ENCLOSURE 1

PENNSYLVANIA POWER AND LIGHT COMPANY

UNIT OF INSTRUCTION APPROVAL SHEET

SY015 B-10	RESIDUAL HEAT REMOVAL SYSTEM	4 Hours ~~SY015 B-10~~ 7/11/89
UNIT NO.	UNIT TITLE	UNIT LENGTH
1	William G. DiDomenico/John R. Wolfe	10/04/88
REV. NO.	COMPLETED BY	DATE

REVIEWS

William G. DiDomenico	6/30/89
INSTRUCTOR	DATE
[signature]	7/18/89
TRAINING SUPERVISOR	DATE
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APPROVALS / CBT APPROVALS

APPROVALS		CBT APPROVALS	
[signature]	7/14/89		
REQUESTING SUPERVISOR/COST AREA HEAD	DATE		
[signature]	7/18/89	/	
SUPERVISOR-NUCLEAR TRAINING SUPPORT SERVICES	DATE	INITIALS	DATE
[signature]	7/19/89	/	
SUPERVISOR-NUCLEAR INSTRUCTION	DATE	INITIALS	DATE
[signature]	7/19/89		
MANAGER-NUCLEAR TRAINING	DATE		

CHANGE NO.	DATE	CHANGE NO.	DATE	CHANGE NO.	DATE
1	4/27/90				
2	2/14/92				
3	4/15/92				

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File No. R11-3

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INSTRUCTIONAL MATERIALS LIST

1. Pen, Pencil, Pad & Highlighters (one per student)
2. Overhead Projector
3. Whiteboard and pens
4. Transparencies
5. Student Handouts

RESIDUAL HEAT REMOVAL SYSTEM

LIST OF REFERENCES

	LOCATION
System Description #10, Residual Heat Removal System	TRDC
Study Guide #27, Residual Heat Removal System	TRDC
IOM 55	TRDC
P&ID M-151, M-2151, M-112	TRDC
OP-16-001, Rev 3, and OP-49-001, Rev. 4, OP-50-001	TRDC
GEK - 73611A RHR Operation & Maintenance Manual	TRDC
RHR Elementary Diagram 791E418WJ	TRDC
FSAR Sect. 6.3	TRDC
Schematic Diagrams E-153	TRDC
RHR Surv Procedure S0 49-001	TRDC
SOER 84-7	TRDC
IOM #55	TRDC

RESIDUAL HEAT REMOVAL SYSTEM

OBJECTIVES

Terminal Unit Objectives:

Upon completion of this Unit of Instruction the student should be able to demonstrate a basic understanding of the Residual Heat Removal System (RHR). The student will demonstrate this knowledge by attaining a minimum score of 70 percent in the unit test.

Specific Unit Objectives:

Upon completion of this Unit of Instruction the student should be able to:

1. State the purpose of the system, each subsystem and when each subsystem is used.
2. Given a one-line diagram, label the major components and show the flowpaths of all RHR subsystems.
3. List the signals (not setpoints) which initiate the system in the LPCI mode.
4. State how the system functions to cool the core (Suction and Discharge flows) in the LPCI mode.
5. State the relationships to other plant systems.
6. Discuss the importance of ensuring that this system is "kept filled". Include in your discussion the locations for the "keep filled" stations and vent stations for each unit.
7. State the purpose/location of major components and instrumentation.
8. Using OP-149-001, discuss RHR System Readiness (normal setup for automatic response).
9. Using OP-149-001, discuss initial fill and vent, and checking loops and pumps ready for operation.

RESIDUAL HEAT REMOVAL SYSTEM

SUGGESTED ACTIVITIES

Walkdown the system in plant as radiological conditions permit.

Discuss Industry Events Section with Class.

RESIDUAL HEAT REMOVAL SYSTEM

INFORMATION SHEETS

I. Purpose — The Residual Heat Removal (RHR) System purpose is to transfer all decay heat or residual heat from the reactor core and components. It can perform this function under both normal and emergency conditions:

A. The following subsystems or modes of RHR will meet the above purpose.

1. LPCI
2. Suppression Pool/Containment Spray
3. Suppression Pool Cooling
4. Shutdown Cooling/Head Spray
5. Fuel Pool Cooling

B. The purpose of each of the modes of operation are as follows:

1. Low Pressure Coolant Injection (ECCS System)

   Used to restore and maintain reactor vessel water level following a Loss of Coolant Accident (LOCA).

2. Suppression Pool and Containment Spray Cooling (Post Accident System).

   Sprays water inside the primary containment and/or suppression chamber to condense steam released following a LOCA.

3. Suppression Pool Cooling

   Maintains suppression pool temperature within Technical Specification limits to protect the suppression pool from excessively high water temperatures which could limit steam condensing capabilities.

B. LPCI Flowpath (See Figures 3 and 4)

1. The RHR System is normally lined up for LPCI injection.

2. Each RHR pump suction is supplied from the suppression pool thru the two 100% suction strainers and valve F004. Should the strainers become 50% clogged there is still 100% suction available to the pump. Each pump has a discharge relief valve which discharges to the Liquid Radwaste System.

3. The discharge of the pumps is connected to a common minimum flow bypass line routed back to the suppression pool. Bypass lines allow pumps to run without overheating (prevents running at shut off head and overheating the pump).

4. Each RHR pump discharge is then routed thru a check valve F031 which prevents reverse flow thru the idle pump.

5. Each RHR pump discharge is routed thru an orifice and isolation valve F034 to a common discharge header. The orifice limits the pump flow to 14,500 gpm, which limits pump runout and subsequent Diesel generator overload (if the Diesel is the power supply).

6. The flow then passes thru the heat exchanger bypass (F048) valve. F048 receives an Open Signal upon LPCI initiation. The operator may close or throttle F048 from (2)C601 at a time. The RHR Heat Exchanger isolation valves are normally open and do not get a closed signal on LPCI initiation. Therefore some LPCI flow will go through the Heat Exchanger.

7. Within the common discharge header is a flow element (for measuring pump performance) and the motor operated isolation valves.

8. Before reaching F017, flow could go thru F010 to the other RHR loop if F010 were opened. One of the F010 valves A or B must be de-activated in the shut position. Normal plant lineup has both 10 valves closed and deactivated per Tech Specs.

9. There is a relief valve located before F017 which relieves to radwaste. This protects the discharge line against over pressurization. F017 receives an open signal on LPC1 initiation and RPV pressure less than or equal to 436 psig. (Locks open for 5 minutes)

10. Located after F017 the motor operated isolation valve F015 opens when reactor pressure is less than or equal to 436 psig and a LPCI initiation signal is present per Tech Specs.

2. Pump discharge is directed to the RHR Heat Exchanger for cooling, thru the inlet F047 valve and exiting thru the F003 valve. The Heat Exchanger Bypass Valve (F048 is throttled. The F017 valve is throttled open to control system flow.

3. Water passes through the drywell isolation valves F015 and F060 and check valve F050 and enters the Reactor Recirculation Pump Discharge piping. In this mode the reactor recirc pump is stopped and the discharge valve is closed. (Prevents reactor recirculation pump cavitation.)

4. Water enters the Reactor Vessel through the Jet Pumps.

5. A pipe connects the "A" RHR Loop to the Reactor Vessel Head spray connection.

F. Fuel Pool Cooling (See Figure 7)

1. Suction from the Fuel Pool Cooling System enters the RHR System through manual valve 1-51-060 and motor operated F006 valve.

2. The F004 valve for that pump would be closed.

3. The Heat Exchanger bypass would be closed and the inlet F047 and outlet F003 would be opened.

4. Manual valve 1-51-070 would be opened and flow would return to the fuel pool cooling system.

III. Detailed Descriptions

A. Components

1. RHR Pumps (Figure 9)

a. Two 50% capacity pumps per loop.

b. Centrifugal type 4 stage vertically mounted.

c. Design parameters - 12,200 GPM each 204 psig. Per Tech Specs.

d. 2000 horsepower motor power supplied from a separate 4160 Volt engineered safeguards bus.

e. Pump flow limited by orifices to less than 14,500 gpm per pump to prevent Diesel Generator overload in the event of a pipe break.

3. RHR Valves

   a. All motor operated valves and all valves within the containment have position indication in the control room.

   b. Motor operated isolation valve power is either 250 VDC or 480 VAC from the essential service busses. Certain essential 480 VAC Valves are powered thru the isolated swing bus M-G sets, which have had their undervoltage trip devices removed to prevent undesireable trips when LOCA Voltage dips occur.

   c. Relief valves are provided in various piping runs for over pressurization protection.

   d. Testable Check Valves.

      1) Located inside the drywell.

      2) Each testable check valve (one on each loop) can be checked to be free by operating a solenoid gas valve which activates a gas cylinder, which rotates the valves shaft thereby lifting the disc. The shaft has a limit switch connected to it which verifies operation of the valve in the control room.

      3) The second solenoid gas valve admits gas to the actuator on check valve bypass valve. This opens the bypass valve thus equalizing the pressure across the check valve disc which reduces the force required to open the testable check valve.

      4) Free floating disc opens in event of injection regardless of position of the gas cylinder.

4. RHR discharge piping keep filled system

   a. Locations of keep filled valves:

      Loop A, area 29 - 683 ft evaluation, valve #151F092A

      Loop B, area 28 - 683 ft elevation, valve #151F092B

   b. Available instrumentation

      1) Local RHR keep fill pressure indicator RVP15187 location 25 - 683 ft elevation

         a) Normal reading with filled piping is 110 to 150 psig.

C. Important Trips, Isolations & Initiations

1. LPCI Subsystem initiation Signals

   a. Level 1 (-129") in the Reactor Pressure Vessel (RPV)

   b. Drywell High Pressure (1.72 psig)

   c. Manual

2. LPCI - RHR pump start signals

   a. RPV vessel 1 (-129")

   b. D.W. pressure 1.72 psig and RPV pressure $\leq$ 436 psig

   c. Manual

3. LPCI injection valve open signal (F015 and F017)

   a. RPV Level 1 (-129") + RPV pressure $\leq$ 436 psig

   b. D.W. pressure 1.72 psig + RPV pressure $\leq$ 436 psig

   c. Manual + RPV pressure $\leq$ 436 psig

4. All other subsystems are manually initiated

D. Local Alarms

None

IV. System Interrelationships

1. Cooling and Service Water System

The RHR Service Water System may be cross connected to the RHR system to provide a source of water for post accident containment flooding, if necessary. Each cross connect header connects the discharge piping of the RHR service water pump to its respective RHR loop heat exchanger shell side discharge line via F073A(B) and F075A(B). These motor operated gate valves are controlled from control room panel 1C601 and are normally keylocked closed. A check valve F074A(B) in each cross connect header ensures flow in the proper direction when the two systems are cross connected. Because the purpose of the cross connect is to provide containment flooding, any RHR loop discharge path to the primary containment may be used to flood the primary containment with RHR service water. In this case the RHR Pumps must be shut off to allow RHR SW to overcome the systems operating pressure.

5. Liquid Radwaste (LRW) Handling System

Because the water contained in the RHR system is potentially radioactive, various equipment and piping drains, vents and relief valve discharges are directed to liquid radwaste (LRW) for processing. This system drain connection originates between the RHR loop "A" crosstie valve, HV-1F010A and the loop "B" crosstie valve F010B in the common piping. Only 1 cross tie valve may be open at a time to allow drainage to LRW. Drainage is directed to the LRW Handling System via F040 and F049.

6. Sampling and Leak Detection System

Each RHR heat exchanger has a sample connection on its shell side discharge piping that enables a water sample to be drawn at this location and directed to the process sampling system for analysis. These sample connections may be isolated from the process sampling system by solenoid valves F079A(B) and F080A(B). Analysis of heat exchanger discharge would be performed after the heat exchanger has been refilled and prior to placing it in service for another RHR operating mode, primarily shutdown cooling.

7. Reactor Recirculation System

The LPCI injection header of each RHR loop directs water to its respective reactor recirculation loop between the reactor vessel and the recirculation pump discharge valve. This location provides a direct flow path for the injection of the LPCI flow into the lower plenum of the reactor vessel. As the LPCI flow accumulates the level rises inside the shroud. When the level reaches the top of the jet pumps, spill-over occurs for a time, raising the level outside the shroud. As the subcooled LPCI flow begins spilling into the region outside the shroud, the depressurization effect of the break is reduced since the subcooled water is now flowing out the break. Another connection between the RHR system and the Reactor Recirculation System exists for the RHR shutdown cooling mode. The "B" reactor recirculation loop provides the suction source for shutdown cooling via the shutdown cooling suction header. This header connects into the "B" reactor recirculation loop between the reactor vessel and the "B" recirculation pump suction valve to enable the shutdown cooling process to be accomplished with the "B" reactor recirculation loop isolated.

8. Reactor Vessel Internals System the reactor vessel head spray nozzle, used during the RHR shutdown cooling mode, is supplied by RHR loop "A". Reactor vessel head spray aids the cooldown process by condensing steam being generated by the hot reactor vessel walls and internals.

12. Compressed Air System

The Compressed Air System may be used to blowdown each RHR heat exchanger via the heat exchanger inlet piping vent line.

13. AC Electrical Distribution (4160V and above) System

Power must be available to 4160V switchgear 1A201, 1A202, 1A203 and 1A204 for operation of the RHR pump motors. These are engineered safeguards buses 1A, 1B, 1C, and 1D respectively. The availability and source of this power is used in the initiation logic for the LPCI mode of the RHR system.

14. AC Electrical Distribution (480V and below) System

Various motor operated valves in the RHR system require this power for both opening and closing operations in two ways. First, the 480 VAC power is used directly by the valve motors for operation. Secondly, the 480 VAC power for each valve is transformed down to 120 VAC for use in that valve's motor control circuits. All solenoid operated valves in the RHR system also require 120 VAC power for operation.

15. DC Electrical Distribution System

a. 125 VDC Power System

The relay and control power for the LPCI initiation system is derived from two independent 125 VDC power systems. The logic of the LPCI mode and the normal start logic is of the "energize to operate" type and therefore requires that this power be available. The 125 VDC power system also provides the necessary control power for operation of RHR pump motor circuit breakers.

b. 250 VDC Power System

The 250 VDC power system provides the necessary motor power and valve control circuit power for the following DC motor operated valves in the RHR system.

Shutdown cooling header outboard isolation, HV-F008

Reactor vessel head spray outboard isolation, HV-F023

RHR system drain to LRW outboard isolation, HV-F049

These valves each have a corresponding inboard isolation valve that is AC motor operated. All three sets of inboard

c. Shutdown Cooling and Reactor Vessel Head Spray Mode

1) The shutdown cooling and RPV head spray system is an integral part of the RHR system.

2) It is operated during a normal shutdown and cooldown.

3) Shutdown cooling subsystem operation removes the residual heat (decay heat and sensible heat) from the reactor system to permit refueling and servicing.

4) Spraying of the vessel head area accomplishes the following, during operation in the Head Spray Mode of SDC:

a) Condenses steam generated from the hot walls of the vessel while it is being flooded, maintaining saturated pressure and temperature conditions, thereby keeping system pressure down to facilitate vessel flooding.

5) Reactor shutdown cooling and head spray is initiated by manual action only via manual valve control switches in the control room.

6) The F008 and F009 valves (Rx Recirc Loop B to RHR S/D clg isolation valves) have been identified as valves subject thermal binding and pressure locking. See Industry Events Section for more information.

d. Suppression Pool Cooling Mode

1) The suppression pool cooling subsystem cools the suppression pool by using the RHR pumps and heat exchangers in a closed loop with the suppression pool.

2) The suppression pool cooling subsystem is put into operation to limit the water temperature to ensure complete compensation immediately after a blowdown.

3) During this mode of operation, water is pumped from the suppression pool through the RHR system heat exchanger and back to suppression pool.

the pump flow through the minimum bypass lines to the suppression chamber.

c) LPCI Test Mode

(1) A test flow (12,200 gpm per pump, as required by Tech Specs) functional test of the RHR system pumps is performed for each pair of pumps during plant operation by taking suction form the suppression pool and discharging through the test lines back to the suppression pool.

(2) In-plant operators are required to check pump oil levels and system operation during Routine Surveillances.

g. In-Plant operator's procedural responsibilities for the Residual Heat Removal System include:

1) Venting System and operating keep-filled station

2) Checking pump oil levels as required

3) Performing parts of checkoff lists verifying Valve Positions, and Breaker and Switch positions required for System operability

4) Performing equipment outages as required by plant supervision.

RESIDUAL HEAT REMOVAL SYSTEM

INDUSTRY EVENTS

1. SOER 84-7 — Pressure Locking and Thermal Binding of Gate Valves

INPO has on record a number of events involving gate valves that have failed to open due to disc binding in the closed position as a result of differential thermal contraction (thermal binding) or high pressure water trapped in the valve bonnet cavity (pressure locking).

Types of gate valves affected are flexible wedge gate valves and double disc valves.

The F008 and F009 valves (Rx Recirc Loop B to RHR S/D clg suction isolation valves) have been identified as valves subject to this failure mode at SSES because they are flexible wedge gate valves.

INPO has made several recommendations as potential solutions to this problem. At SSES the process being considered is to orifice the upstream disc (hi pressure side) valves to eliminate the threat of pressure locking. At this time (03/10/88) the required PMRs exist, but have not been implemented.

RESIDUAL HEAT REMOVAL SYSTEM

I. PURPOSE

A. THE RESIDUAL HEAT REMOVAL (RHR) SYSTEM PURPOSE IS TO TRANSFER ALL DECAY HEAT OR RESIDUAL HEAT FROM THE REACTOR CORE AND COMPONENTS. IT CAN PERFORM THIS FUNCTION UNDER BOTH NORMAL AND EMERGENCY CONDITIONS:

THE FOLLOWING SUBSYSTEMS OR MODES OF RHR WILL MEET THE ABOVE PURPOSE:

1. LPCI
2. SUPPRESSION POOL/CONTAINMENT SPRAY
3. SUPPRESSION POOL COOLING
4. SHUTDOWN COOLING/HEAD SPRAY
5. FUEL POOL COOLING

B. THE PURPOSE OF EACH OF THE MODES OF OPERATION ARE AS FOLLOWS:

1. LOW PRESSURE COOLANT INJECTION (ECCS SYSTEM)

   USED TO RESTORE AND MAINTAIN REACTOR VESSEL WATER LEVEL FOLLOWING A LOSS OF COOLANT ACCIDENT (LOCA).

2. SUPPRESSION POOL AND CONTAINMENT SPRAY COOLING (POST ACCIDENT SYSTEM).

   SPRAYS WATER INSIDE THE PRIMARY CONTAINMENT AND SUPPRESSION POOL TO CONDENSE STEAM RELEASED FOLLOWING A LOCA.

3. SUPPRESSION POOL COOLING

   MAINTAINS SUPPRESSION POOL TEMPERATURE WITHIN TECHNICAL SPECIFICATION LIMITS TO PROTECT THE SUPPRESSION POOL FROM EXCESSIVELY HIGH WATER TEMPERATURES WHICH COULD DAMAGE THE POOL.

FIGURE 1

RESIDUAL HEAT REMOVAL SYSTEM

TRANSPARENCY MASTERS

4. SHUTDOWN COOLING
   THE SHUTDOWN COOLING MODE OF RHR CONTROLS REACTOR COOLDOWN RATE WHEN THE REACTOR IS BEING SHUTDOWN OR IS SHUTDOWN AND THE MAIN CONDENSER IS NOT AVAILABLE FOR HEAT REMOVAL.

5. FUEL POOL COOLING
   THE FUEL POOL COOLING MODE OF RHR ALLOWS RHR HEAT EXCHANGERS TO AUGMENT OR SUBSTITUTE FOR THE FUEL POOL COOLING HEAT EXCHANGERS.

FIGURE 1

RESIDUAL HEAT REMOVAL SYSTEM

OBJECTIVES

TERMINAL OBJECTIVES

AFTER THE COMPLETION OF THIS UNIT OF INSTRUCTION, THE STUDENT SHOULD BE ABLE TO DEMONSTRATE A BASIC UNDERSTANDING OF THE RESIDUAL HEAT REMOVAL SYSTEM (RHR). THE STUDENT WILL DEMONSTRATE THIS KNOWLEDGE BY ATTAINING A MINIMUM SCORE OF 70 PERCENT IN THE UNIT TEST.

SPECIFIC OBJECTIVES

AT THE COMPLETION OF THIS UNIT OF INSTRUCTION THE STUDENT SHOULD BE ABLE TO:

1. STATE THE PURPOSE OF THE SYSTEM AND EACH SUBSYSTEM AND WHEN EACH SUBSYSTEM IS USED.
2. LABEL THE MAJOR COMPONENTS AND FLOWPATHS ON A ONE LINE DRAWING OF THE SYSTEM.
3. LIST THE SIGNALS (NOT SETPOINTS) WHICH INITIATE THE SYSTEM IN THE LPCI MODE.
4. STATE HOW THE SYSTEM FUNCTIONS TO COOL THE CORE. (SUCTION AND DISCHARGE FLOWS) IN THE LPCI MODE.
5. STATE THE RELATIONSHIPS TO OTHER PLANT SYSTEMS.
6. DISCUSS THE IMPORTANCE OF ENSURING THAT THIS SYSTEM IS KEPT FILLED. INCLUDE LOCATIONS FOR THE "KEEP FILL" STATIONS AND VENT STATIONS FOR EACH UNIT.

FIGURE 2

A 400 SHT.50 REV.45 DATE 6/20/90

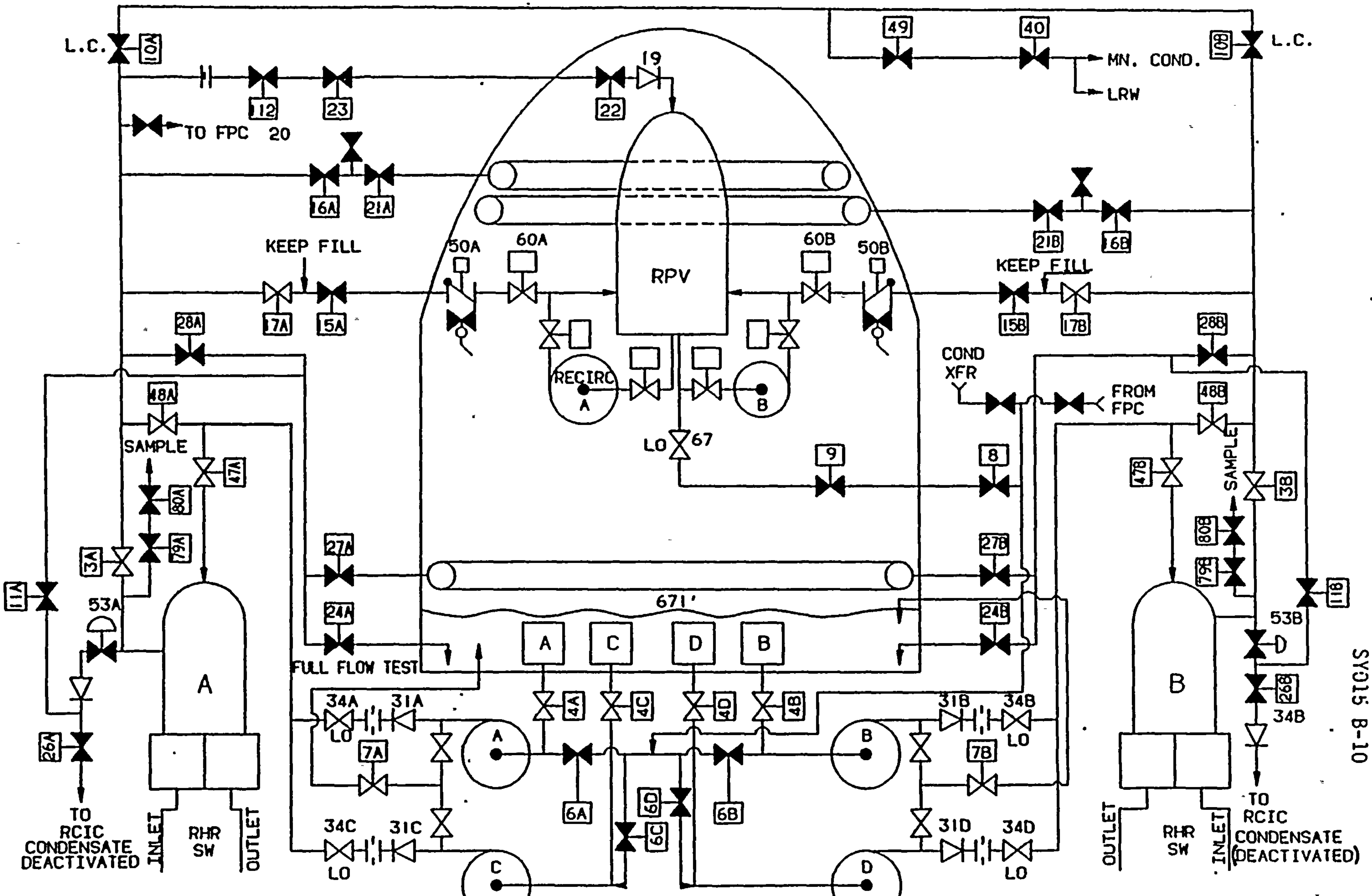


FIGURE 3

RHR STANDBY LINEUP

SY015 B-10

A 400 SHT.847 REV. 2 DATE 11/30/89

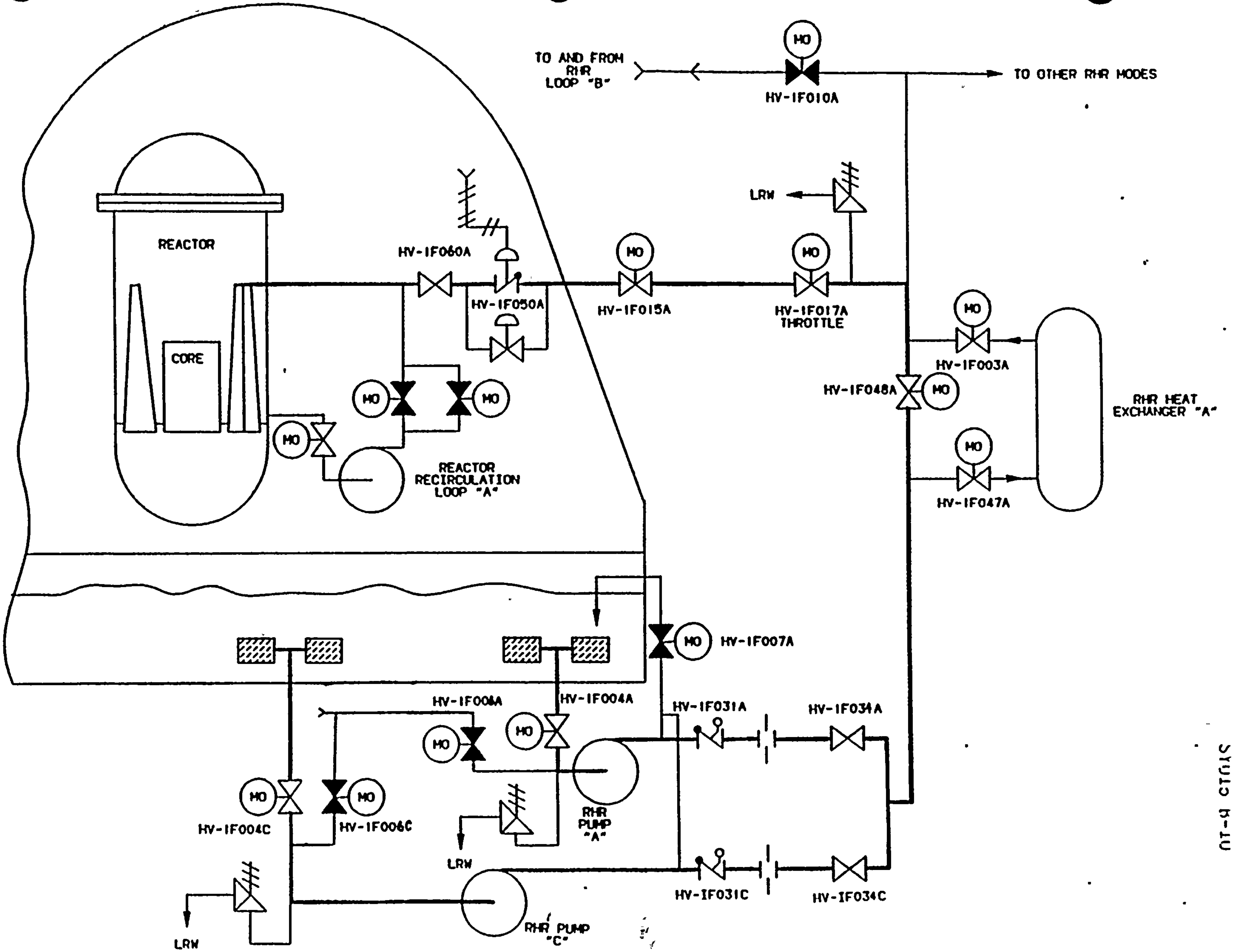


FIGURE 4

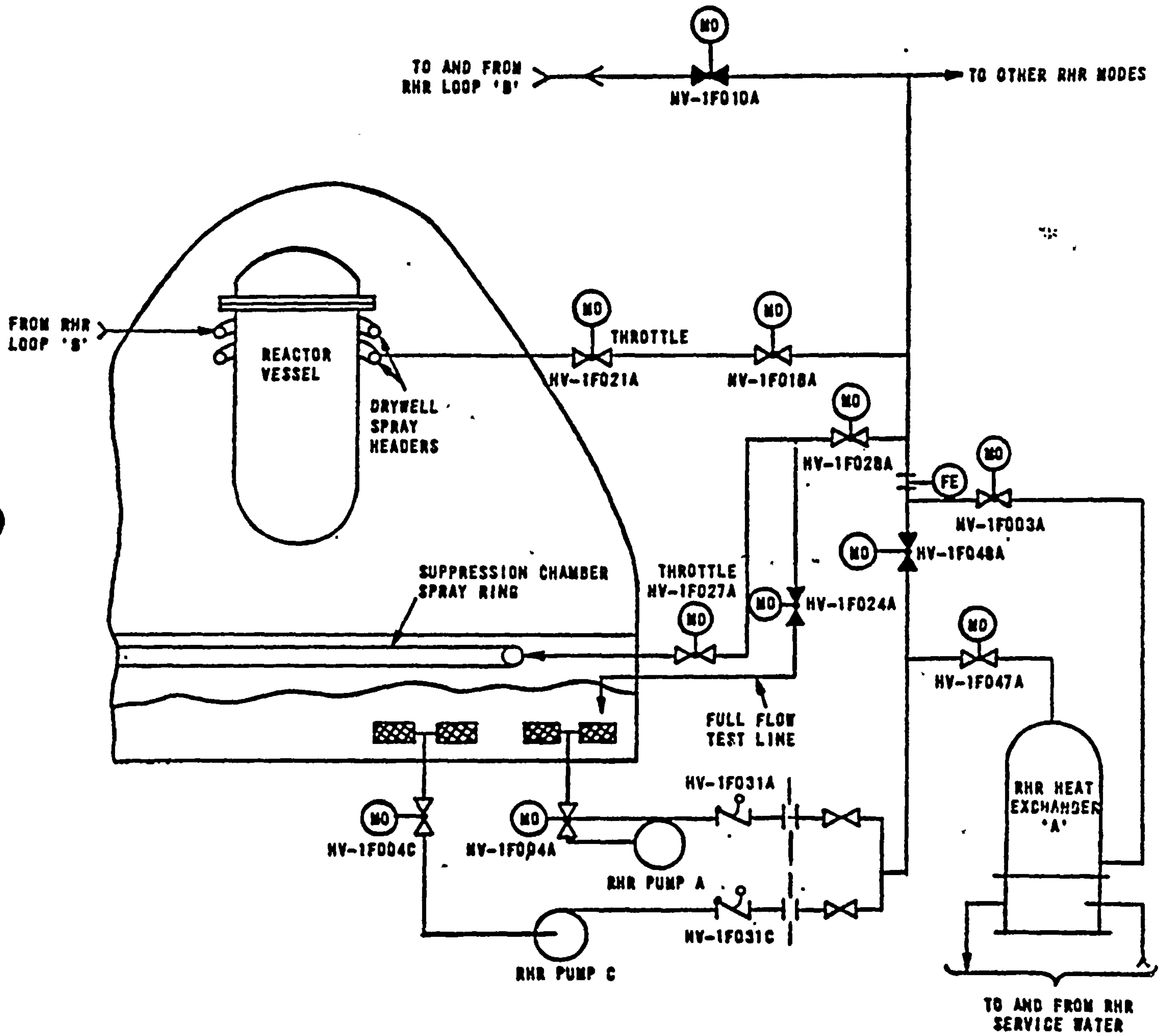
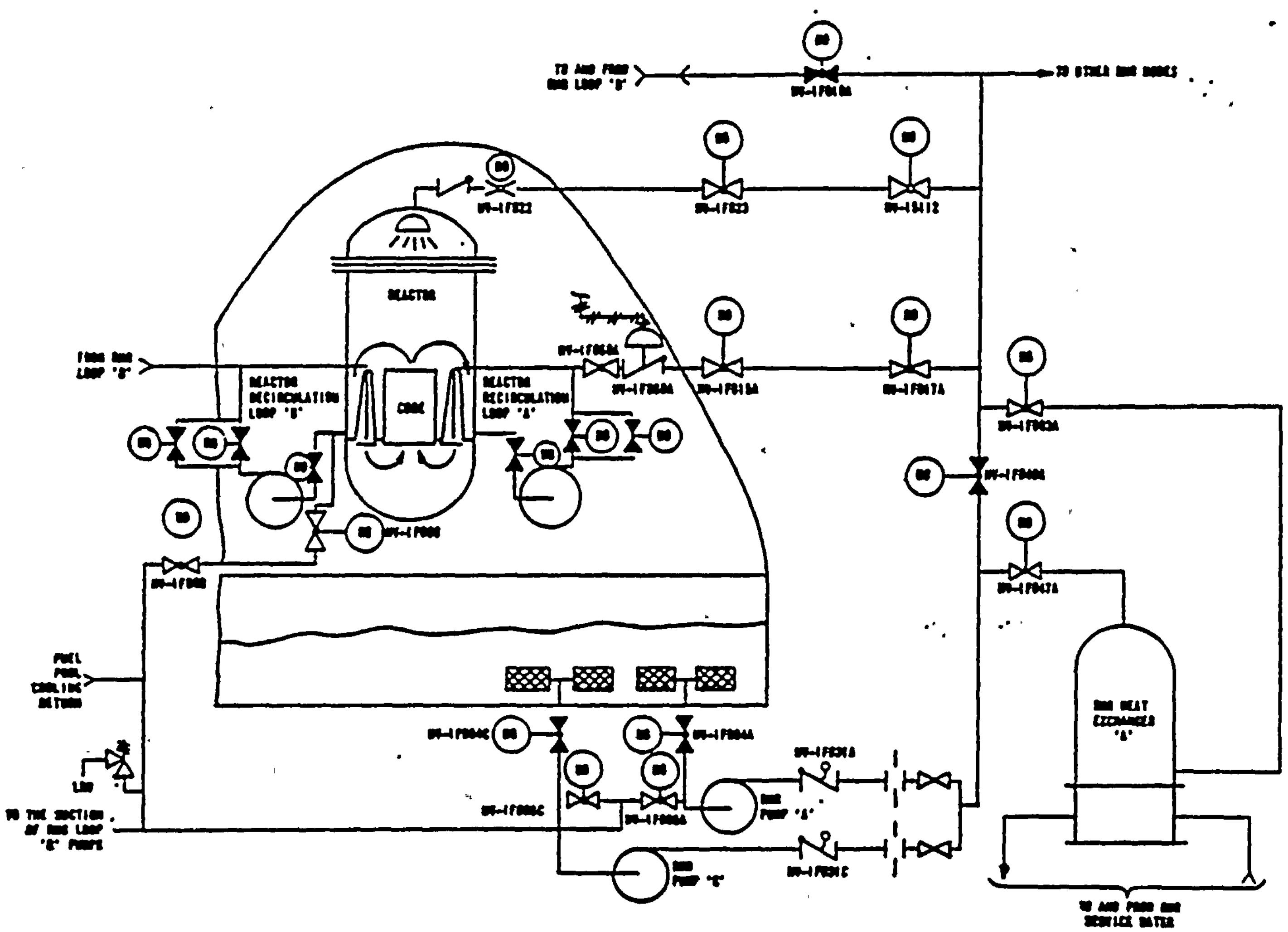


FIGURE 5

SIMPLIFIED DIAGRAM OF CONTAINMENT SPRAY COOLING, SUPPRESSION POOL COOLING AND FULL FLOW TEST FLOWPATHS FOR RHR LOOP 'A'



SIMPLIFIED DIAGRAM OF RHR LOOP "A" SHUTDOWN COOLING FLOWPATH

FIGURE 6

A 400 SHT. 23 REV. 2 DATE 9/20/90

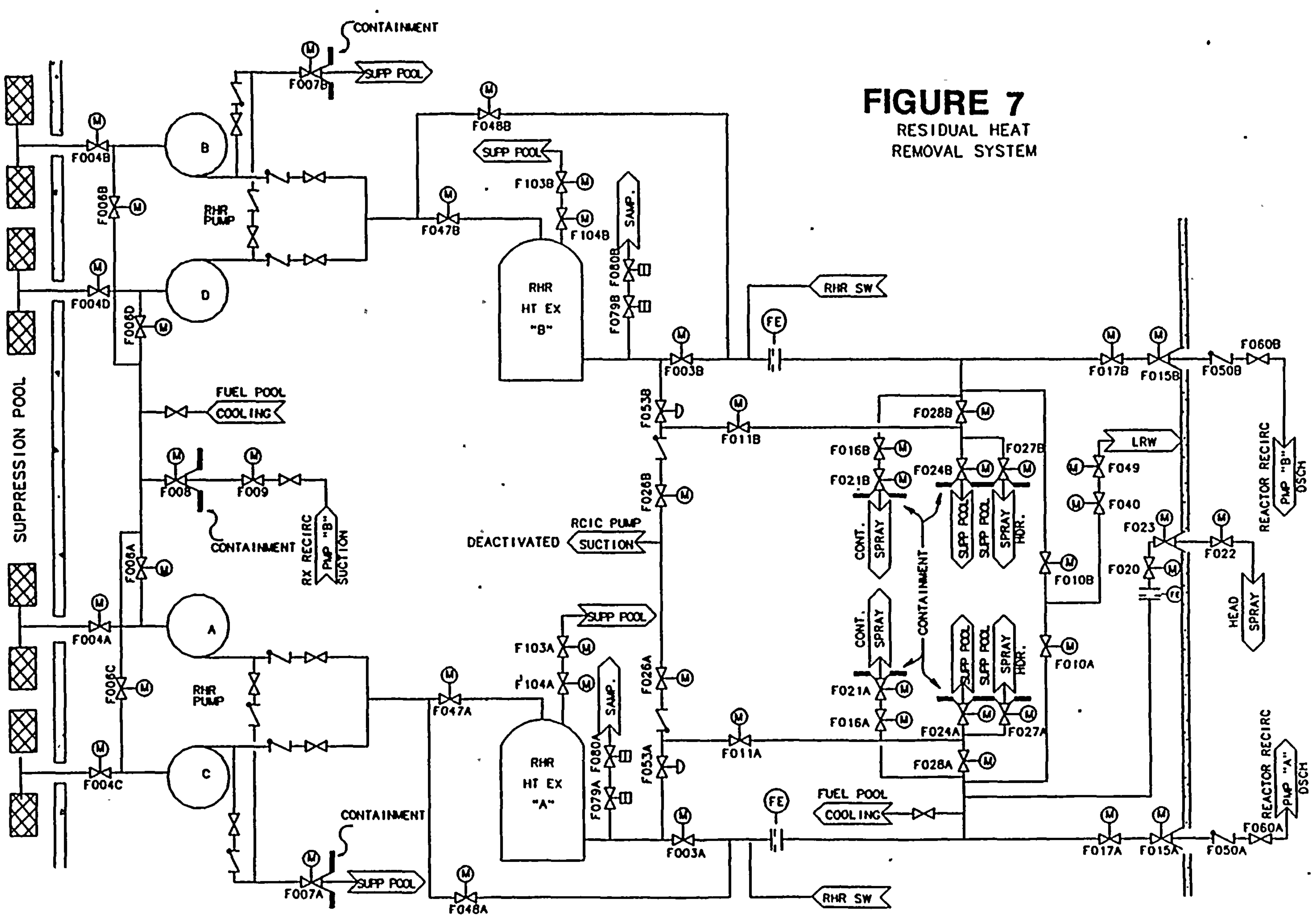


FIGURE 7
RESIDUAL HEAT
REMOVAL SYSTEM

ST-6-LU

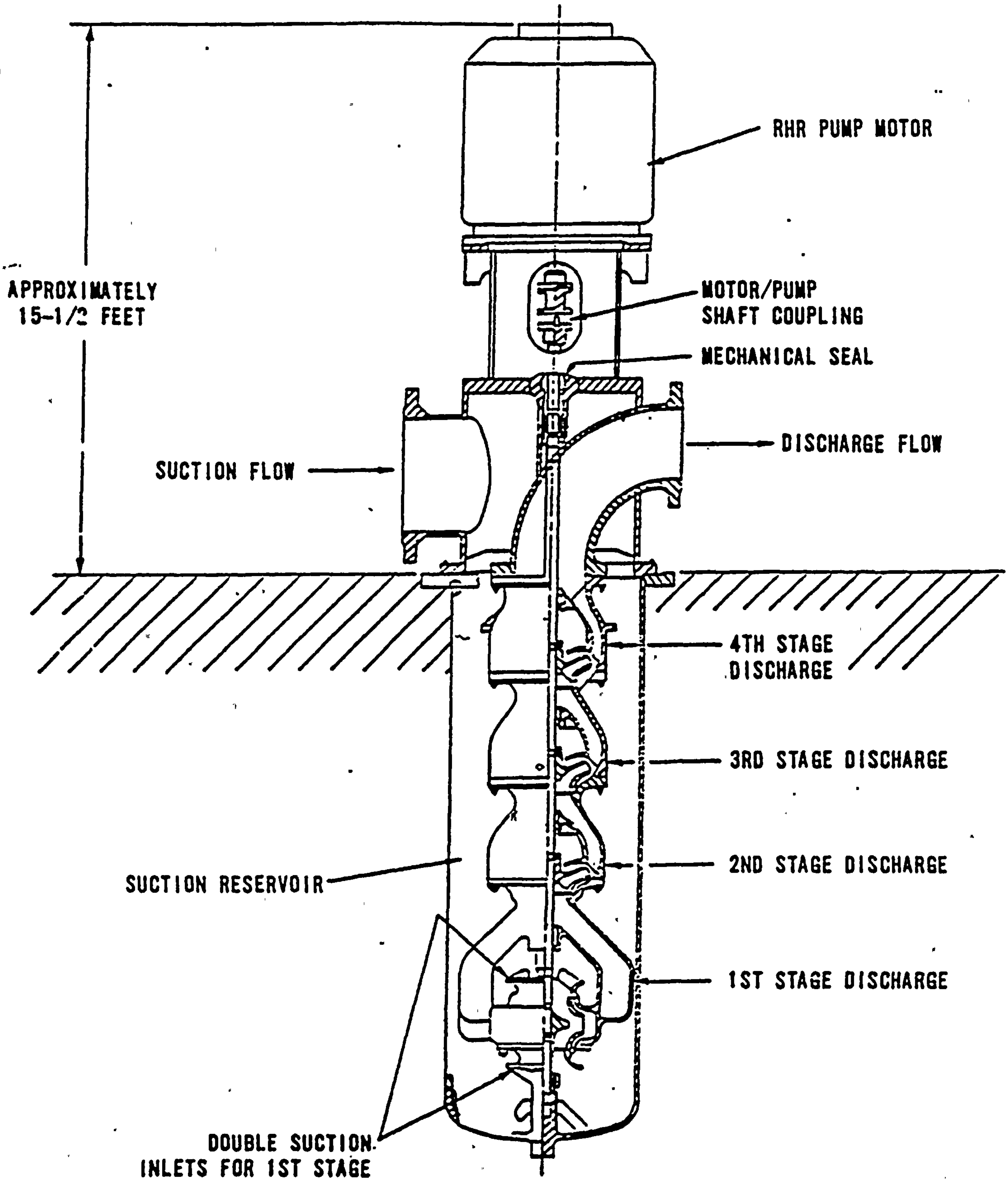


FIGURE 8

RHR PUMP SIMPLIFIED DIAGRAM (4 TYPICAL)

RESIDUAL HEAT REMOVAL SYSTEM

EVALUATION

Evaluation can be found in STC Exam Bank.

RESIDUAL HEAT REMOVAL SYSTEM

EVALUATION CRITERIA

Evaluation Criteria can be found in STC Exam Bank.