The control rod drive mechanisms are discussed in subsection 3.9.4. The control rod drive mechanism support and cooling function is discussed in Section 4.6. The reactor vessel head vent function is discussed in subsection 5.4.12. The function and requirements of the in-core instrumentation are discussed in Chapter 7.

3.9.7.1 Design Bases

Components, including the shroud and control rod drive mechanism seismic support plate, required to provide seismic restraint for the control rod drive mechanisms and the valves and piping of the reactor head vent are AP1000 equipment Class C, seismic Category I. The shroud and seismic support plate are designed in accordance with the ASME Code, Section III, Subsection NF requirements.

The loads and loading combinations due to seismic loads for these components are developed using the appropriate seismic spectra.

The structural design of the integrated head package is based on a design temperature consistent with the heat loads from the vessel head, the control rod drive mechanisms, and electrical power cables. The design also considers changes in temperature resulting from plant design transients and loss of power to the cooling fans.

Components required to provide cooling to the control rod drive mechanisms are nonnuclear safety-related AP1000 equipment Class E. Section 4.6 offers a discussion of the effect of failure of cooling of the control rod drive mechanisms.

Those components that function as part of the lifting rig are required to be capable of lifting and carrying the total assembled load of the package. This includes the vessel head, control rod drive mechanisms, control rod drive mechanism seismic supports, shroud, ~~instrumentation guide tubes,~~ cooling ducts, ~~instrumentation support structure,~~ and insulation. The lifting rig components are required to meet the guidance for special lifting rigs, in

NUREG-0612 (Reference 10). The lifting rig components are nonsafety-related, AP1000 equipment Class E.

~~The components of the in-core instruments support system (IISS) are required to remove and support the in-core instrumentation thimbles during refueling and maintenance. The routing of the tubing for the in-core instrumentation system is required to permit the installation of the instrumentation without binding and to prevent radiation shine through the tubing. The in-core instrumentation support system is AP1000 equipment Class E and is non-seismic.~~The components of the Incore Instrumentation System (IIS) that interface with the IHP are the QuickLoc stalk assembly and the IIS cables and connectors. Access to each QuickLoc assembly, including connection/disconnection of the QuickLoc, connection/disconnection of the IIS cables, and attaching/removing the bullet nose assembly, is a maintenance requirement for design of the IHP shroud. The IHP must also provide support of the IIS cables.

The shroud assembly is required to provide radiation shielding of the control rod drive mechanism ~~and the conduit for in-core instrumentation when the instrumentation is withdrawn into the conduit. The radiation level at the exterior surface of the shroud during refueling with the in-core instrument thimble withdrawn is included in the radiation levels discussed in Section 12.2~~.

The shroud also minimizes the effects of external events such as jets from through-wall cracks in high- and moderate-energy pipes. The control rod drive mechanisms and small diameter piping, tubing and conduit within the shroud do not represent credible sources of missiles or jets due to breaks or cracks. Therefore, the shroud is not required to act as a missile shield to contain missiles generated within the integrated head package. It is also not required to deflect any jets originating within the integrated head package.

The cables and connectors, within the integrated head package, for the in-core instrumentation system are AP1000 equipment Class C, Class 1E. These cables are required to be physically and electrically independent of other cables including control rod drive mechanism power cables. Section 7.1 describes separation requirements. The cables and connector must be environmentally qualified, as discussed in Section 3.11. The cables are required to terminate at a connector plate located so that the cables can be readily connected or disconnected. The other cables within the integrated head package, including power cables and cables for the digital rod position indicator system, are not Class 1E.

The cable support provides seismic support and maintains separation for instrumentation and power cables.

3.9.7.2 Design Description

The integrated head package combines several separate components in one assembly to simplify refueling of the reactor. The purpose of the integrated head package is to reduce the outage time and personnel radiation exposure by combining operations associated with movement of the reactor vessel head during the refueling outage. In addition, the integrated head concept reduces the laydown space required in the containment. With the integrated head package, disconnections from and connections to the control rod drive mechanisms and

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rod position indicators (RPI) and other components within the cooling shroud assembly are not made at the individual component.

The integrated head package consists of the following main elements:

- Shroud assembly
- Lifting system
- Mechanism seismic support structure
- Cable support structure
- Cables

- ~~In-core instrumentation support structure~~

Brief descriptions of the principal elements of the integrated head package are provided in the following paragraphs.

Shroud assembly - The shroud assembly is a carbon steel structure that includes a shielding shroud and an air baffle. During normal operation, it directs the flow of cooling air to the control rod drive mechanism coil stacks. The rod position indicators are also cooled by this air flow. The duct work and air baffle are integral with, and supported by, the shroud assembly. The air cooling fans are supported ~~on a separate platform~~attached to the IHP. Structurally, the shroud is integrated with ~~the head lifting system and~~ the mechanism seismic support structure. The shroud also provides shielding at the vessel flange region.

The shroud structure is bolted to attachment lugs on the reactor vessel head.

Cabling, conduit and their supports and attachment hardware for the control rod drive mechanisms, control rod drive mechanism coil, and in-core instrumentation are routed around the cable support attached to the shroud.

Lifting system - This apparatus lifts the reactor vessel head and integrated head package as a unit. ~~The lifting system attaches to the control rod drive mechanism seismic support structure.~~ The lift legs transfer the head load during a head lift from the head attachment lugs ~~through the control rod drive mechanism seismic support structure~~ to the lift rig. The lifting system consists of lift legs, sling block, clevises, and sling rods required to interface with the polar crane hook.

Mechanism seismic support structure - This structure provides seismic restraint for the control rod drive mechanisms. It is located near the top of the control rod drive mechanism rod travel housings. The ~~spike on the top of the control rod drive mechanism rod travel housing interfaces with this support.~~digital rod position indication connector plate attached to the rod travel housing interfaces with spacer plates, where required, to form a system of bumpers that interface with the mechanism seismic support structure. This support interfaces with the shroud assembly to transfer seismic loads from the mechanisms to the reactor vessel head. ~~In addition to this function, the mechanism seismic support structure acts as a spreader for the lift system and transfers the reactor vessel head loads to the lift system. The in-core instrument support structure is also supported from the mechanism seismic support structure.~~

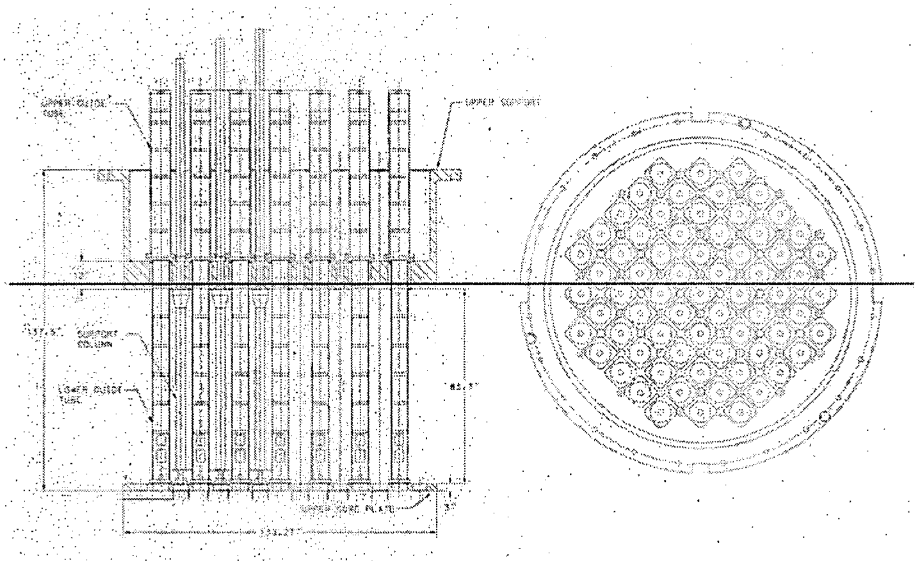
Cable support structure - The cable support is located at an elevation above the top of the rod travel housings. It provides permanent support and routing for the control rod drive mechanism power cables and rod position indication cables, which remain with the integrated head package and are normally not disturbed. These cables terminate at the connector plates, which constitute the interface with the mating cables. Cable disconnects are made at the connector plates.

Cables - The integrated head package cables include those portions of the control rod drive mechanism power cables, in-core instrumentation, and rod position indication instrumentation cables extending from the connector plates to the user devices. These cables remain with the integrated head package and are normally not disturbed. The individual cable length is sized to provide an orderly arrangement. For a refueling or other operation requiring movement of the integrated head package, the cables that span the space over the cavity from the operating deck to the integrated head package are disconnected at the connector plates. The cables are then moved away from the integrated head package.

In-core instrumentation – ~~**support structure (IISS)** – The in-core instrumentation support structure is used during refueling operations. This support structure is used for withdrawing the in-core instrumentation thimble assemblies into the integrated head package. It protects and supports the thimble assemblies when they are in the fully withdrawn position.~~ The in-core instrumentation system consists of thermocouples to measure fuel assembly coolant outlet temperature, and in-core flux thimbles containing fixed detectors for measurement of the neutron flux distribution within the reactor core. The incore thimble tubes have enhanced resistance to fluid-induced vibration and wear. The thimble is stiffer than the design in previous operating plants and the gap between the thimble tube and the tubes used to guide and protect the thimble inside the reactor vessel is smaller to minimize vibration. The design of the thimble tube assembly also precludes an non-isolable leak of reactor coolant. The thermocouples and neutron detectors are routed through the integrated head package. These are inserted into the core through the reactor vessel head and upper internals assembly. ~~Also, the in-core instrumentation support structure includes a platform which provides access to the in-core instrumentation during maintenance and refueling and to attach the lifting system to the crane hook.~~

3.9.7.3 Design Evaluation

The components of the integrated head package, which provide seismic support including the control rod drive mechanism seismic support and the shroud, are designed using the ASME Code, Section III, Subsection NF. Because of the application of mechanistic pipe break evaluations, the supporting elements do not have to be designed for loads due to a postulated break in a reactor coolant loop pipe. Pipes down to 6-inch nominal diameter are evaluated using mechanistic pipe break criteria and the integrated head package is analyzed for movement of the reactor vessel due to a break of any pipe not qualified for leak-before-break. See subsection 3.6.3 for a discussion of the mechanistic pipe break requirements.



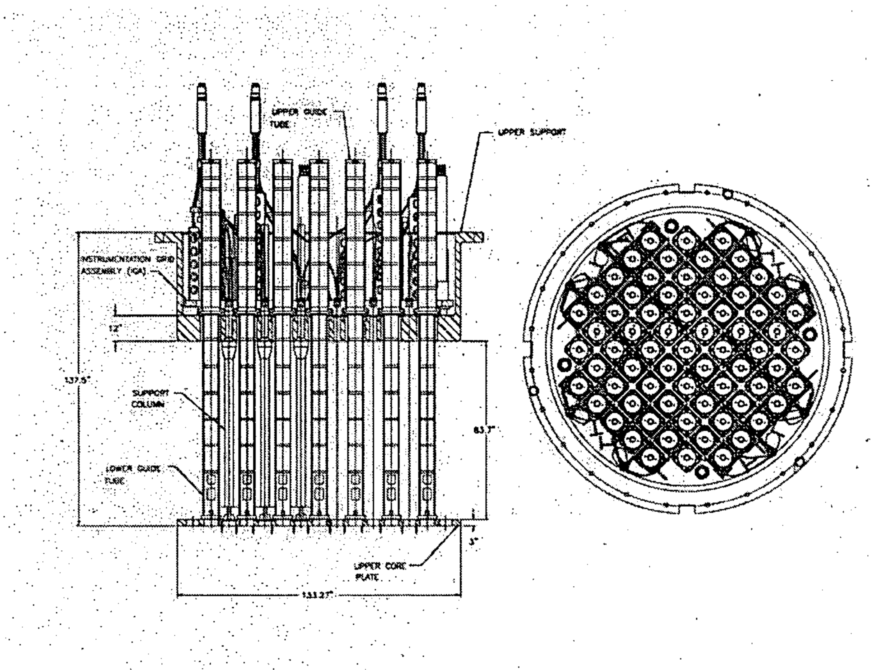
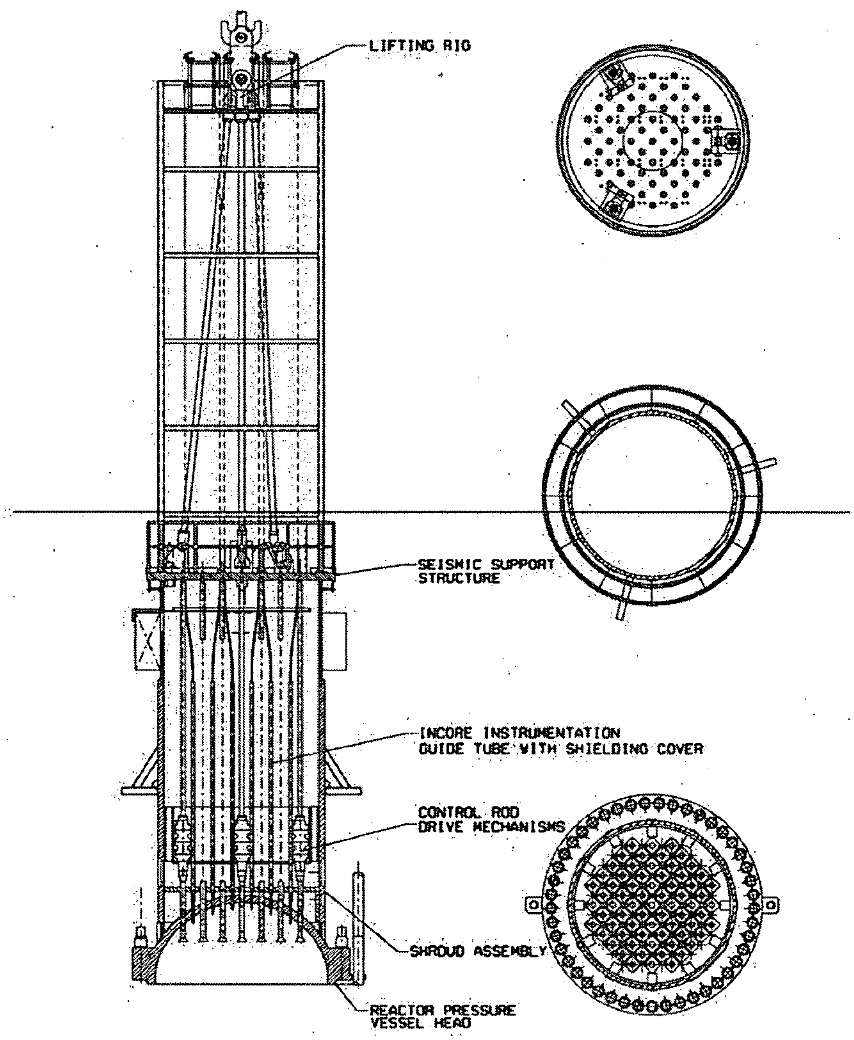


Figure 3.9-6

Upper Core Support Structure


LIFTING RIG
SEISMIC SUPPORT STRUCTURE
INCORE INSTRUMENTATION GUIDE TUBE WITH SHIELDING COVER
CONTROL ROD DRIVE MECHANISMS
SHROUD ASSEMBLY
REACTOR PRESSURE VESSEL HEAD

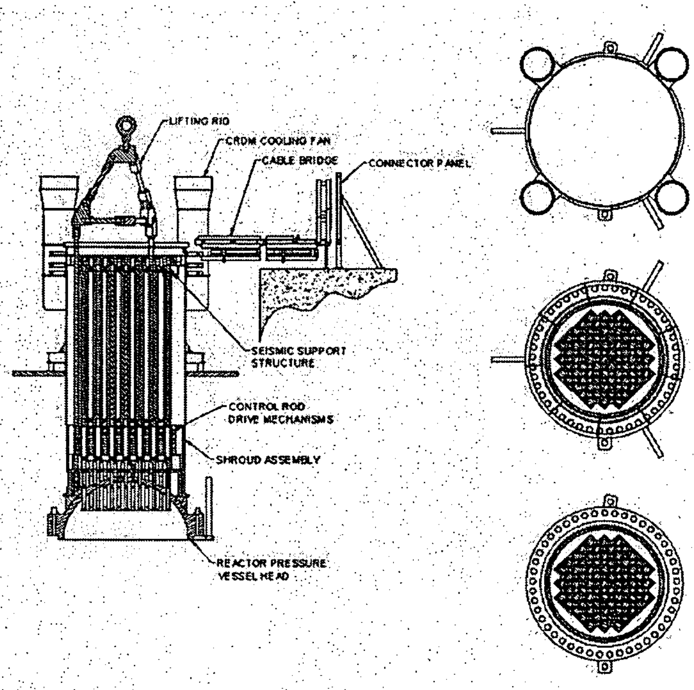
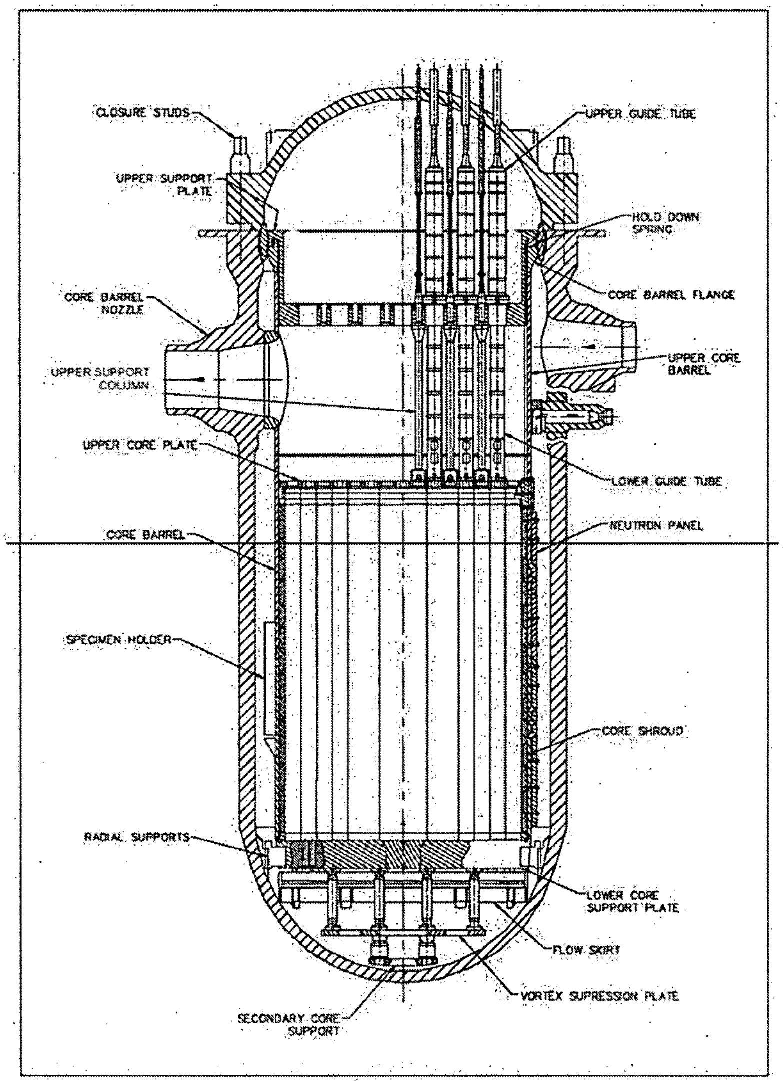


Figure 3.9-7

Integrated Head Package


CLOSURE STUDS
UPPER SUPPORT PLATE
CORE BARREL NOZZLE
UPPER SUPPORT COLUMN
UPPER CORE PLATE
CORE BARREL
SPECIMEN HOLDER
RADIAL SUPPORTS
SECONDARY CORE SUPPORT
UPPER GUIDE TUBE
HOLD DOWN SPRING
CORE BARREL FLANGE
UPPER CORE BARREL
LOWER GUIDE TUBE
NEUTRON PANEL
CORE SHROUD
LOWER CORE SUPPORT PLATE
FLOW SKIRT
VORTEX SUPRESSION PLATE

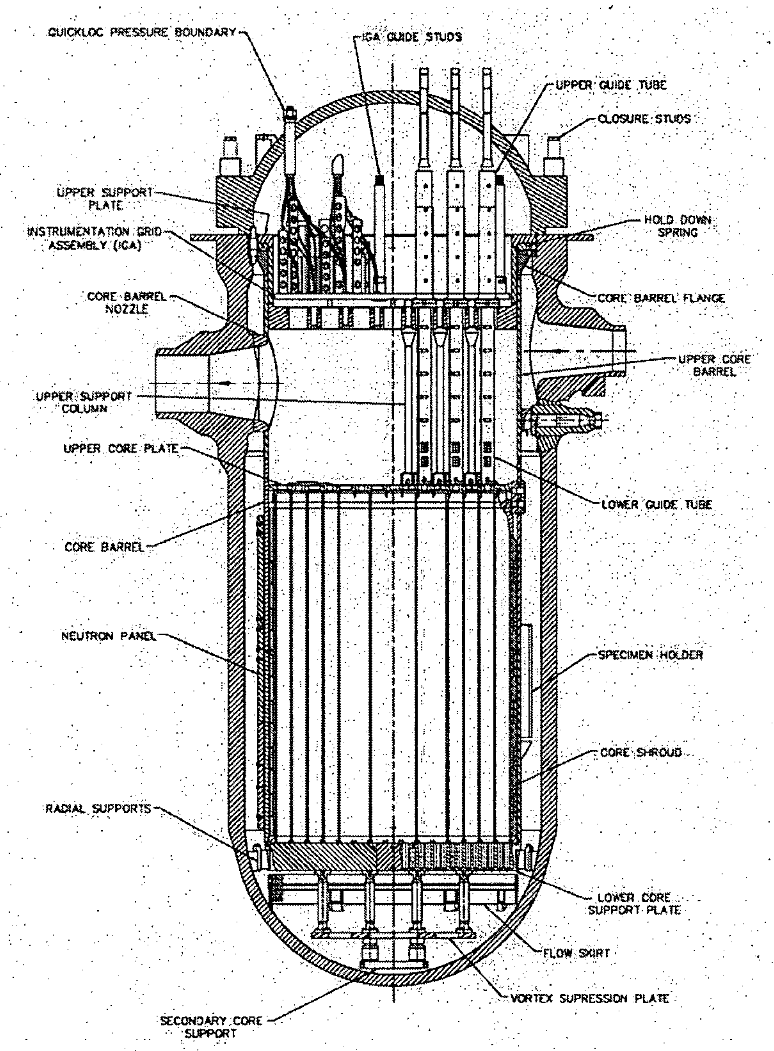


Figure 3.9-8

Reactor Internals Interface Arrangement

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 3H.5-1 (Sheet 3 of 3)

[Nuclear Island Critical Sections
Section A-A]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

The hardware and software which performs the three-dimensional power distribution calculation are capable of executing the calculation algorithms and constructing graphical and tabular displays of core conditions at intervals of less than one minute. The software provides information to enable the reactor operator to ascertain how the measured peaking factor performance agrees with the peaking factor performance predicted by the design model used to determine the acceptability of the fuel loading pattern. The analysis software provides information required to activate a visual alarm display to alert the reactor operator about the current existence of, or the potential for, reactor operating limit violations. The calculation algorithms are capable of determining the core average axial offset using a minimum set of the total 42 incore monitor assemblies. A minimum set of incore monitor assemblies is at least 30 operating assemblies, with at least two operating assemblies in each quadrant, prior to nuclear model calibration; and at least 21 operating assemblies, with at least two operating assemblies in each quadrant, after nuclear model calibration. The nuclear model calibration is performed after each new core load. The hardware which performs the online power distribution monitoring is configured such that a single hardware failure will not necessitate a reactor maximum power reduction or restrict normal reactor operations.

During plant operation, the incore instrument thimble assembly is positioned within the fuel assembly and exits through the top of the reactor vessel ~~to containment.~~ Quicklok seal connection. The fixed incore detector and core exit thermocouple signal exit the detector through a multipin connector to the incore instrument thimble tube cables. The fixed incore detector and core exit thermocouple cables are then routed to different data conditioning and processing stations. The data is processed and the results are available for display in the main control room.

4.6.1 Information for Control Rod Drive System

The control rod drive mechanism (CRDM) and operation of the control rod drive system are described in subsection 3.9.4. Figure 3.9-4 provides the details of the control rod drive mechanisms. Figure 4.2-8 provides the configuration of the driveline, including the control rod drive mechanism. No hydraulic system is associated with the functioning of the control rod drive system. The instrumentation and controls for the reactor trip system are described in Section 7.2. The reactor control system is described in Section 7.7.

The control rod drive mechanisms are contained within an integrated head package located on top of the reactor vessel head as described in subsection 3.9.7. This assembly provides the support required for seismic restraint in conjunction with the attachment of the control rod drive mechanisms to the reactor vessel head. An outer shroud, which is an integral portion of the head lifting system and the seismic restraint structure, isolates the control rod drive mechanisms from the effects of ruptures of high-energy lines outside the shroud, and from missiles. The shroud also is used to direct air from the cooling fans past the control rod drive mechanisms. The cooling system maintains the temperatures of the coils in the control rod drive mechanisms below the design operating temperature. The integrated head package provides the proper support and required separation for electrical lines providing power to the control rod drive mechanisms and signals from the rod position sensors.

The lines for the reactor head vent system ~~and the conduits for the in-core instrumentation are~~ is located among the control rod drive mechanisms and ~~are~~ is supported by the integrated head package. ~~These lines are~~This line is pressurized to reactor coolant system pressure and considered to be high-energy lines. ~~These lines are~~ This line is constructed to the appropriate requirements of the ASME Code. Figure 3.9-7 shows elements of the integrated head package surrounding the control rod drive mechanisms.

Table 5.2-1 (Sheet 1 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Reactor Vessel Components		
Head plates (other than core region)	SA-533 or SA-508	Type B, CL 1 or GR 3 CL 1
Shell courses	SA-508	GR 3 CL 1
Shell, flange, and nozzle forgings	SA-508	GR 3 CL 1
Nozzle safe ends	SA-182	F316, F316L, F316LN
Appurtenances to the control rod drive mechanism (CRDM)	SB-167 SB-166 or SA-182	N06690 N06690 or F304, F304L, F304LN, F316, F316L, F316LN
Instrumentation ~~tube appurtenances~~ nozzles, upper head	SB-167 SB-166 ~~or~~ and SA-182, or SA-479 ~~SA312(1)~~ ~~SA376~~	N06690 N06690 ~~or~~ and F304, F304L, F304LN, F316, F316L, F316LN 304, 304L, 304LN 316, 316L, 316LN ~~TP304, TP304L, TP304LN, TP316, TP316L, TP306LN~~ ~~TP304, TP304LN, TP316, TP316LN~~
Closure studs	SA-540	GR B23 CL 3 or GR B24 CL 3
Monitor tubes	SA-312(1) or SA-376 or SA-182	TP304, TP304L, TP304LN, TP316, TP316L, TP316LN TP304, TP304LN, TP316, TP316LN F304, F304L, F304LN, F316, F316L, F316LN

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Title: Impact of In-core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package

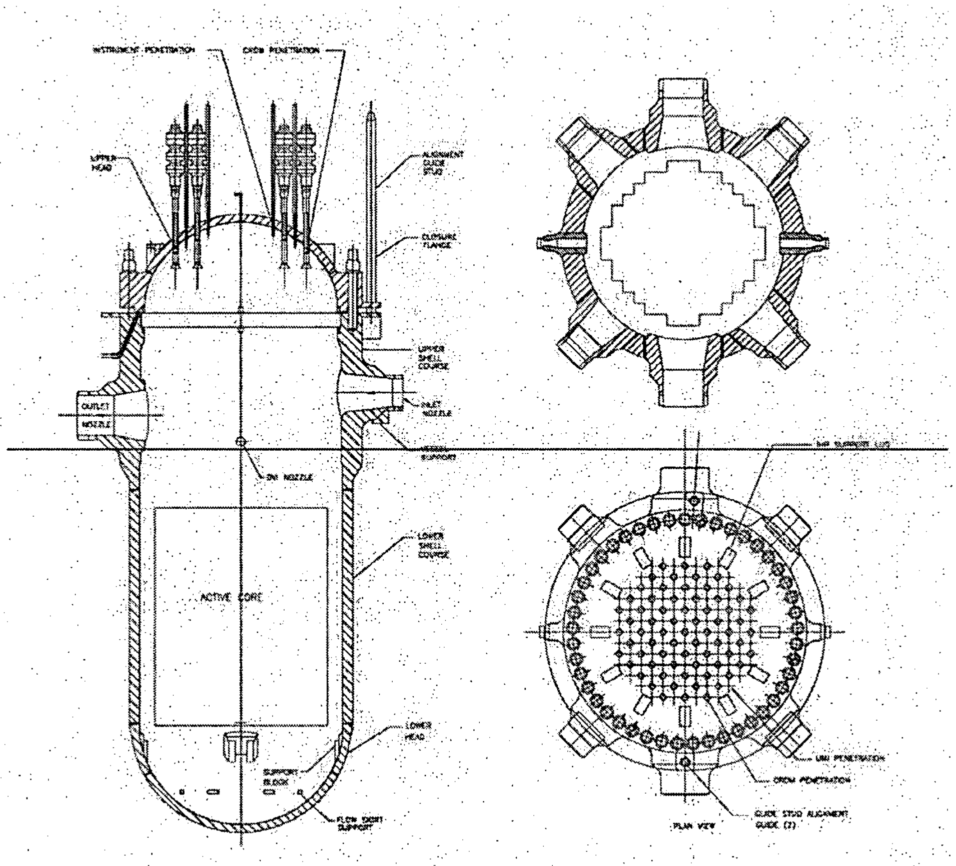
The reactor vessel supports the internals. An internal ledge is machined into the top of the upper shell section. The core barrel flange rests on the ledge. A large circumferential spring is positioned on the top surface of the core barrel flange. The upper support plate rests on the top surface of the spring. The spring is compressed by installation of the reactor vessel closure head and the upper and lower core support assemblies are restrained from any axial movements.

Four core support pads are located on the bottom hemispherical head just below the transition ring-to-lower shell circumferential weld. The core support pads function as a clevis. At assembly, as the lower internals are lowered into the vessel, the keys at the bottom of the lower internals engage the clevis in the axial direction. With this design, the internals are provided with a lateral support at the furthest extremity and may be viewed as a beam supported at the top and bottom.

The interfaces between the reactor vessel and the lower internals core barrel are such that the main coolant flow enters through the inlet nozzle and is directed down through the annulus between the reactor vessel and core barrel and through the flow skirt and flows up through the core. The annulus is designed such that the core remains in a coolable configuration for all design conditions.

Prior to installation of the internals into the reactor vessel, guide studs are assembled into the upper shell. Dimensional relationships are established between the guide studs and the core support pads such that when the lower internals lifting rig engages the guide studs, the keys at the bottom of the lower internals are in relative circumferential position to enter the core support pads.

There are 69 penetrations in the removable flanged hemispherical head (closure head) that are used to provide access for the control rod drive mechanisms. Each control rod drive mechanism is positioned in its opening and welded to the closure head penetration. In addition there are eight~~42~~ penetrations in the closure head used to provide access for in-core and core exit instrumentation. ~~A tube is inserted into each of the 42 penetrations and is welded into place.~~ Lugs are welded to the outside surface of the closure head along the outer periphery of the dome section. The purpose of these lugs is to provide support and alignment for the integrated head package.


UPPER SHELL COURSE
INLET NOZZLE
OUTLET NOZZLE
DVI NOZZLE
LOWER SHELL COURSE
ACTIVE CORE
LOWER HEAD
SUPPORT BLOCK
PLAN VIEW
CRDM PENETRATION
GUIDE STUD ALIGNMENT GUIDE (2)

Document Number: APP-GW-GLE-016-NS **Revision Number:** 0

Title: Impact of In-core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package

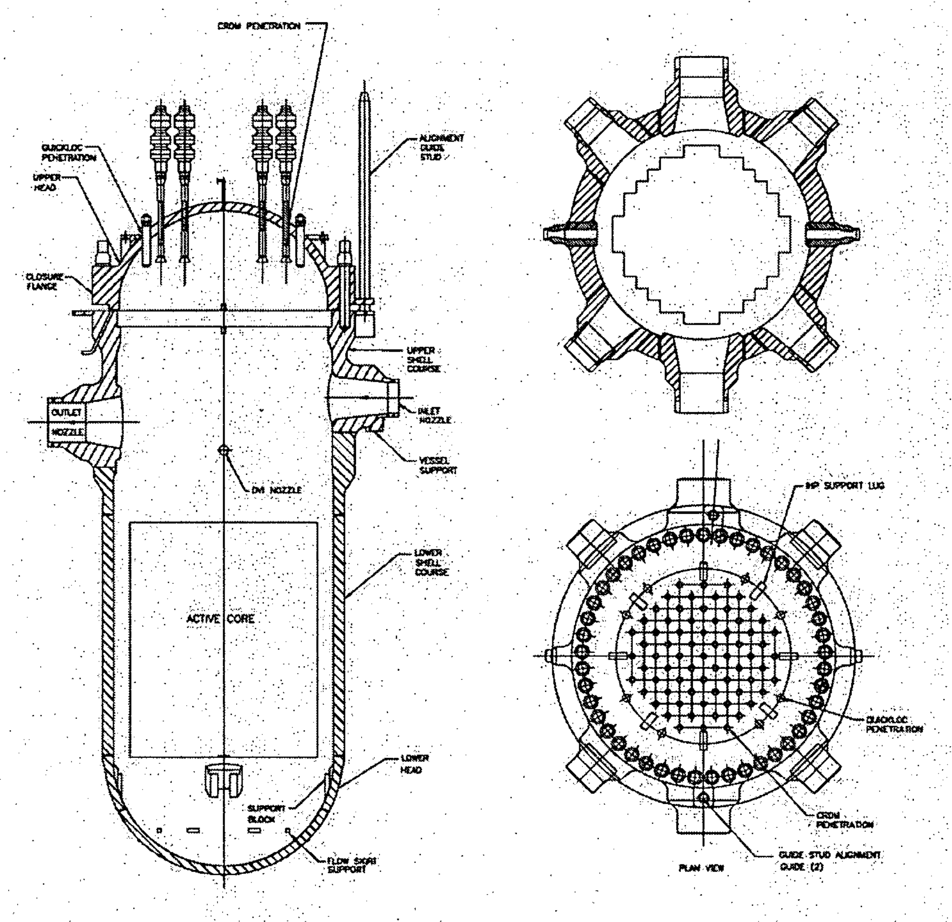
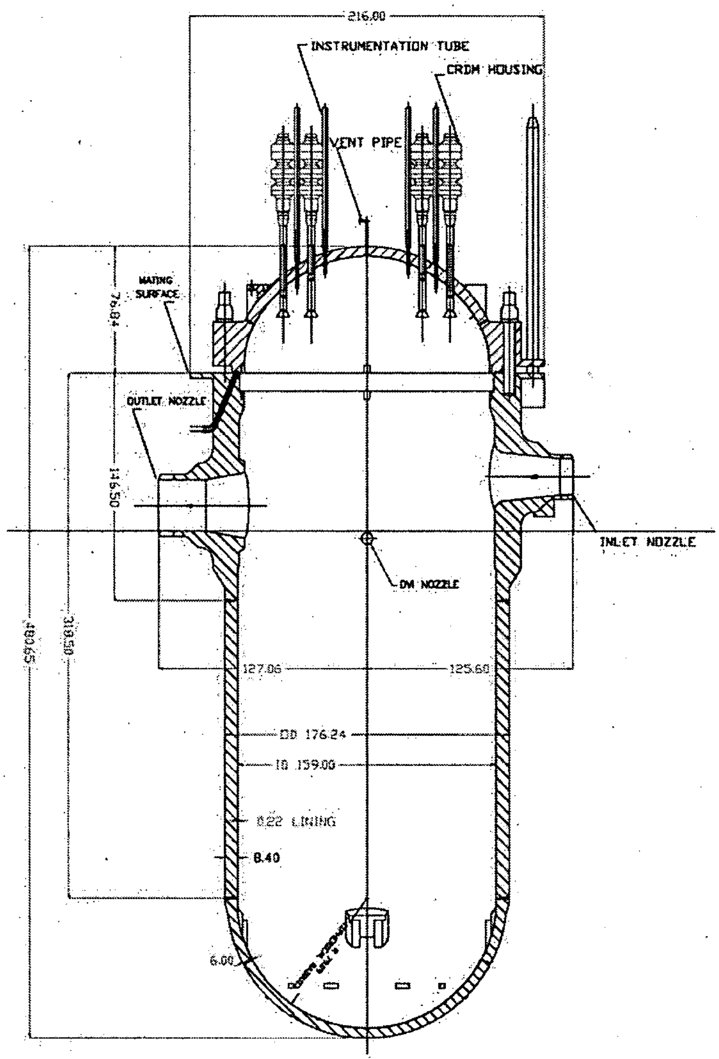


Figure 5.3-1

Reactor Vessel


216.00
INSTRUMENTATION TUBE
CRDM HOUSING
VENT PIPE
MATING SURFACE
76.84
OUTLET NOZZLE
146.50
INLET NOZZLE
DVI NOZZLE
318.50
127.06
125.60
OD 176.24
ID 159.00
0.22 LINING
8.40
6.00

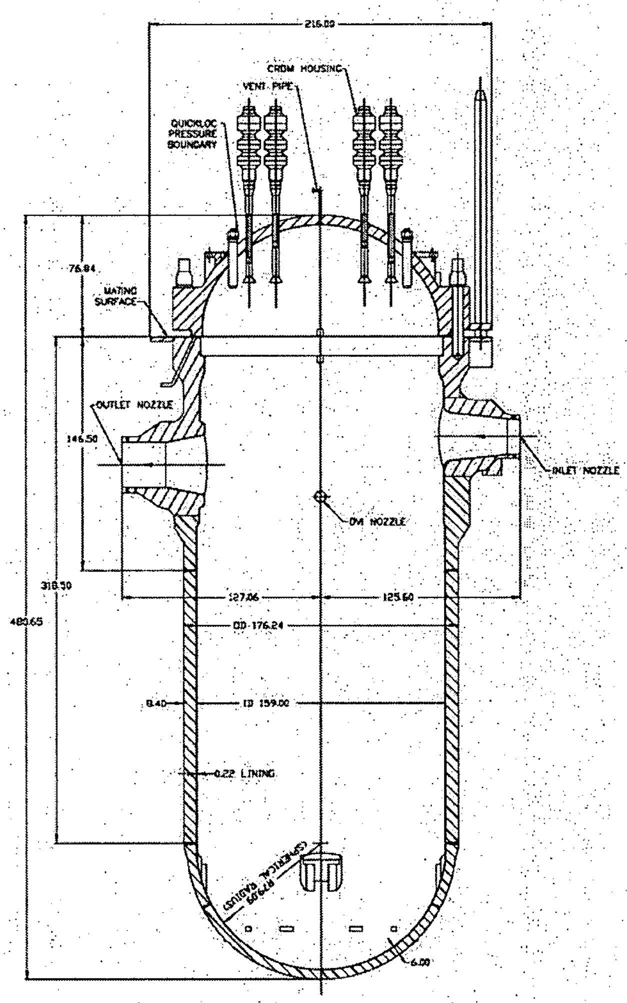


Figure 5.3-6

Reactor Vessel Key Dimensions, Side View

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Figure 6.2.4-9

Hydrogen Igniter Locations
Plan View Elevation 118′-6″

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 6.2.4-10

Hydrogen Igniter Locations
Plan View Elevation 135'-3"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 6.2.4-11

Hydrogen Igniter Locations
Plan View Elevation 162'-0"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 9A-1 (Sheet 6 of 16)

[Nuclear Island Fire Area
Plan at Elevation 117'-6"]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Security-Related Information. Withhold Under 10 CFR 2.390d

Figure 9A-1 (Sheet 7 of 16)

[Nuclear Island Fire Area
Plan at Elevation 135'-3"]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 9A-1 (Sheet 8 of 16)

[Nuclear Island Fire Areas
Plan at Elevation 153'-0" & 160'-6"]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

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Figure 9A-1 (Sheet 10 of 16)

*[Nuclear Island Fire Area Section A-A]**

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

12.2.1.2 **Sources for Shutdown**

In the reactor shutdown condition, the only additional significant sources requiring permanent shielding consideration are the spent reactor fuel, and the residual heat removal system, and the incore.

detector system. Individual components may require shielding during shutdown due to deposited crud material. Estimates of accumulated crud in the reactor coolant system are given in subsection 12.2.1.1. The radiation sources in the reactor coolant system and other systems addressed in subsection 12.2.1.1 are bounded by the sources given for full power operation with the exception of a short time period (less than 24 hours) following shutdown, during which crud bursts can result in increased radiation sources. Crud bursts are the resuspension of a portion of the accumulated deposited corrosion products into the reactor coolant system during shutdown operation. Activity increases also occur during planned coolant oxygenation procedures prior to refueling activities.

12.2.1.2.5 Incore Flux Thimbles

Irradiated incore flux thimble gamma ray source strengths are given in Table 12.2-19. ~~These source strengths are used in determining shielding requirements during refueling operations when the flux thimbles are withdrawn from the reactor core.~~

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Figure 12.3-1 (Sheet 7 of 16)

Radiation Zones, Normal Operations/Shutdown
Nuclear Island, Elevation 117'-6"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 12.3-1 (Sheet 8 of 16)

Radiation Zones, Normal Operations/Shutdown
Nuclear Island, Elevation 135'-3"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 12.3-1 (Sheet 9 of 16)

Radiation Zones, Normal Operations/Shutdown
Nuclear Island, Elevation 153'-0" & 160'-0"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 12.3-2 (Sheet 7 of 15)

Radiation Zones, Post-Accident
Nuclear Island, Elevation 117'-6"

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Figure 12.3-2 (Sheet 8 of 15)

Radiation Zones, Post-Accident
Nuclear Island, Elevation 135'-3"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 12.3-2 (Sheet 9 of 15)

Radiation Zones, Post-Accident
Nuclear Island, Elevation 153'-0" & 160'-6"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 12.3-3 (Sheet 7 of 16)

Radiological Access Controls, Normal Operations/Shutdown
Nuclear Island, Elevation 117'-6"

Security-Related Information. Withhold Under 10 CFR 2.390d

Figure 12.3-3 (Sheet 8 of 16)

Radiological Access Controls, Normal Operations/Shutdown
Nuclear Island, Elevation 135'-3"

Security-Related Information, Withhold Under 10 CFR 2.390d

Figure 12.3-3 (Sheet 9 of 16)

Radiological Access Controls, Normal Operations/Shutdown
Nuclear Island, Elevation 153'-0" & 160'-6"

15.4.8.1.1.6 Effect of Rod Travel Housing Circumferential Failures

If circumferential failure of a rod travel housing occurs, the broken off section of the housing is ejected vertically because the driving force is vertical and the position indicator coil assembly and the drive shaft tend to guide the broken-off piece upward during its travel. Travel is limited by the missile shield and thereby limits the projectile acceleration. When the projectile reaches the missile shield, it partially penetrates the shield dissipating its kinetic energy. The water jet from the break continues to push the broken-off piece against the missile shield.

If the broken-off piece of the rod travel housing is short enough to clear the break when fully ejected, it rebounds after impact with the missile shield. The top end plates of the position indicator coil assemblies prevent the broken piece from directly hitting the rod travel housing of a second drive mechanism. Even if a direct hit by the rebounding piece occurs, the low kinetic energy of the rebounding projectile is not expected to cause significant damage (sufficient to cause failure of an adjacent housing).