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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 26 Related to ESBWR Design Certification Application – Isolation Condenser – RAI Numbers 5.4-21, 5.4-23 through 5.4-26, 5.4-28 through 5.4-30, 5.4-32 through 5.4-35, 5.4-38, 5.4-41, 5.4-42, 5.4-44 through 5.4-46, 5.4-48, 5.4-50, and 5.4-52**

Enclosure 1 contains GE's response to the subject NRC RAI transmitted via the Reference 1 letter.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Reference:

1. MFN 06-141, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 26 Related to ESBWR Design Certification Application,* May 3, 2006

Enclosure:

1. MFN 06-249 – Response to Portion of NRC Request for Additional Information Letter No. 26 Related to ESBWR Design Certification Application – Isolation Condenser – RAI Numbers 5.4-21, 5.4-23 through 5.4-26, 5.4-28 through 5.4-30, 5.4-32 through 5.4-35, 5.4-38, 5.4-41, 5.4-42, 5.4-44 through 5.4-46, 5.4-48, 5.4-50, and 5.4-52

cc:	WD Beckner	USNRC (w/o enclosures)
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ENCLOSURE 1

MFN 06-249

Response to Portion of NRC Request for

Additional Information Letter No. 26

Related to ESBWR Design Certification Application

Isolation Condenser

RAI Numbers 5.4-21, 5.4-23 through 5.4-26,

5.4-28 through 5.4-30, 5.4-32 through 5.4-35, 5.4-38, 5.4-41,

5.4-42, 5.4-44 through 5.4-46, 5.4-48, 5.4-50, and 5.4-52

NRC RAI 5.4-21

Submit the Piping and Instrumentation Diagram (P&ID) for the isolation condenser system (ICS).

GE Response

GE has prepared a P&ID for the Isolation Condenser System (ICS) and has transmitted to the NRC in MFN 06-107.

DCD change will not be made.

NRC RAI 5.4-23

Since the ICS is part of emergency core cooling system (ECCS), the main applicable section of the standard review plan (SRP) is Section 6.3. Add a reference to the DCD Section (i.e. 6.3.3) that addresses SRP Section 6.3 in DCD Tier 2, Section 5.4.6.

GE Response

DCD Tier 2 Section 6.3, "ECCS performance Evaluation" references SRP Section 6.3. To avoid duplicate information, DCD Tier 2 Section 5.4.6 will reference in Tier 2 Section 6.3, thereby referencing SRP Section 6.3.

The following modifications (identified with tracked changes) will be made in the next revision of the DCD Tier 2 Subsection 5.4.6.2.3.

5.4.6.2.3 System Operation

Isolation Condenser Operation

After reactor isolation and automatic IC System operation, the control room operator can control the venting of noncondensable gases from the IC, to enable it to hold reactor pressure below safe shutdown limits.

The ICS is also designed to provide makeup water to the RPV during LOCA event by draining the IC and condensate return line standby inventory into the RPV. The emergency core cooling system (ECCS), see Section 6.3, and the ICS are designed to flood the core during a LOCA event to provide required core cooling. By providing core cooling following a LOCA, the ECCS and ICS, in conjunction with the containment, limits the release of radioactive materials to the environment following a LOCA.

NRC RAI 5.4-24

Since the ICS is part of ECCS, GDC 2 (seismic design), 17 (electric power), 35 (Emergency core cooling), 36 (Inspection of ECCS) and 37 (Testing of ECCS) apply. Include application of these GDC in the DCD Tier 2, Section 5.4.6. Also, add 10 CFR 50.46, in regard to the ECCS being designed so that it's cooling performance is in accordance with an acceptable evaluation model. We understand that the above GDC are included in DCD Tier 2, Section 6.3 for ECCS, but for clarity, please refer to them for the individual ECCS systems.

GE Response

With respect to the remaining GDC cited in this RAI (GDC 2, 17, 35, 36, 37 and 10 CFR 50.46), GE will add the following text to subsection 5.4.6.3 (Safety Evaluation):

5.4.6.3 Safety Evaluation

Three out of four ICS trains remove post-reactor isolation decay heat and depressurize the reactor to safe shutdown conditions when the reactor is isolated after operation at 100% power.

As protection from missile, tornado and wind, the ICS parts outside the containment (the Isolation Condenser itself) are located in a subcompartment of the safety-related IC/PCC pool to comply with 10 CFR 50 Appendix A, Criteria 2, 4 and 5.

For its function to provide makeup water to the RPV during a LOCA, the ICS is designed to meet the requirements of GDC 2, 17, 35, 36 and 37 and 10 CFR 50.46 in conjunction with the other ECCS systems. Conformance to these criteria is discussed in Section 6.3, Emergency Core Cooling Systems.

The IC steam supply pipes include flow restrictors. The IC condensate drain pipes are of limited area so that, in the event of an IC piping or tube rupture in the IC/PCC pool, the resulting flow induced dynamic loads and pressure buildup in the IC/PCC pool are limited.

NRC RAI 5.4-25

Explain in detail how the ICS meets GDC 29, as it relates to the system design having an extremely high probability of performing its safety function in the event of anticipated operational occurrences.

GE Response

The ICS is not a reactivity control system. Therefore, GDC 29 does not apply to the ICS and will be deleted from the required guidelines and the modification will be made in the next revision of the DCD Tier 2.

DCD change is required, see markup in response to RAI 5.4-24

NRC RAI 5.4-26

Explain in detail how the ICS meets GDC 4, as related to dynamic effects associated with flow instabilities and loads (e. g., water hammer). Describe the design features and procedures incorporated into the ICS design to reduce voids and water hammer effects. In operating reactor core isolation cooling (RCIC) systems, steam lines are sloped downward and steam traps are provided to reduce the potential for water hammer. Describe the steam piping layout in the ESBWR ICS, and discuss the potential for water hammer.

GE Response

The ICS meets GDC 4 as it relates to water hammer, by continuously sloping the condensate return lines downward from the IC to an elevation below reactor water level to avoid the trapping and collapse of the steam in the drain piping. The ICS P&ID states in Note 4 a slope value for the steam piping toward the reactor pressure vessel as 1/100 and a drain piping minimum slop of 1/25, after thermal expansion.

DCD change is not required

NRC RAI 5.4-28

In DCD Tier 1, Table 2.4.1-1 for Inspection, Testing, Analysis and Acceptance Criteria (ITAAC) Items, item # 2 states that the flow limiter is shown on ITAAC Figure 2.4.1-1 in DCD Tier 1. But the flow limiter is not shown on this figure, this is noted in note 1 of the P&ID. Update DCD Tier 1, Figure 2.4.1-1 to include the flow limiter.

GE Response

The flow limiter is 'built-in' and therefore cannot be viewed on the ICS schematic or the ICS P&ID. Tier 1 of the DCD will be revised to:

Table 2.4.1-1 ITAAC For The Isolation Condenser System

Each ICS Class 2 branch line from the steam supply line outside the containment has a flow limiter located in the Class 1 line upstream of the Class 2 branch. ~~as indicated on Figure 2.4.1-1.~~

NRC RAI 5.4-29

The isolation condenser (IC) for the ESBWR is a vertical heat exchanger significantly different from operating plants' ICs. Provide the following: a detailed description of the heat exchanger, the heat transfer coefficient required for this heat exchanger, and a drawing of the ESBWR IC in DCD Tier 2.

GE Response

(A) Provide a Detailed Description of the Heat Exchanger

The following is the description of the Isolation Condenser (IC) heat exchanger:

Each IC heat exchanger is designed to transfer a minimum of 33.75 MWt heat when the reactor is at or above Reactor Pressure Vessel (RPV) rated pressure and with IC/PCC pool water saturation temperature of 100°C. The design pressure is 10.34 MPag (1500 psig) and temperature of 314.5°C (598°F); these conditions correspond to ATWS event conditions. An IC unit is designed to remove 33.75 MWt, nominal at the following conditions:

- Pure saturated steam at 289°C
- Pool water at atmospheric pressure and 100°C
- Margin of 5% for tube plugging
- Fouling factor on secondary side is 0.00009°C/W

A vertical 350 mm steam supply line feeds an upper header through 4-150 mm pipes, each provided with a built-in flow limiter. Steam is condensed in the 135 Inconel 600 vertical tubes, 50.8 mm OD, 2.3 mm wall thickness and 1.8 m of average length. The condensate is collected in the lower header and drains by gravity through a 200 mm pipe to the pressure vessel. A small vent line (15 mm) is provided for both upper and lower headers to remove noncondensable gasses.

The rate of heat loss from an IC heat exchanger and its piping does not exceed 0.06 MWt. The IC heat exchangers are designed with removable components to allow servicing and replacement of parts, if needed, during plant shutdowns. The drums of the heat exchangers are designed with gasketed removable flanges, which allow access during plant shutdowns for such maintenance actions as interior inspections of tube-to-drum welds and for plugging tubes in the event such corrective measures are needed.

(B) Provide a Heat transfer Coefficient Required for this Heat Exchanger:

The heat transfer coefficient required for each IC heat exchanger is 8,650 $W/m^{2o}C$.

(C) Provide a Drawing of the ESBWR IC in DCD Tier 2

A schematic of the IC heat exchanger was provided to the NRC in the SEIT Panther ICS Test Report. In Appendix A of this letter is a copy of the schematic found in the Panther Test Report and an ANSALDO P&ID. A drawing of the IC will not be included in Tier 2 of the DCD.

DCD change is not required.

NRC RAI 5.4-30

DCD Tier 2, Section 5.4.6.2.2 states that two normally closed or fail closed, motor-operated lower header bypass vent valves allow the operator to vent non-condensable gases in case of failure of the automatic lower head vent valves. Bypass valves are not included on the upper header. Provide a discussion as to why bypass valves are not required for the upper header.

GE Response

SIET Panther – IC Test Report discussed noncondensable gas effects in vent lines. Part of the Panther test was to examine if the flow of noncondensable gases went to the upper or lower header. Based on the test performed, the noncondensable gas accumulates both in the upper and lower header; however, the lower header vent line gave a largely predominant contribution to venting. In the tests conducted, the opening of the lower header vent line was sufficient to bring the IC pressure back to the value very close to the initial pressure.

DCD change is not required

NRC RAI 5.4-32

Explain how the nitrogen rotary motor operated (NMO) and the Nitrogen piston operated (NO) valves perform their function.

GE Response

Nitrogen Rotary Motor Operated Valve (NMOV)

The purpose of the NMO valve is to protect against loss of pressure boundary integrity of the outside containment portion of the ICS.

The NMO valve closes upon either a signal of excess flow (high DP) in the IC pipeline or a signal of high radiation in the IC/PCC pool vent line to the atmosphere

Pneumatic Piston-Operated Globe Valve (NO)

The NO valve provides diversity of actuator type (mounted in parallel with F005); actuator holds valve closed; valve is opened by spring on shutoff or loss of pneumatic pressure/electrical signal.

The NO valve is normally closed; one of two IC condensate return valves in parallel; opens upon initiation of the IC system to permit return of condensed reactor steam back to the reactor vessel

DCD change is not required.

NRC RAI 5.4-33

The ICS is an ECCS system and the ESBWR ICS design principle is similar to the ICS in operating plants (Dresden 2 & 3, Millstone 1, Nine Mile Point 1 and Oyster Creek). A search of the Institute for Nuclear Power Operations (INPO) Nuclear Plant Reliability Data System (NPRDS) for operational events related to ICS indicated numerous operational problems with ICS in those plants. The NPRDS search indicated more than 150 operational events related to the ICS reported by licensee event reports (LERs) for the above plants between1980 and 1992. Confirm that GE conducted a systematic study of the operational events associated with operating reactor ICS. What design changes were implemented in the ESBWR ICS design to address operational performance issues? Describe in detail differences between the ESBWR ICS design and those in the above plants. Discuss how these differences in the design will impact the frequency of operational event.

GE Response

The ICS has proven itself as a reliable reactor decay heat removal system. Operating plant critical path unavailability caused by the ICS has been 0.5%. The major part of which was due to problems with sensitized stainless steel piping at one plant. Of the total plant critical path unavailability, piping contributed to almost 0.4%, whereas 0.1% was attributed to other causes.

This reliability information is based on the results of a search of two databases that contain Isolation Condenser data during 1980 to 1992 time period. The databases were GE's Comprehensive Performance Analysis and Statistics System (COMPASS) data, and INPO's NPRDS data. The searches were for operating BWR data relating to failures of Isolation Condenser systems and components.

The following design improvements have now been included in the ESBWR ICS design to improve from past designs (plants listed in the RAI) and further (reduce) the plant critical unavailability of the ICS:

1. Use of carbon steel supply piping, Inconel tubes with butt-welded end attachments and low carbon or nuclear grade stainless steel condensate return piping which is resistant to IGSCC.
2. The condensate return lines are continuously sloped downward from the IC to an elevation below reactor water level to avoid the trapping and collapse of steam in the drain piping.
3. The water quality of the makeup to the IC pools is such that pool boil off to the atmosphere and the surrounding should not require cleanup.
4. Four IC loops are provided; three or more IC loops will allow reactor operation at 100% or higher power. This enables plant availability goals to be met should IC valve open-close cycling problems develop on any one IC unit during periodic operational readiness testing which is done during reactor power operation.

DCD change is not required.

<u>NRC RAI 5.4-34</u>

In operating reactor RCICs, the steam supply line to the turbine has a warm up line (i.e. a throttling valve in the bypass) to slowly warm up the steam line. While during full power operation the ICS upper header is filled with steam, this is not the case for the startup of the reactor plant. Are there any provisions for warm up of the ICS upper header during the startup of the reactor plant?

<u>GE Response</u>

ESBWR IC system is configured with a purge line connection from the top of the IC steam line piping which discharges to the Main steam line. This purge line is normally open with a small stream of steam flowing through the line during normal operation. During cold startup, the top vent valves (F007 and F008) are opened to warm the IC steamline and purge noncondensables. This keeps the IC steam line heated, similar to the RCIC warm up line.

DCD change is not required

NRC RAI 5.4-35

Four IC heat exchangers with total heat transfer capacity of 135 mega-watts of thermal power (MWt) (4 x 33.7 MWt) corresponding to 3% of rated power are provided for the ESBWR. Following a SCRAM, how long does it take for ICS to be activated? What is the technical basis for designing the ICS to 135 MWt of heat transfer capacity?

GE Response

With a minimum of three of its four divisions operational, the ICS shall be designed to automatically limit the reactor pressure and prevent SRV operation when the reactor becomes isolated following scram during 100% power operation. Three out of four ICS loops are initially needed to remove post reactor isolation decay heat, after sustained reactor operation at 100% power.

(A) Following a SCRAM, how long does it take for ICS to be activated?

In DCD Tier 2 Tables 15.2-13 and 15.2-22, list SCRAM Sequence of Events for Closure of all MSIV and Loss of all Feedwater Flow, respectively, are examples of events were the ICS is initiated after a scram. Also, see GE Responses 5.4-42 for time delay value.

(B) What is the technical basis for designing the ICS to 135 MWt of heat transfer capacity?

The technical basis for sizing each IC unit to 33.75 MWt capacity is to prevent Safety Relief Valve (SRV) lift during normal operation. DCD Tier 2 Subsection 5.2.2 states "For overpressure protection, the Isolation Condensers have sufficient capacity to preclude actuation of the SRVs, during normal operational transients."

DCD change is not required

NRC RAI 5.4-38

Confirm that the ICS will not be operated during normal plant shutdown in conjunction with the main condenser or reactor water cleanup and shut down cooling system.

GE Response

The ICS is not used in conjunction with Reactor Water Cleanup/Shutdown Cooling System (RWCU/SDC) for decay heat removal during normal plant shutdown. Two ICS trains are operable as a backup to the RWCU/SDC.

Therefore, the ICS is operational during normal plant shutdown.

DCD change is not required.

NRC RAI 5.4-41

Include a requirement for mechanical and electrical separation of the ICS in the ITAAC.

GE Response

The level of detail requested is beyond the intent of what is needed to assure the system will perform as required. There are ongoing discussions with the industry and the NRC as to the content that is required in Tier 1. When such requirements are settled upon, each system in Tier 1 may go through a thorough review to satisfy the agreed upon requirements. Please see GE's Response to RAI 14.3-1 (MFN-06-204).

DCD change is not required.

NRC RAI 5.4-42

Specify the time delay for Level 2 automatic start up of the ICS.

GE Response

The value for the time delay is 30 seconds to start the ICS for a Level 2 signal. This is also listed in DCD Tier 2:

1. Table 15.1-5, NSOA System Event Matrix. The table states "ICS – RPV Low Water Level (L2 30-sec delay)".
2. Subsection 15.2.2.3.3 Core and System Performance: The pressurization and/or the reactor scram may compress the water level to the low level trip setpoint (Level 2) and initiate the CRD high pressure makeup function, and if the low level signal remains for 30 seconds, MSIV closure, and isolation condenser (IC) operation.

DCD change is not required

NRC RAI 5.4-44

In the simplified boiling water reactor (SBWR) design, a catalytic converter was provided on the steam distributor at the end of the steam supply line to the IC. Are there any catalytic converters in the ESBWR design?

GE Response

No, the ESBWR IC design does not include a catalytic converter since the radiological oxygen production remains below the concentration that poses a risk of hydrogen burning. See DCD Tier 2 Section 6.2.5 for further details.

DCD change is not required.

NRC RAI 5.4-45

Include a discussion about the IC pool level monitoring or add a reference in DCD Tier 2 to the specific DCD Section where the IC pool level monitoring is discussed (i.e. Section 9.1.3.5).

GE Response

A DCD change will be made in the next revision of Tier 2 Subsection 5.4.6.2.2 "Detailed System Description" to the following.

5.4.6.2.2 Detailed System Description

"IC/PCC pool makeup clean water supply for replenishing level during normal plant operation and level monitoring is provided from the Fuel and Auxiliary Pools Cooling System (FAPCS) (Subsection 9.1.3).

A safety-related independent FAPCS makeup line is provided to convey emergency makeup water into the IC/PCC pool, from piping connections located at grade level in the reactor yard external to the reactor buildings."

NRC RAI 5.4-46

Include a reference in the DCD Tier 2 to the section of the DCD that describes the ICS operation during ATWS events.

GE Response

A DCD change will be made in the next revision of Tier 2 Subsection 5.4.6.1 "Safety Design Bases" to the following.

The ICS removes excess sensible and core decay heat from the reactor, in a passive way and with minimal loss of coolant inventory from the reactor, when the normal heat removal system is unavailable, following any of the following events:

- Sudden reactor isolation from power operating conditions;
- Station blackout (i.e., unavailability of all AC power); and
- Anticipated Transient Without Scram (ATWS) (see Subsection 15.5.4.3)
- Loss of Coolant Accident (LOCA)

The ICS is designed as a safety-related system to remove reactor decay heat following reactor shutdown and isolation. It also prevents unnecessary reactor depressurization and operation of other Engineered Safety Features (ESFs) which can also perform this function."

NRC RAI 5.4-48

Specify the type of material used for the IC tubes and describe in detail the suitability of the material. Specify material specifications and/or criteria used in the final selection.

GE Response

The IC tube material type is referenced in DCD Tier 2 Table 6.1-1. The following were the general design criteria for selecting the IC tubes material:

- The material of the IC tubes and components shall be compatible with normal operation requirements of the reactor system
- Material must be nuclear grade stainless steel or inconel, or other material which is not susceptible to Intergranular Stress Corrosion (IGSC).
- Corrosion allowance shall be part of the determination of the required wall thickness

Based on the above criteria, and past tested design, the ESBWR selected Alloy Steel – SB-163 (Inconel 600) as the material for the ICS condenser tubes. This is in accordance with the referenced DCD Table 6.1-1 listed above.

DCD change is not required.

NRC RAI 5.4-50

What is the maximum percentage of the IC tubes for a single IC that can be plugged, or otherwise obstructed, and allow continued safe plant operation?

GE Response

The IC tubes in the heat exchangers have been designed for 5% plugging. For example, the heat transfer area was calculated and was sized to assume 5% plugging in the design of the heat exchanger to ensure safe operation.

DCD change is not required.

<u>NRC RAI 5.4-52</u>

Describe in detail the periodic heat removal capability testing of the IC in the DCD Tier 2.

<u>GE Response</u>

The DCD Tier 2 Subsection 5.4.6.4 "Testing and Inspection Requirements" describes in detail the periodic heat removal capacity. However, the following will be added to the DCD in the next revision.

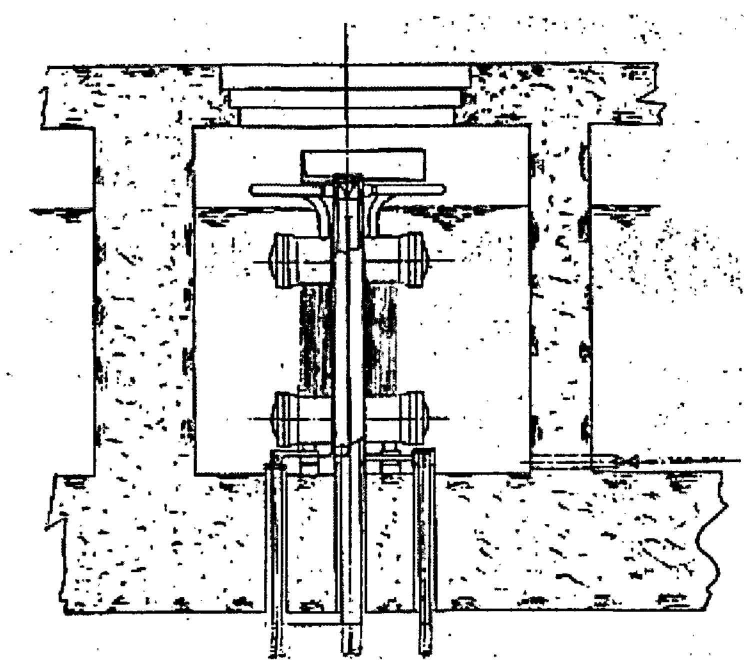
5.4.6.4 Testing and Inspection Requirements

Testing

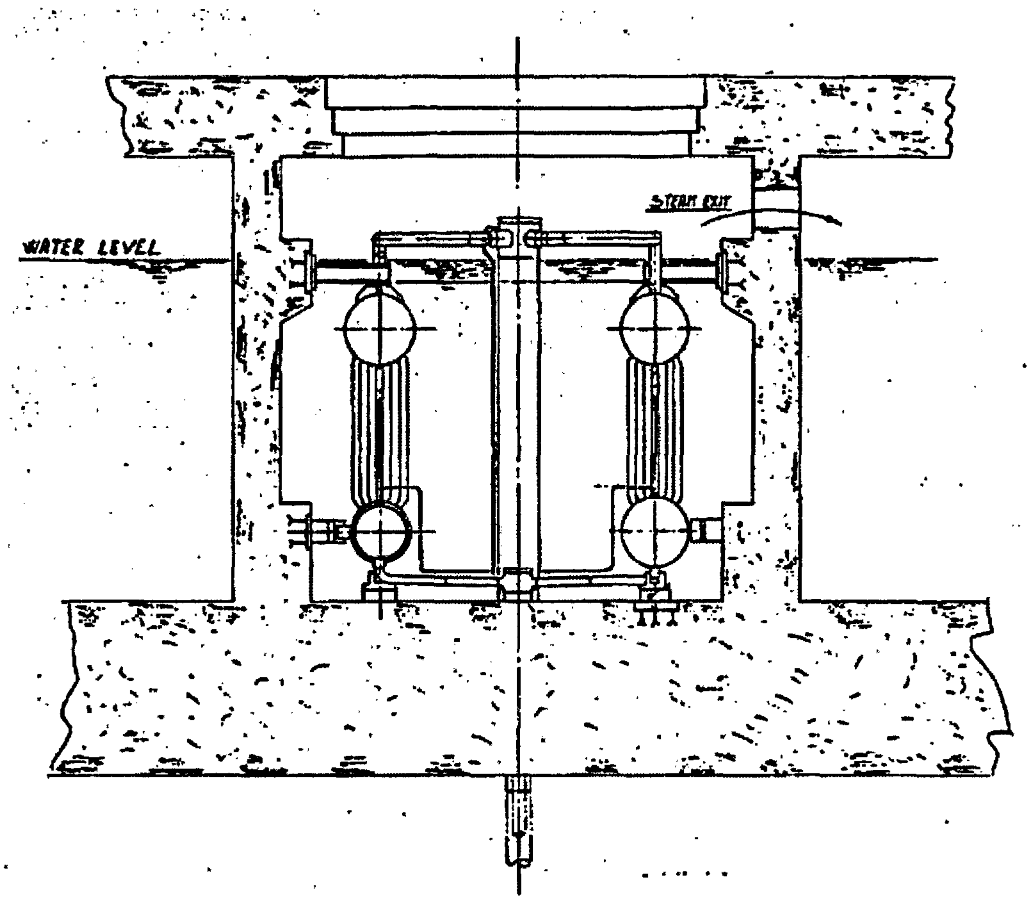
"Periodic heat removal capability testing of the ICs is required during plant operation at five-year intervals. This test is accomplished using data derived from the temperature sensor located downstream of the condensate return isolation valve (F004), together with the LD&IS differential pressure signal from one of the dPTs, on the condensate return line.

During normal plant operation, a periodic surveillance test of normally-closed condensate return and condensate return bypass valves on condensate line to RPV, being moved into an open condition, are performed."

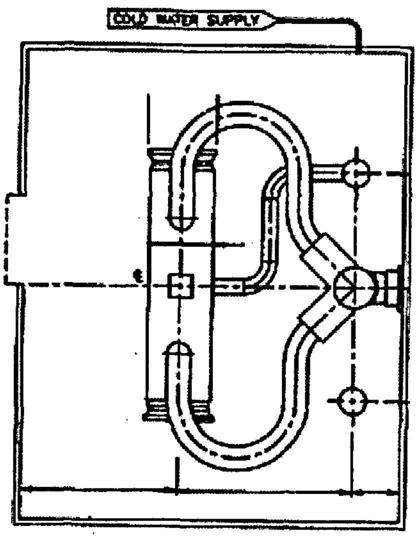
Appendix A

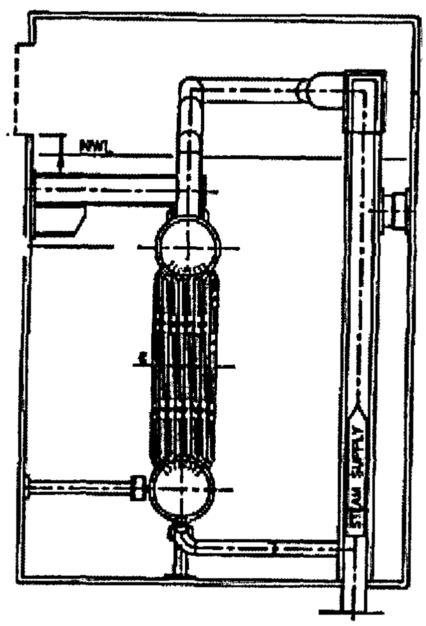


Appendix A



Appendix A





Appendix A