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Operations Division
Reactor Operations Section

OPERATING MANUAL FOR THE HIGH FLUX ISOTOPE REACTOR

Operating Procedures

Part 2

Compiled by

High Flux Isotope Reactor Staff

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NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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DEPARTMENT OF ENERGY

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J. H. Swanks, Director
Operations Division

R. V. McCord, Head
Reactor Operations Section

S. S. Hurt
Reactor Supervisor

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5. RESEARCH FACILITIES

5. 1. Beam Tubes

5.1.1 References

Drawings

E-42068 Horizontal Beam Tubes, Cooling Water Metering Control Station and Leak Detector Lines

E-42027 Horizontal Beam Tubes Installation Assembly

E-49433 Pressure Vessel Flow Monitoring Flow Sheet

E-50177 HB Flow Diagram

E-50189 EF Tube No. 2 Flow Diagram

E-49745 Flow Sheet - Service Piping for HB Tubes

5.1.2 Introduction

The horizontal beam tubes are cooled by high pressure primary water. This coolant enters an aluminum jacket from the high pressure side of the reactor core, is routed over the surface of the beam tube, and discharges beneath the core of the low pressure side (see Fig. 5.1). The horizontal beam tubes are flushed internally with low pressure water from the pool cleanup system.

5.1.3 High pressure water flow monitoring (see Fig. 5.2)

1. All horizontal beam tube flows are monitored by the PDP-11/60 computer at 15-min intervals. If a scan of the flows indicates one out of its operating range, the computer will print on the control room typewriter a set of data and indicate which of the datum is not within range.
2. A complete set of hydraulic data is normally printed out by the typewriter on each midnight shift by entering function HYSCAN on the PDP-11/60 computer. This printout is kept on record for future reference.

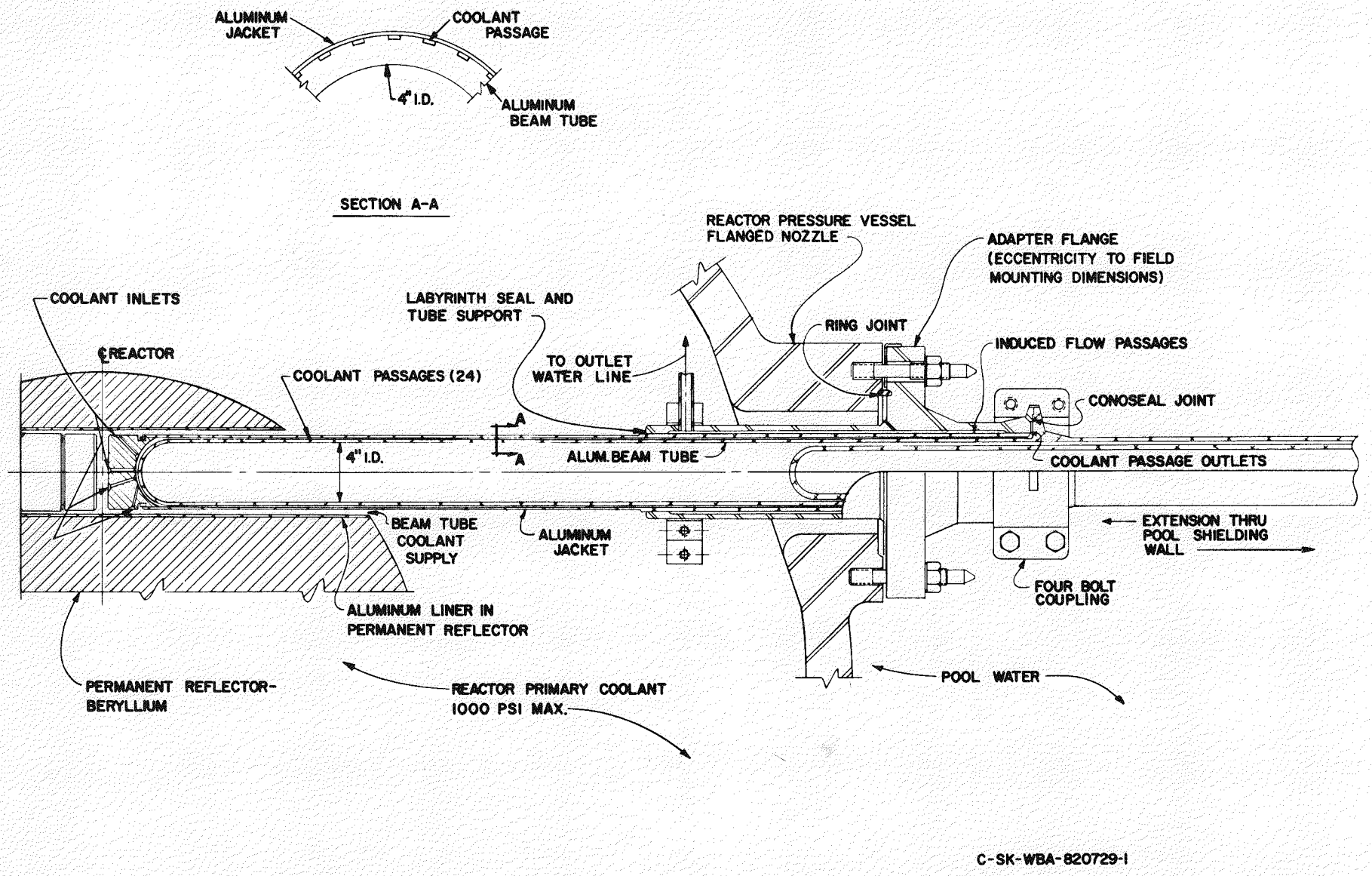


Fig. 5.1. Beam tube cooling.

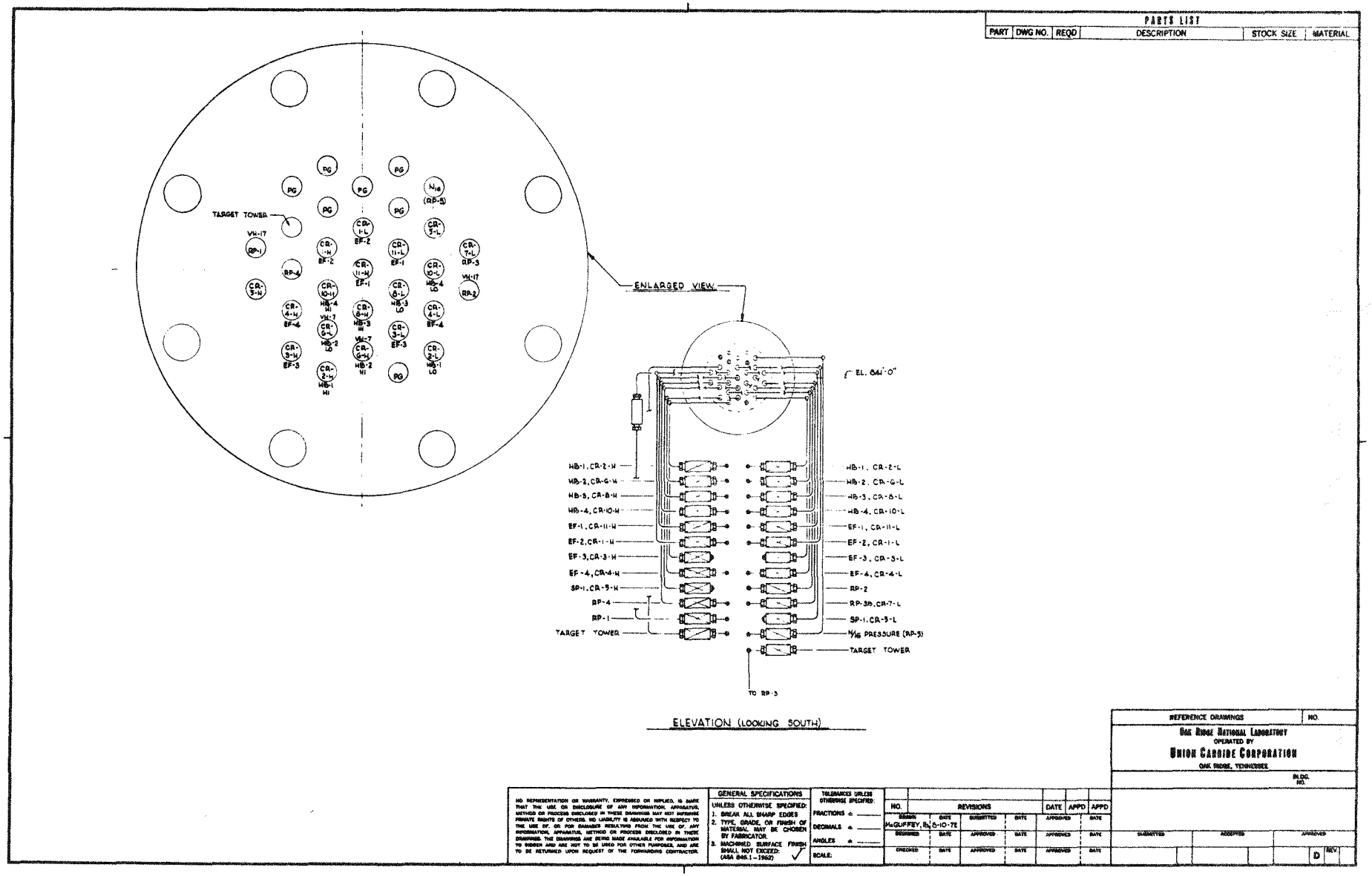


Fig. 5.2. Beam tube coolant monitoring station.

5.1.4 Horizontal beam tube facility servicing (see Fig. 5.3)

5.1.4.1 References

Drawings:

E-50177 Service Piping for Horizontal Beam Tubes

E-50178 Service Piping for Beam Tube No. 1

E-49745 Flow Sheet - Service Piping for Horizontal Beam Tubes

5.1.4.2 Precautions

Potentially serious radiation hazards exist under certain conditions at the horizontal beam tubes. Because of these hazards, the following precautionary measures must be observed:

1. Any time the beam tube shield plug or collimator is drained of water, the rotating shutter must be closed and locked unless the experimenter's shield is in front of the beam.
2. Health Physics coverage is required while draining water from the shield plug or collimator.

5.1.4.3 Normal operating conditions (valve numbers are identical for all four beam tubes; see Fig. 5.3)

During normal operation the following conditions should exist:

1. Cooling water is supplied from the pool cleanup system with the necessary pressure obtained by throttling valves V-1244 and V-1273 on the cleanup discharge lines to the reactor and clean pools, respectively.

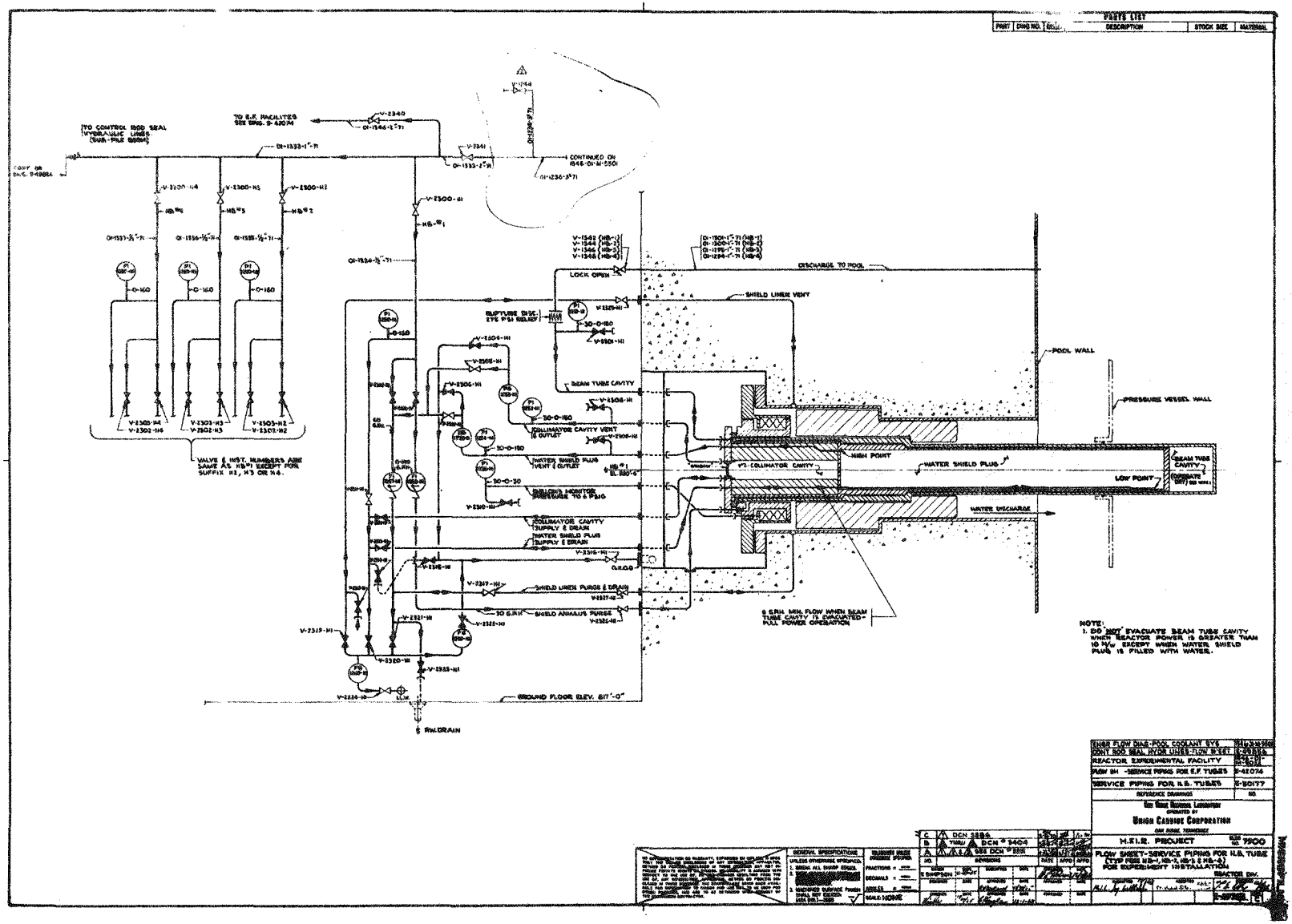


Fig. 5.3. HB -1, 2, 3, and 4 flow sheet.

2. Water from the pool cleanup system is circulated through the water shield plug at the rate of 6 gph, as indicated by FI-1257 and discharged to the pool by purging through the shield liner.
3. A flow of 1 gph is circulated through the collimator cavity and joins the flow from the water shield plug which is then discharged to the pool via the shield liner purge and drain line.
4. A flow of 30 gph, as indicated by FI-1258, is to be maintained to purge the shield annulus.
5. The beam tube cavity should be filled with helium to a pressure of 15 psig, as indicated by PI-1251.
6. The bellows should be filled with helium to a pressure of 6 psig, as indicated by PI-1256.

5.1.4.4 Water shield plug - to fill with water

1. Close the following valves:
   a. V-2302 (bypass to shield liner)
   b. V-2303 (supply to shield annulus)
   c. V-2312 (supply to collimator cavity)
   d. V-2314 (service line)
   e. V-2320 (drain to ILW)
2. Open the water supply valve, V-2341 (in pipe corridor).
3. It may be necessary to throttle valves V-1244 and V-1273 in the pipe corridor on the pool cleanup discharge lines into the pools to obtain adequate pressure for flow. If throttling of these valves is

required, throttle so that a pressure of 35 to 40 psig is obtained on pressure indicator PI-1267, located at the EF-2 facility.

4. Open valve V-2300 (water supply valve.)
5. Open valve V-2311 (supply to water shield plug and collimator.)
6. Open valve V-2313 (supply to water shield plug.)
7. Vent to the ILW by:
   a. Closing valves
      (1) V-2309 (service valve to water shield plug)
      (2) V-2306 (from water shield plug to OHOG)
      (3) V-2305 (from collimator cavity vent and outlet)
      (4) V-2319 (shield liner vent)
   b. Opening valves
      (1) V-2307 (vent and outlet from water shield plug)
      (2) V-2321 (drain to ILW)
      (3) V-2324 (drain to ILW)
8. Observe flow guage FG-1260. When water is seen flowing through the gauge, allow it to continue for one or two minutes until it is obvious that all air has been forced from the collimator and lines.
9. Stop the water flow to the ILW and redirect it to the shield liner by opening V-2317 and V-2327 (to the shield liner); closing V-2321 (drain to ILW) and V-2324 (drain to ILW).

10. Observe the flow rate through the flow indicator, FI-1257. Adjust the flow to approximately 6 gph.
11. If water was circulating through the collimator cavity prior to filling the water shield plug, re-establish flow by opening V-2312 and V-2305 and adjust the flow to approximately 1 gph by noting an increase to approximately 7 gph on FI-1257.

5.1.4.5 Water shield plug - to drain

1. Drain the water shield plug to the ILW, which is serviced by the OHOG system. Thus, any radioactive gases released will be removed to the gaseous waste system.
2. Stop the water flow through the water shield plug by closing valves V-2311 and V-2307.
3. Open valves V-2313, V-2320, and V-2324.
4. Observe a decrease in pressure on PI-1254.
5. Vent the water shield plug by opening V-2309.
6. Observe FG-1260 for water flow. When all of the water has been removed, allow the air flow to continue for at least 10 min to dry the inside of the water shield plug.
7. Isolate the water shield plug by closing valves V-2309, V-2306, V-2307, and V-2313.

5.1.4.6 Collimator cavity - to fill with water

1. Close the following valves
   a. V-2302 (bypass to shield liner)
   b. V-2303 (supply to shield annulus)
   c. V-2313 (supply to water shield plug)

d. V-2314 (service line)
e. V-2320 (drain to ILW)

2. Open the water supply valve, V-2341 (in pipe corridor).
3. It may be necessary to throttle valves V-1244 and V-1273 (in the pipe corridor) on the pool cleanup discharge lines into the pools to obtain adequate pressure for flow. If this is necessary, throttle so that a pressure of 35 to 40 psi is obtained at PI-1267 located at the EF-2 facility.
4. Open valve V-2300 (water supply valve).
5. Open valve V-2311 (supply to water shield plug and collimator).
6. Open valve V-2313 (supply to water shield plug).
7. Vent to the ILW by:
   a. Closing valves
      (1) V-2308 (service valve)
      (2) V-2304 (from collimator of OHOG)
      (3) V-2307 (from water shield plug vent and outlet)
      (4) V-2317 (supply to shield liner)
      (5) V-2319 (shield liner vent)
   b. Opening valves
      (1) V-2305 (vent and outlet from collimator)
      (2) V-2321 (drain to ILW)
      (3) V-2324 (drain to ILW)

8. Observe flow gauge FG-1260. When water is seen flowing through the gauge, allow it to continue for one or two minutes until it is obvious that all air has been forced from the collimator and lines.
9. Stop the water flow to the ILW and redirect it to the shield liner by opening V-2317 (to shield liner) and V-2327 (to shield liner); closing V-2321 (drain to ILW).
10. Observe the flow rate through FI-1257. Adjust to approximately 1 gph.
11. If water was circulating through the water shield plug prior to filling the collimator, re-establish flow by noting an increase to approximately 7 gph on FI-1257.

5.1.4.7 Collimator cavity - to drain

1. Drain the collimator cavity to the ILW, which is serviced by the OHOG system. Thus, any radioactive gases released will be removed to the gaseous waste system.
2. Stop the water flow through the collimator by closing valves V-2311 and V-2305.
3. Open valves V-2320 and V-2324.
4. Observe a decrease in pressure on PI-1252.
5. Vent the collimator by opening V-2308.
6. Observe flow gauge FG-1260. When all the water has been removed, allow the air flow to continue for at least 10 min to dry the collimator.
7. Isolate the collimator cavity by closing valves V-2308, V-2304, V-2305, and V-2312.

5.1.4.8 Shield annulus - to establish water flow

1. Open valves V-2326, V-2303, and V-2300.
2. Observe FI-1258 and adjust valve V-2303 until a flow of 30 gph is established.

5.1.4.9 Shield liner - to vent

1. Close valves V-2322, V-2321, and V-2320.
2. Open valves V-2325, V-2319, and V-2324.
3. When water is observed flowing through flow gauge FG-1260, close V-2319 and V-2324.

5.1.4.10 Beam tube cavity - pressurizing with helium

1. Prior to filling with helium, it is necessary to evacuate the cavity of all moisture.
   CAUTION: EVACUATION OF THE CAVITY IS NOT PERMITTED unless a flow of at least 6 gph is circulating through the water shield plug. THE RUPTURE DISK IS RATED AT 26 PSI REVERSE ΔP. The pool head (water in pool) exerts 13 psi; therefore, THE PRESSURE MUST NOT BE REDUCED GREATER THAN 10 PSI (3 psi allowed for discrepancies) which is 4.7 psia. The gauge reading, PI-1251, is in inches of Hg. Therefore, a reading of 20 in. should not be exceeded.
2. To remove the moisture from the cavity, open valve V-2301 and connect the vacuum pump to this line. Start the pump and evacuate to 4.7 psia. Close valve V-2301. Isolate the vacuum pump. Connect the helium bottle to this line. Open valve V-2301 and fill to atmospheric pressure with helium.

3. Repeat step 2 at least twice.
   Adjust the regulator on the helium bottle to 15 psig. Open valve V-2301 and pressurize to 15 lbs as indicated by PI-1251. Close valve V-2301 and observe that the pressure is constant.

5.1.4.11 Bellows monitor - to pressurize

1. Connect the helium supply to the line at V-2310.
2. Adjust the regulator on the helium bottle to 6 psi.
3. Open valve V-2310 and observe PI-1256 as the bellows is pressurized.
4. Close valve V-2310 and observe that the pressure is constant.

5.1.5 Low pressure beam hole coolant

NOTE: These procedures are written for HB-1 and assume all valves are closed initially. The numbers in parenthesis refer to HB-2, -3, and -4, respectively.

1. Establish water flow through the beam hole plug and cavity
   a. Open main low pressure water supply valve V-2341.
   b. Open HB-1 supply valve V-2304 (V-2305, V-2306, V-2307).
   c. Open shield liner purge and drain valve V-2312 (V-2313, V-2314, V-2315).
   d. Open water supply valve to shield plug V-2332 (V-2333, V-2334, V-2335) until flow indicator FI-1250 (FI-1251, FI-1252, FI-1253) shows 1 gpm or approximately 1/3 full scale.
   e. Open shield annulus purge valve V-2336 (V-2337, V-2338, V-2339) until the flow indicator increases to 2 gpm or approximately 2/3 full scale.

f. Open shield liner vent valve V-2300 (V-2301, V-2302, V-2303) until water appears and then close it tightly.

2. Drain water from the beam hole plug
   a. Close the plug water supply valve, V-2332 (V-2333, V-2334, V-2335).
   b. Close the liner shield purge and drain valve, V-2312 (V-2313, V-2314, V-2315).
   c. Open the plug water return vent valve, V-2316 (V-2317, (V-2318, V-2319).
   d. Open the plug water supply drain valve, V-2324 (V-2325, V-2326, V-2327).
   e. When draining is completed, close the plug water return vent valve V-2316 (V-2317, V-2318, V-2319) and the plug water supply drain valve V-2324 (V-2325, V-2326, V-2327).
3. Monitor beam tube bellows seal
   a. Read pressure gauge PI-1262 (PI-1263, PI-1264, PI-1265). If any pressure is indicated, a leak is possible between the beam hole cavity and the first bellows seal.
   b. Open the bellows drain V-2308 (V-2309, V-2310, V-2311) and then close it tightly. If any water drains out, a leak has probably developed between the beam hole cavity and the first bellows seal.

5.2. Slant Engineering Facilities

5.2.1 References

Drawings:

E-49775 Engineering Facility Tubes Assembly

E-49776 Engineering Facility Tubes Assembly - Typical Installation

E-42074 Flow Sheet - Service Piping for EF Tubes

E-50189 EF Tube #2 - Service Piping and Flow Sheet

E-50177 Service Piping for Horizontal Beam Tubes

5.2.2 Introduction

The engineering facility tubes are cooled by high pressure primary water. The coolant enters an aluminum jacket from the high pressure side of the reactor core, is routed over the surface of the tube, and discharges beneath the core of the low pressure side.

The engineering facility tubes are continuously flushed with low pressure water from the pool cleanup system to prevent stagnant water. NOTE: This procedure is written for EF-2 as this is the only EF tube in service at this time.

5.2.3 High Pressure Water Flow Monitoring (Fig. 5.2)

See section 5.1.3 for hydraulic data monitoring procedures.

5.2.4 Engineering facility servicing procedure (EF-2)

During normal operations, the following conditions should exist at the EF facilities (see Fig. 5.4):

1. Cooling water is supplied from the pool cleanup system with the necessary pressure obtained by throttling valve

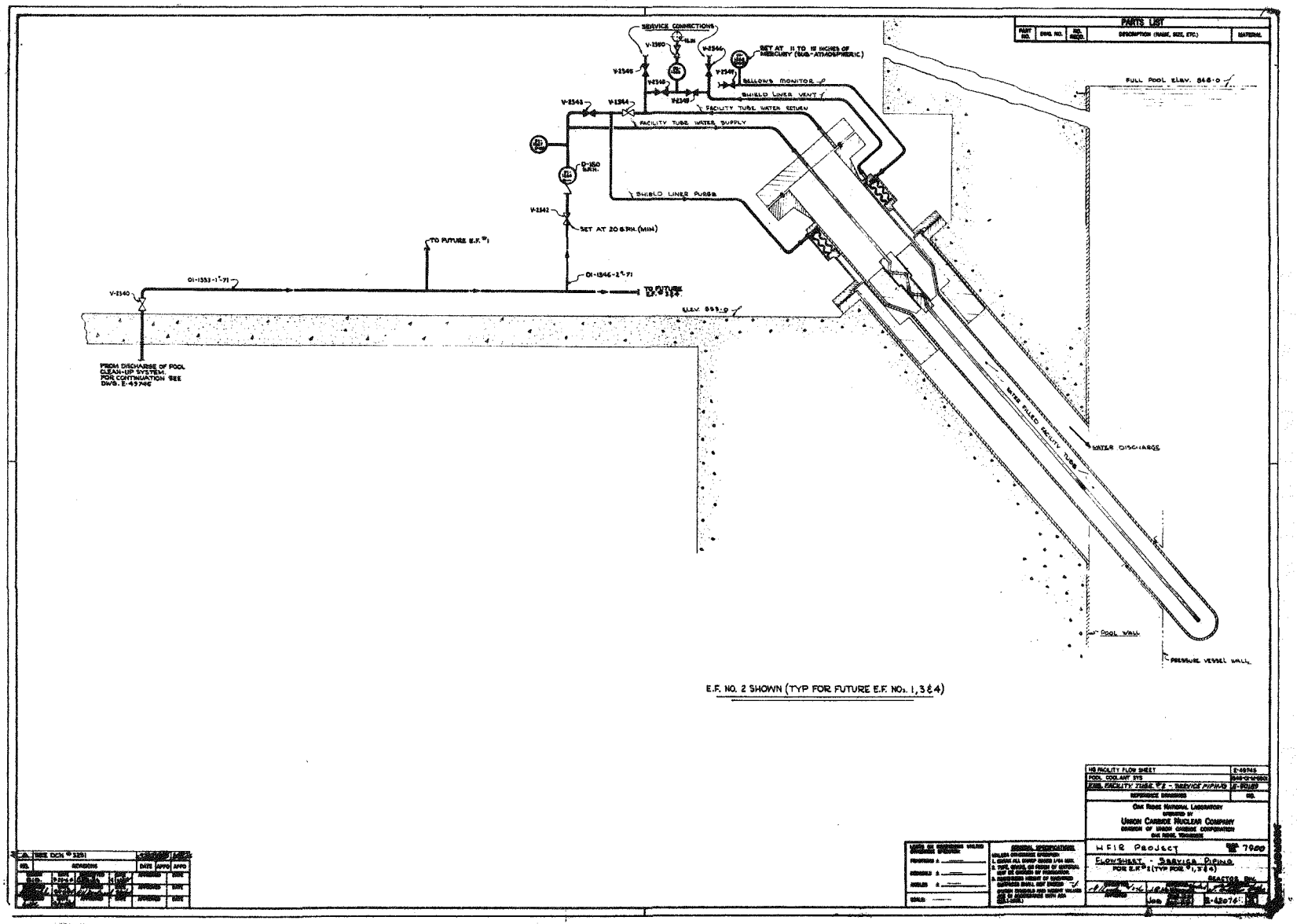


Fig. 5.4. Engineering facility coolant flow diagram (EF-2).

V-1244 and/or V-1273 on the cleanup discharge lines to the reactor pool and clean pools, respectively.

2. A flow should exist through the facility tube of 60 gph (minimum 48 gph) as indicated by FI-1266. The discharge from the facility tube is then routed through the shield liner purge and discharged into the pool.

3. The expansion bellows should be evacuated to a pressure of minus 6 psi (minus 12 in. Hg) as indicated by PI-1268.

5.2.4.1 Facility Tube - to fill with water

1. Open valve V-2340 (near column C-5).
2. Open valve V-2341 (in pipe corridor).
3. Throttle valve V-1244 and V-1273 (in pipe corridor) on the pool cleanup discharge lines into the pools to obtain a pressure on PI-1267 or 35 to 40 psig. Check the pool cleanup flow which should still be approximately 200 gpm.
4. At the facility, open valve V-2348, which vents the return line. Open valve V-2350 to the ILW.
5. Close valve V-2343, V-2344, and V-2349.
6. Open the water supply valve V-2342, and observe flow gauge FG-1266.
7. When water is observed flowing through FG-1266, and it is obvious that all air has been removed, close V-2348 and open V-2344. This permits the water to return to the pool via the shield liner purge.

5.2.4.2 Shield liner - to vent

1. Close valve V-2346.

2. Open valve V-2349 and V-2350. When water is observed flowing through flow gauge FG-1266, close valve V-2349 and V-2350.

5.2.4.3 Expansion bellows - to evacuate

1. Connect the vaccuum pump to the bellows monitor line at valve V-2347. Start the pump.
2. Open valve V-2347 and observe PI-1268.
3. When a vacuum of 12 in. Hg is observed on PI-1268, close valve V-2347 and shut off the pump.
4. Recheck PI-1268 to assure that this vacuum is maintained.

5.3 Target

5.3.1 Introduction

The target assembly consists of a bundle of 31 target rod positions. Thirty of these positions usually contain the actinide feed materials. The central target rod position in the bundle accommodates the hydraulic rabbit tube in-pile section. When installed in the reactor, the target holder rests on the inner fuel element and is held down by the target tower assembly which rests on top of the upper support ring of the target hold.

5.3.2 Precautions

1. Structural integrity of the target rods in extremely important. A defective target rod may leak radioactive material into the primary coolant system. It is, therefore, important to handle the target holder and target rods carefully so that they are not damaged.

2. High levels of radiation are emitted from the irradiated target rods. Do not raise the target too close to the surface of the pool water.
3. Upon removal of the target bundle from the reactor after power operation, and its subsequent transfer to the center pool, the pool cover may be used to prevent the possible escape of gaseous activity into the reactor bay if a leaky or ruptured target rod is believed to be in the target bundle.

5.3.3 Replacement of target rods in target holder assembly

1. References

Drawings:

(no number)	HFIR Target Loading
E-49722	Target Holder Assembly, Model "D"
E-50170	Target Selector Plates
D-M-A70582N	Target Element Assembly
M-10070-ØC-250-E	Target Holder Handling tool, Assembly "B"
M-10070-ØC-265-E	Target Picker Tool, Model "B"

2. Tools required
   a. Short target holder handling tool
   b. Target picker tool
   c. Target work platform
   d. Periscope
3. Data
   a. Weight: Target rod - dry <1 lb
      Target picker tool - dry approximately 7 lb
4. Work conditions
   a. Transfer target holder from center pool storage to

target work platform. Refer to Section 4.2.5 for proper attachment of short target holder handling tool to target holder.

b. Make certain that the target holder is properly oriented in the grid at the bottom of the work platform target bundle holder. It should drop approximately 3/4 in. after first touching. For proper orientation, align the tool key with any one of the six places marked on the target bundle holder.

c. Refer to Target Bundle Work Schedule for the outline of changes. This is included in the Reactor Shutdown Schedule.

d. Each target moved must always be identified.

e. Do not remove two adjacent rods at the same time.

5. Removal and replacement procedures

a. To operate the target picker tool, set the tool on the target rod in the unlocked position, lock the tool and lift the target rod.

b. Using the target picker tool, place the appropriate target selector plate on top of the bundle and orient it in the same keyway that is used for handling the bundle.

c. Using the target picker tool, pick up the selected rod, identify with the periscope, and transfer to its scheduled location. When a target rod is placed in the bundle, be sure that it is seated before unlocking the tool.

d. Repeat steps b and c until scheduled work is finished.

e. When all target moves are completed, thoroughly inspect the bundle to make certain all rods are seated properly and that no debris or foreign material in inside the bundle.

f. Transfer the target holder from its work platform to center pool storage or to PTP work platform if changes are scheduled there.

5.3.4 Replacement of peripheral target position (PTP) experiment in target holder assembly

1. References

Drawings:

(no number)	HFIR Target Loading
D-49186	Peripheral Target Position Orifice Assembly
M-10070-ØC-290-E	Outside Experiment Handling Tool Model "A"
M-10070-ØC-295-E	Outside Experiment Handling Tool Model "B"

2. Tools required

a. Short target holder handling tool

b. Outside experiment handling tool Model "A"

c. Outside experiment handling tool Model "B"

d. PTP work platform

e. Periscope and mirror

3. Data

a. Weight: PTP orifice assembly - approximately 1 lb
Model "A" tool - dry approximately 3 lb
Model "B" tool - dry approximately 5 lb

4. Work conditions
   a. Target holder located in PTP work platform attached to short target holder handling tool (see Section 4.2.5).
   b. Refer to Target Bundle Work Schedule for the outline of changes.
   c. An experiment or an orificed dummy made to the same size must always be in the six PTP positions when inserted in the reactor.
5. Removal and replacement procedures
   a. The identity of each PTP position is marked on the side of the target holder. Using the mirror and rotating the target holder with the short handling tool, locate in the open slot of the platform holder the PTP experiment or orifice to be removed.
   b. Insert the Model "A" tool below the shoulder of the bottom seat. Lift lightly and swing the lower end away from the bundle. Attach the Model "B" tool to the body of the experiment (orifice), identify and remove to storage.
   c. Install the scheduled experiment by leaning it into position with the bottom outward away from the target holder and then lifting it lightly and moving the bottom into place. To check its being in place, simply rotate the target holder. If the PTP experiment is not properly in place, the target holder will not rotate in the work platform.
   d. Transfer the target holder from the work platform to center pool storage.

5.4 Hydraulic Rabbit Facility

5.4.1 References

Drawings:

10300 R 026 R2	Central Rabbit Facility Flow Sheet
10300 R 010 R4	Central Rabbit Facility Loading Station Piping
10300 D 011 R3	Central Rabbit Facility Piping
10300 D 014 R1	Central Rabbit Facility Target Tube Assembly
10300 R 028 R2	Central Rabbit Facility Bayonet Lock Release Tool
100300 R 016 R4	Central Rabbit Facility Rabbit Loading Station

5.4.2 Introduction

The hydraulic rabbit facility is used to irradiate isotopes for varying lengths of time from minutes up to several days. It utilizes the highest thermal flux region in the reactor and is located in the central target position. The main advantages over other irradiation facilities are the ability to insert and remove samples at will without affecting reactor operation and the access to thermal fluxes of 2 to 3 x 10^{15} $n/cm^{-2}.s^{-1}$.

5.4.3 Procedure

1. Loading station operation
   a. Before opening the loading station, place HS-3 in the "block" position and make sure the following valves are closed:

CR-1	CR-5
CR-2	CR-6
CR-3	CR-7A

CR-4 Cr-7B

Valve CR-8 remains open during routine operation of the system.

b. Bleed the pressure from the loading station by opening valve CR-4. Note the pressure decrease on PI-4. When the pressure in the isolated portion of the loop is zero, close valve CR-4. Red lights on the instrument panel will indicate that valves CR-3, CR-7A, and CR-7B are closed.

c. To open the loading station, remove the locking pin assembly by turning Shaft A clockwise 15 1/2 turns and then turn Shaft B, the drive gear bolt, counterclockwise. This moves the housing away from the locking pin assembly and exposes the rabbit loading tube.

d. Place the rabbits in the loading tube located in the center of the loading station. The rabbits should be positioned according to the directions on the schedule sheet. Record the rabbit number and position it occupies on the Sample Schedule Sheet. Position No. 1 is designated as that rabbit nearest the entrance to the concentric tube. (The rabbit occupying position No. 1 will be the bottom rabbit in the core.)

e. To close the loading station, first open CR-4, then turn Shaft B, the drive gear, in the clockwise direction. This moves the containment housing over the loading tube. When the containment housing is in the closed position, insert the locking pin assembly by turning Shaft A in a

counterclockwise manner 15 1/2 turns. Check that the locking pin has secured the containment housing at attempting to turn Shaft B counterclockwise.

f. Close CR-4. The loading station is now ready to be valved into the high pressure system.

2. Rabbit insertion in core (all valves closed)

a. Open valve CR-3. A green light will indicate that the valve is fully open. An amber light and buzzer indicate that valve CR-3 in between fully closed and fully opened positions.

b. Open fully valves CR-5 and CR-6.

c. Open valve CR-1 and the rabbits are transferred to the core suspension zone. Check operating conditions by observing FI-4, PI-4, FI-5, FI-3, and FI-1. These should read about 6 gpm, 700 psig, 11 gpm, 0.7 gpm, and zero gpm, respectively.

d. Slowly close valve CR-3 to insert the rabbits into the core. A red light will indicate that the valve is fully closed. Check operating conditions by oberving FI-4, PI-4, FI-5, FI-3, and FI-1. These should read about 6 pgm, 600 psig, 0.0 gpm, 0.70 gpm, and 5.3 gpm, respectively. If valve CR-3 is closed too fast, the rabbits may attain sufficient velocity to cause damage when they strike the stop at the bottom of the rabbit tube.

e. Place Switch HS-3 in the "auto" position. This will allow automatic ejection of the rabbits when requested by the flow instrumentation.

3. Ejection of Rabbits from Core

   a. Open valves CR-7A and CR-7B by pushing the "eject" button to remove the rabbits from the core to the loading station suspension zone. A green light will indicate that the valves are open. Observe FI-4, PI-4, FI-5, FI-3, and FI-1. These should read about 6.0 gpm, 700 psig, 12.0 gpm, 0.4 gpm, and zero gpm, respectively.

   b. Place switch HS-3 in "block" position and open valve CR-2.

   c. Close valve CR-1, CR-7A, and CR-7B to transfer the rabbits into the loading station. A red light will indicate when these valves (7A and 7B) are closed. After the rabbits have moved into the loading stations, close valves CR-5, CR-6, and CR-2.

   d. Open the loading station as described in steps 5.4.3.1 to remove the rabbits.

   e. Positively identify each rabbit while removing it from the loading station.

4. Record Keeping

A record of insertion time, removal time, and position number is kept on each rabbit. The following is the procedure used for each rabbit irradiated in the hydraulic rabbit facility.

   a. The rabbit is usually delivered to the secretary who completes the Sample Schedule Sheet (see Fig. 5.5). A sample number is assigned the rabbit according to the following example:

      8-82-26. The first two numbers refer to the month and

HFIR HYDRAULIC TUBE

SAMPLE SCHEDULE SHEET

DATE | SAMPLE NO.

MATERIAL AND WEIGHT

PACKAGING

RABBIT WEIGHT

CUSTOMER

Core Position 1 2 3 4 5 6 7 8 9

	SCHEDULED		ACTUAL		
	DATE	TIME	DATE	TIME	BY
IN					
OUT					

POST IRRADIATION STORAGE POSITION	A 1 2 3 4 5 6 7 8 9
	B 1 2 3 4 5 6 7 8 9

DISPOSITION	PICKUP BY	DATE	TIME
Scheduled			
Actual			

REMARKS

APPROVED BY:

UCN-8117
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Fig. 5.5. Sample schedule sheet.

year the rabbit is irradiated. The third number refers to the number of the sample irradiated during the specified month.

b. The assigned number is vibratooled on the sample.

c. Both copies of the Sample Schedule Sheet are sent to the Control Room along with the rabbit. These are kept on a special clipboard near the console. At the end of the irradiation period, the control room copy, fully completed, is sent to the customer and the second copy is retained in the office files.

d. Before the sample may be inserted into the reactor, its irradiation must be approved by a member of the Technical Staff and by a member of HFIR supervision. Signatures must be on the Sample Schedule Sheet.

5.4.3.5 Temporary rabbit removal

In order to remove the hydraulic facility rabbits from the core and reinsert them without opening the loading station, the following abbreviated procedure may be used:

a. Push the eject button. The rabbits will be ejected from the core to the loading station.

b. Place switch HS-3 in the "block" position.

c. Open valve CR-3.

d. Push the insert button. The rabbits will return to the suspension zone above the core.

e. Slowly close valve CR-3 to insert the rabbits into the core.

f. Return switch HS-3 to the "auto" position.

5.4.3.6 Loading station O-ring replacement

Due to the high radiation levels to which the loading station O-ring gasket is subjected, it must be replaced periodically. This operation can be done underwater remotely.

a. Remove the old O-ring with a hook tool. Only the western-most O-ring will be replaced.

b. Remove the magazine stop pin, located at the eastern end of its travel, with a hook tool. Open the magazine to its maximum travel. (NOTE: This will be beyond the point where the gears are engaged.)

c. Install the O-ring insertion tool onto a staff and place a new, glycerine-lubricated O-ring on the outer ledge of the tool with the tool extended.

d. Install a 1/8-in.-diam wire in the top hole to hold the tool extended. Tie a string to the wire for remote removal.

e. Lower the tool into the water and insert it between the end of the rabbit holder and the magazine. Insert the tool into the magazine.

f. Move the magazine and tool up against the half-tube where rabbits are located. Remove the wire with the string and engage the magazine gears.

g. Move the magazine slowly westward with the gear tool and the O-ring will roll off into its groove.

h. Remove the tool from the water and close the loading station. Replace the magazine stop pin at the east end of the loading station.

5.5. HFIR-TRU Hydraulic Rabbit Transfer Tube

5.5.1 References

Drawings:

P-11313-EC-001-D Water Supply and Pump Piping Plan and Section

M-11313-EL-010-D Rabbit Loading Station Assembly

M-11313-EL-015-D Rabbit Loading Tool - Assembly

M-11313-EL-016-D Rabbit Loading Tool - Details

5.5.2 Tools required

1. Handle (ORNL Dwg. M-11313-EL-012-D)
2. Rabbit Loading tool (ORNL Dwg. M-11313-EL-015-D)
3. Loading Rod (ORNL Dwg. M-11313-EL-016-D)

5.5.3 Introduction

The HFIR to TRU hydraulic rabbit tube is used primarily to transfer irradiated HFIR hydraulic tube rabbits to the TRU facility hot cells by means of water flow. The system originates in the HFIR east clean pool in close proximity to the HFIR hydraulic tube rabbit loading-unloading station and storage rack. The transfer tube loading station is sufficiently below the pool normal water level (9 ft) to insure adequate protection from radiation. The driving force for the transfer is supplied by a centrifugal pump capable of pumping 100°F water at the rate of 10 gpm at 110 ft TDH. The motor is driven by three-phase 440-V electric power. The "ON-OFF" control for the pump motor is located on the east wall of the reactor bay directly east of the loading station. The pump and loading station can be valved out from the transfer tube if need be.

5.5.4 Precautions

The water depth above the loading station should be sufficient to protect the individual from excessive radiation. However, a radiation detection instrument should be at the scene and energized at any time a transfer is to made as protection against the unforeseen and unusual condition.

The settings of the pump and transfer tube valves should be checked before a transfer is attempted.

If at any time a transfer is to be attempted with the pool water level below its normal depth, radiation detection surveillance must be in effect.

5.5.5 Transfer procedure

1. Prepare the rabbit "boat" for loading into the Rabbit Loading Tool Release Tube.

   "Boat" is an aluminum object of two pieces. It is 6 in. in overall length and 7/8 in. in diameter. It has one rounded closed end and one open end. The open end is the shorter of the two pieces and is threaded (hand tight) to the longer piece. Fitted into the shorter piece is an approximately 3/4-in.-diam neoprene washer with a center opening of approximately 0.4 in. This washer serves to retain the rabbit after it has been forced through the washer into the lower section of the boat.

2. Load the release tube of the rabbit loading tube.

   a. Pull the wire rope of the loading tool until the release tube is at its maximum angle (approximately 30°) in relation to the loading tool funnel.

b. Insert the boat with its open end up into the bottom of the release tube.

c. Release the wire rope thus permitting the release tube to resume its normal position (spring loaded).

3. With the "handle" tool, engage the hinge of the loading station closure bolt. Raise the hinge vertically. The bolt should jackknife at the hinge to open the station. With the "handle tool" removed, the bolt should remain in the open position.

4. Set the prepared rabbit loading tool in the rabbit loading station positioned with the loading tool cable on the east side.

5. Transfer the HFIR hydraulic tube rabbit to the funnel of the loading tool. Radiation detection instrument should be energized and in location to advise of conditions.

6. With HFIR hydraulic tube rabbit vertically positioned in the loading guide (neck of the funnel) use the loading rod to force the rabbit through the neoprene washer into the lower section of the boat.
(The loading rod is approximately 7/16-in.-diam at the point of contact with the rabbit. The rabbit should be as near vertical as possible. The end of the loading rod should be as concentric as possible with the rabbit end. Considerable pressure is required to force the rabbit through the washer. Be sure the rabbit is completely through the top piece of the boat.)

7. Pull the wire rope of the loading tool and incline the release tube and loaded boat to the 30° angular position.

The loaded boat should fall from the release tube into the loading station.

8. When it is evident that the boat is in the loading station, remove the loading tool.
9. With the "handle" tool, push down on the hinge of the bolt forcing the bolt to its closed horizontal position and pushing the loaded boat into position for transfer by hydraulic force.
10. Set the valving of the transfer pump and transfer tube to permit transfer of the boat.
11. Notify TRU personnel and turn the pump "on" at the control station on the east wall of the reactor bay.
12. Await information from TRU personnel that the transfer has been successful before shutting off the pump.
13. Store tools properly.
14. Reset pump and transfer tube valves as necessary.

6. COOLING SYSTEMS

6.1. Reactor Primary Coolant System

6.1.1 References

Drawings:

1546-01-M-5502 Secondary Coolant Water - Engineering Flow Diagram

1546-01-M-5506 Piping Arrangement - Primary Pumps and Heat Exchangers

1546-01-M-5507 Plan and Section - Pump and Heat Exchanger Cell

1546-01-M-5509 Section through Primary Loop Tunnel

1546-01-M-5534 Primary Coolant Low Pressure System - Engineering Flow Diagram

1546-01-M-5541 Primary Coolant High Pressure System - Engineering Flow Diagram

1546-01-I-4001 Primary Coolant Instrumentation

1546-01-I-4002 Primary Coolant Instrumentation

Section 6 of HFIR Description Manual

Singmaster & Breyer Specifications: Section 60 High Pressure System

Section 64 Low Pressure System

Section 66 Secondary Coolant System

6.1.2 Introduction

The main components in the reactor primary high-pressure coolant system are the reactor vessel, high-pressure piping, primary

heat exchangers, pressurizer pumps, and main coolant pumps, Fig. 6.1. Demineralized water circulates under pressure through the reactor core and transfers the heat output of the fuel element, through the primary heat exchangers, to the secondary coolant loop. The primary coolant loop must be in "normal" operation before the reactor is brought to power. "Normal" operation of this loop is defined by the following parameters:

Coolant flow - approximately 17,000 gpm

Coolant temperature (core inlet) - 120°F or less

Coolant pressure (core inlet) - 750 psi

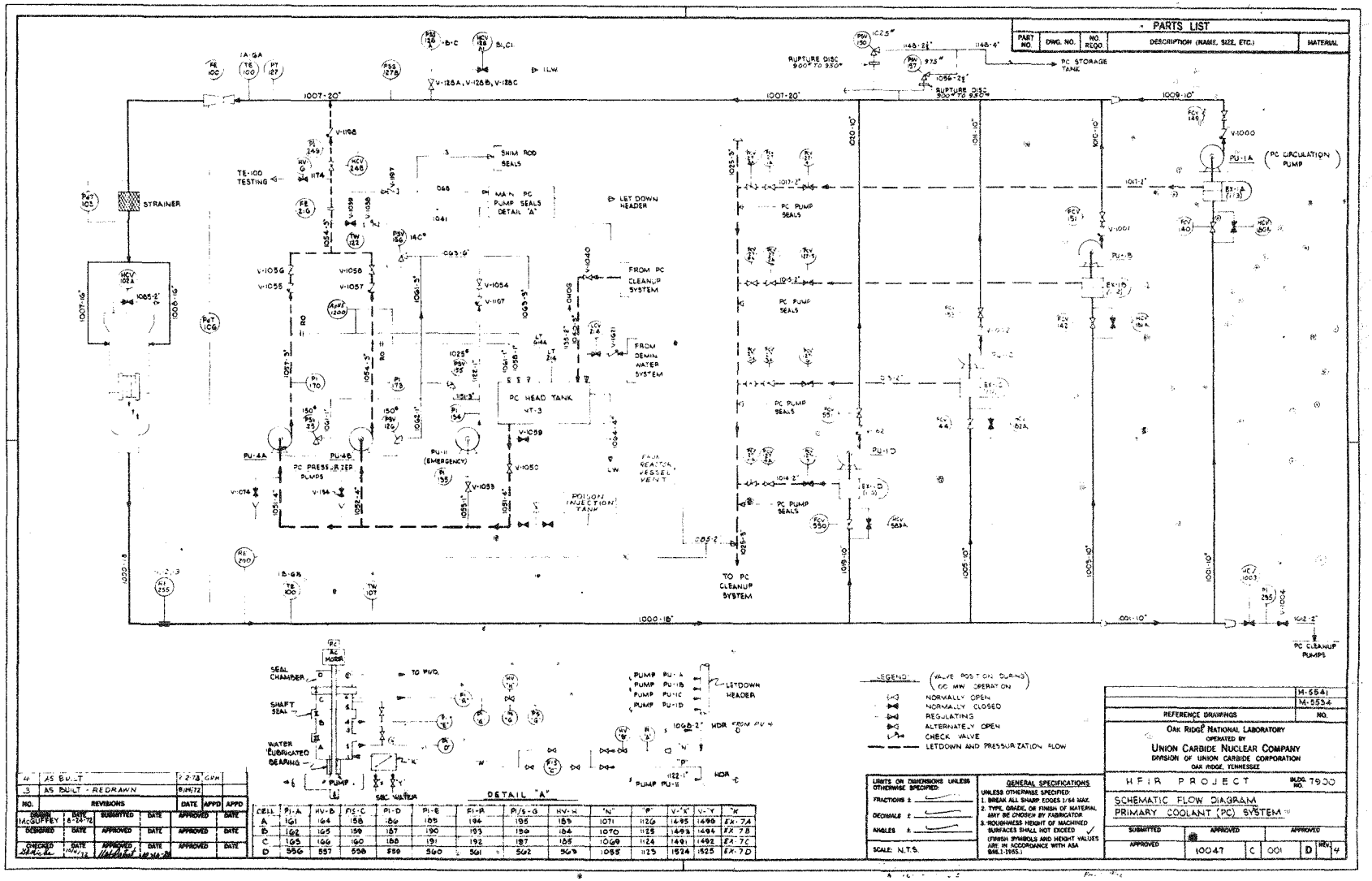
Secondary coolant flow - a maximum 6,000 gpm per heat exchanger

6.1.3 Precautions

Except for the pressurizer pumps and related lines, all process components of the primary high pressure system are heavily shielded. During reactor operation the shielded components are extremely radioactive and must be approached with care. The heat-exchanger cells must be carefully monitored before entry. They can be entered only when the heat exchanger and pump are out of service or when the reactor is shutdown.

High pressure water must be handled with care. When sampling or venting high pressure equipment, never stand in front of an outlet. If sampling flasks are used, hold them securely. Always open valves very slowly. It should always be assumed that the high-pressure water is contaminated unless proven otherwise. Proper radiation precautions must be taken.

Water in the primary system must be >70°F before pressurization.



CELL	PI-A	HV-B	PS-C	PI-D	PI-E	FI-R	PI/S-G	HV-H	"N"	"P"	V-"R"	V-"Y"	"K"
A	161	164	158	186	185	194	195	189	1071	1126	1495	1498	EX-7A
B	162	165	159	187	190	193	190	184	1070	1125	1493	1496	EX-7B
C	160	166	160	188	191	192	187	186	1069	1124	1491	1492	EX-7C
D	556	557	558	559	560	561	562	563	1085	1125	1524	1525	EX-7D

Fig. 6.1. Primary coolant system.

6.1.4 Place system in "normal" operation

The primary high pressure coolant system is readied for reactor operation in three major steps:

pressurize the system,

establish primary coolant flow, and

establish secondary coolant flow to the primary heat exchangers.

NOTE: Before these procedures can be started, the primary system must be filled with water (Section 6.6) and sealed (Section 4). The primary cleanup system must be ready for operation (Section 6.2), and the secondary coolant system should be circulating water (Section 6.5).

Pressurize the Primary System

1. Valve in the pressurizer pumps (see Fig. 6.2)
   a. Make sure V-1040, in line 1040 from the cleanup system to the head tank, is open.
   b. Open V-1679 and V-1680 on each side of flow meter FIT-215 in demineralized water supply line 1612 to the head tank.
   c. Open the suction valves in lines 1051, 1052, and 1053 from the head tank to the three pressurizer pumps, V-1050, V-1051, V-1052, and V-1053.
   d. Open pressurizer pump discharge valves V-1054, V-1056, and V-1058.
   e. Open V-2248 ad V-2249 to the pump couplings in potable water cooling lines 2256 and 2257.
   f. Open V-1197, in line 1063, which supplies high pressure water to rod drive seals and circulating pump seals.

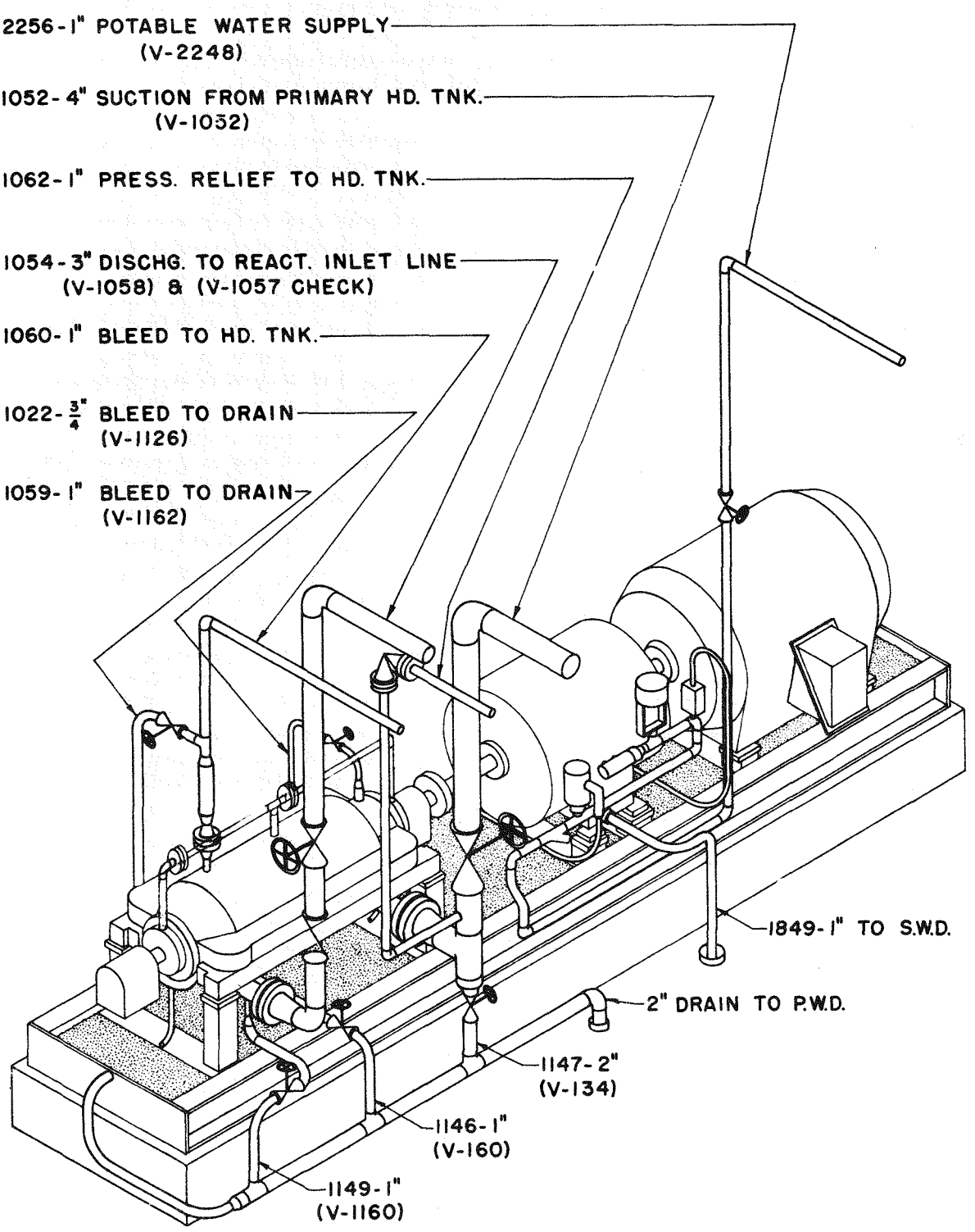


Fig. 6.2. Primary pressurizer pump 01-415-PU-4B.

2. Open block valves FCV-550, -144, -142, -140, -551, -153, -151, and -149 on the inlet and outlet to the heat exchanger cells.
3. Pressurize the system. (Make sure water temperature is >70°F.)
   a. Set the system pressure recorder controller, PRC-127, located in the control room, at its minimum value and place the controller in "auto" mode. Place the letdown block valve override switch in the "unblock" position.
   b. Start the pressurizer pump
      (1) Make sure the variable speed coupling potentiometers are set at their minimum speed setting.
      (2) Start one of the pressurizer pumps, either PU-4A or PU-4B, with the manual start switch located in the control room. Start the second pump.
      (3) Raise the PRC-127 setpoint to the desired system operating pressure (normally 750 psi).
   c. Manually increase one of the pump's speed with the potentiometer until the system pressure (readout on PRC-127) reaches the desired operating pressure.
   d. Place the letdown block valve override switch in the "normal" position.
4. Establish letdown flow
   a. Slowly increase the speed of the operating pressurizer

pump until a flow of 150 gpm* is observed on FR-216. NOTE: The system pressure should remain at this set-point of PRC-127.

b. Adjust the speed of the second pressurizer pump until it begins to assume part of the load and there is a slight increase in cleanup flow. Stop this pump and place it in standby.

c. Place the selector switch SS-2 in position to start the operating pressurizer pump in the "automatic sequence" startup mode.

5. Place auxiliary pressurizer pump in standby condition

a. Place the auxiliary pressurizer pump "run-auto-off" switch (located at the auxiliary pressurizer pump) in the "auto" position. This should clear the "PU-11-pump off" alarm in the control room.

Establish Primary Coolant Flow

1. Establish cooling water supply to the primary circulating pump seals.

a. Open the manual block valves in the seal water supply lines:

(1) HV-166 in line 1069.

(2) HV-165 in line 1070.

(3) HV-164 in line 1071.

(4) HV-557 in line 1055.

---

*This is a nominal valve which in practice depends upon the pressure drop throughout the cleanup system.

b. Open the block valves on each side of the seal inlet-water rotometers:
   (1) V-1062 and V-1063 for FI-158 (located at PU-1C).
   (2) V-1064 and V-1065 for FI-159 (located at PU-1B).
   (3) V-1066 and V-1067 for FI-160 (located at PU-1A).
   (4) V-196 and V-197 for FI-558 (located at PU-1D).

c. Open the block valves in the secondary cooling water lines to and from each seal-water cooler and motor bearing:
   (1) V-1522, V-1523, V-1524, and V-1525 for Ex-7D and PU-1D in cell 110.
   (2) V-1491, V-1492, V-1516, and V-1519 for Ex-7C and PU-1C in cell 111.
   (3) V-1493, V-1494, V-1517, and V-1520 for Ex-7B and PU-1B in cell 112.
   (4) V-1495, V-1496, V-1518, and V-1521 for Ex-7A and PU-1A in cell 113.

2. Adjust the pressure drop and flow across the seals:

a. Open the pressure gauge valve and observe the pressure on the inlet seal-water line. Pressure gauges should indicate system pressure in the "A" seal chamber.
   (1) V-206 and PI-559 on "D" pump.
   (2) V-142 and PI-188 on "C" pump.
   (3) V-144 and PI-187 on "B" pump.
   (4) V-146 and PI-186 on "A" pump.

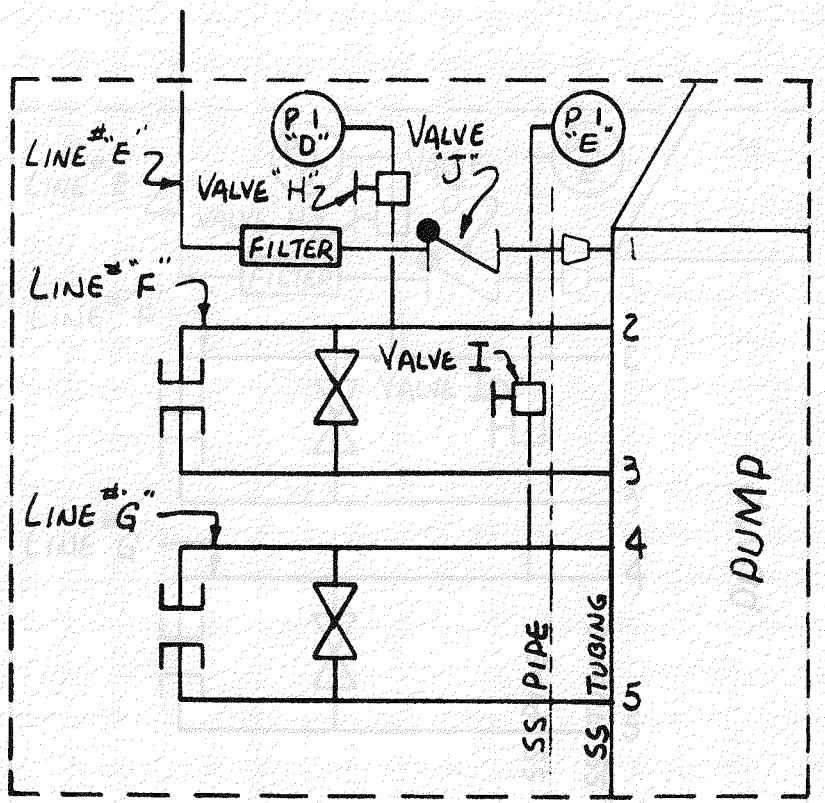
b. Open the pressure gauge valves from the "B" seal chamber.
   (1) V-207 on "D" pump.
   (2) V-143 on "C" pump.
   (3) V-145 on "B" pump.
   (4) V-147 on "A" pump.

c. Open the block valves on each side of the seal-water exit-flow controller:
   (1) V-200 and V-199 on FIS-561.
   (2) V-1070 and V-135 on FIS-192.
   (3) V-1069 and V-137 on FIS-193.
   (4) V-1068 and V-139 on FIS-194.

d. Open the exit water pressure gauge valves:
   (1) V-202 on PI-562 from "D" unit.
   (2) V-1008 on PI-197 from "C" unit.
   (3) V-1010 on PI-196 from "B" unit.
   (4) V-1027 on PI1-95 from "A" unit.

e. Open the block valves in the exit seal-water lines (see Fig. 6.3):
   (1) HV-563 in line 1018 from "D" pump.
   (2) HV-185 in line 1074 from "C" pump.
   (3) HV-184 in line 1073 from "B" pump.
   (4) HV-183 in line 1072 from "A" pump.

f. Observe the pressure which is indicated in the "A" seal chamber, the chamber which is closest to the pump impeller.
   (1) Gauge PI-559 on the "D" pump.
   (2) Gauge PI-188 on the "C" pump.
   (3) Gauge PI-187 on the "B" pump.
   (4) Gauge PI-186 on the "A" pump.



	P I "D"	P I "E"	LINE No. "E"	LINE No. "F"	LINE No. "G"	VALVE "H"	VALVE "I"	VALVE "J"
01-415-PU-1A	186	189	01-1071-1"-60	01-1162-½"-60	01-1163-½"-60	V-146	V-147	V-191
01-415-PU-1B	187	190	01-1070-1"-60	01-1160-½"-60	01-1161-½"-60	V-144	V-145	V-192
01-415-PU-1C	188	191	01-1069-1"-60	01-1158-½"-60	01-1159-½"-60	V-142	V-143	V-193
01-415-PU-1D	559	560	01-1055-1"-60	01-1120-½"-60	01-1121-½"-60	V-206	V-207	V-205

Fig. 6.3. Primary coolant pump seal-water flow diagram.

g. Adjust the manual throttling valves between chambers "A" and "B" and between chambers "B" and "C" so that the pressure in chamber "B" of 50% of the pressure in chamber "A" and the pressure in "C" is 25 psig (as indicated on the discharge pressure gauge) while maintaining a 1/6-gpm flow through the seal-discharge-water rotometer.

(1) Observe pressure gauges PI-559, PI-560, and PI-562 and set the flow on FIS-561 while adjusting the manual throttling valves on the "D" pump.

(2) Observe pressure gauges PI-188, PI-191, and PI-197 and set the flow on FIS-192 while adjusting the manual throttling valves on the "C" pump.

(3) Observe pressure gauges PI-187, PI-190 and PI-196 and set the flow on FIS-193 while adjusting the manual throttling valves on the "B" pump.

(4) Observe pressure gauges PI-186, PI-189, and PI-195 and set the flow on FIS-194 while adjusting the manual throttling valves on the "A" pump.

WARNING: The main pump must never be started until seal water flow is established.

3. Open the valves in primary coolant loop

a. Carefully check each heat exchanger for leaks.

b. Vent air from the tube bundle of each heat exchanger by cracking the tube-side drain valves until water appears in the collection funnel; then close them tightly.

(1) V-204 from the "D" unit.

(2) V-1073 from the "C" unit.

(3) V-1072 from the "B" unit.

(4) V-1071 from the "A" unit.

c. Vent air from the exit plenum of each heat exchanger by cracking the vent valves until water appears in the collection funnel; then close them tightly.

(1) V-189 from the "D" unit.

(2) V-1196 from the "C" unit.

(3) V-1195 from the "B" unit.

(4) V-1194 from the "A" unit.

d. Vent air from each circulating pump by cracking the vent valves until water appears in the collection funnel; then close them tightly.

V-203, V-1011, V-1135, and V-1137 from pumps "D," "C," "B," and "A" respectively.

e. Check that the heat-exchanger-inlet-block valves, (manual controllers in the control room) are open.

FCV-550, FCV-144, FCV-142, and FCV-140 to the "D," "C," "B," and "A" units respectively.

f. Open the valves to the heat-exchanger-exit-pressure gauges

(1) V-190 to PI-554 on the "D" unit.

(2) V-1129 to PI-118 on the "C" unit.

(3) V-1130 to PI-114 on the "B" unit.

(4) V-1131 to PI-110 on the "A" unit.

g. Open the pump-outlet-block valves with the manual controllers in the control room

(1) FCV-551 from the "D" unit.

(2) FCV-153 from the "C" unit.

(3) FCV-151 from the "B" unit.

(4) FCV-149 from the "A" unit.

h. Open the valves to the pump-discharge pressure gauges.

(1) V-191 to PI-555 on the "D" unit.

(2) V-1136 to PI-120 on the "C" unit.

(3) V-1134 to PI-116 on the "B" unit.

(4) V-1132 to PI-112 on the "A" unit.

4. Start the primary circulating pumps

a. Place selector switch SS-3 (located in control room) in position to select the desired pump as the spare unit.

b. Make up the battery pony motor disconnect on each pump before its main drive motor is started.

c. Start each pump to be operated with its manual-start switch in the control room. Unless previously adjusted, an operator should be stationed at the pump seal-water control valves when a pump is started, and he should then adjust seal-cooling water flow as follows:

(1) Adjust the inlet seal-water flow to 6 gpm by throttling the inlet rotometer valves.

(a) V-196 to FI-588 on the "D" pump.

(b) V-1062 to FI-160 on the "C" pump.

(c) V-1064 to FI-159 on the "B" pump.

(d) V-1066 to FI-158 on the "A" pump.

(2) If required, re-adjust the seal-water flow per steps 6.1.4.

(3) Vent the air from the reactor tank. Open tank vent valve HCV-102A by placing the control switch in "normal."

Establish Secondary Coolant Flow

1. Make sure the shell drain valves, at the bottom of each heat exchanger, are closed.
   a. V-1530, V-1531, and V-1532 on the "D" unit.
   b. V-1454, V-1486, and V-1487 on the "C" unit.
   c. V-1453, V-1484, and V-1485 on the "B" unit.
   d. V-1452, V-1482, and V-1483 on the "A" unit.
2. Open the heat-exchanger cooling-water-inlet block valves with the manual controllers in the control room.
   a. FCV-552 to the "D" exchanger.
   b. FCV-348 to the "C" exchanger.
   c. FCV-346 to the "B" exchanger.
   d. FCV-344 to the "A" exchanger.
3. Vent the air from each heat-exchanger shell by cracking the vent valve until water appears and then closing it tightly.
   a. V-1528 on the "D" exchanger.
   b. V-1457 on the "C" exchanger.
   c. V-1456 on the "B" exchanger.
   d. V-1455 on the "A" exchanger.
4. Open the manual block valves to the cooling water inlet and exit pressure gauges of each heat exchanger.
   a. V-1526 and V-1527 on the "D" unit.
   b. V-1416 and V-1419 on the "C" unit.
   c. V-1415 and V-1418 on the "B" unit.

d. V-1414 and V-1417 on the "A" unit.

5. Open the heat-exchanger cooling-water-exit block valves with the manual controllers in the control room.
   a. FCV-553 from the "D" unit.
   b. FCV-349 from the "C" unit.
   c. FCV-347 from the "B" unit.
   d. FCV-345 from the "A" unit.
6. Open the cooling-water supply and return valves for the three cell coolers in each heat-exchanger cell and start the cooler fans.

6.1.5 Shutdown of primary coolant system

The primary system must be placed in "shutdown" status before the reactor vessel can be opened. "Shutdown" status differs from operating conditions in only two respects: (1) the system is not pressurized; and (2) the circulating flow rate is reduced. The cleanup system remains in operation, and water is not drained from the primary system during shutdowns.

It is essential that the main circulating pump ac motors be stopped before the system is depressurized. Therefore, the following sequence of operations must be followed when it is desired to place the primary coolant system in "shutdown" status:

1. After shutdown, circulate cooling water for at least four hours to remove afterheat and clean up the system.
2. Turn off all main circulating pump ac motors with manual switches in the control room.

   CAUTION: At least two pony motors must be left in service as long as an irradiated fuel element is in the reactor.

3. Bypass PSS-127B by putting the "unblock-normal-block" switch in the "unblock" position. (This allows letdown block valves PCV-127-1A, PCV-127-2A, PCV-127-3A, PCV-127-4A, PCV-127-8A, PCV-127-9A, PCV-127-10A, and PCV-127-11A to remain open when the system pressure is reduced below 675 psi. The circulating pump discharge valves must remain open.)
4. The primary coolant system controls are set so that "shutdown" status can be attained by establishing the three following conditions:
   a. Primary system pressure at the top of the vessel must be equal to the pressure in the pool outside the vessel.
   b. A minimum pressure of 225 psi must be maintained in seal chamber "A" of the operating primary circulating pumps.
   c. Primary cleanup system flow should be maintained at a level sufficient to prevent intermixing of pool and primary water when the quick-opening hatch is removed.
5. To depressurize the primary system:
   a. Place the standby pressurizer pump control switch in the "off" position to prevent its starting.
   b. Leave the auxiliary pressurizer pump, PU-11, control switch in the "remote control" position so that the pump will start automatically. Allow it to continue running.
   c. Place HS-127 switch in the "unblock" position to prevent letdown block valve closure.

d. Stop the operating pressurizer pump by placing its control switch in the "stop" position.

e. Lower PRC-127 setpoint to zero and when system pressure drops to approximately zero, place it in manual control.

f. Position the letdown valves as needed to minimize intermixing of pool and primary water during the refueling operation.

CAUTION: At least two pony motor pumps must be kept in operation as long as an irradiated fuel element is in the reactor. This requires that the auxiliary pressurizer pump be kept in operation to provide pump seal lubricant and bearing coolant flow.

6. After the system pressure has dropped to <10 psi, as verified on the calibrated pressure gauge located on the transmitter rack in the beam room, open the primary-pool equalizing valves which are located in the reactor pool.

6.1.6 pH control system

Introduction

ApHC-1200 is the automatic control system which maintains the primary coolant at a pH of 5.0 $\pm$ 0.1. The pH of the pressurizer pump discharge flow is controlled by the automatic addition of 5% nitric acid to the primary head tank. The 5% acid is mixed in the acid day tank and pumped into the head tank by a small acid feed pump (see Fig. 6.4). The pH of the pressurizer pump effluent water is measured by ApHE-1200 which then controls the speed of the acid feed pump to maintain the desired pH of water injected into the primary system.

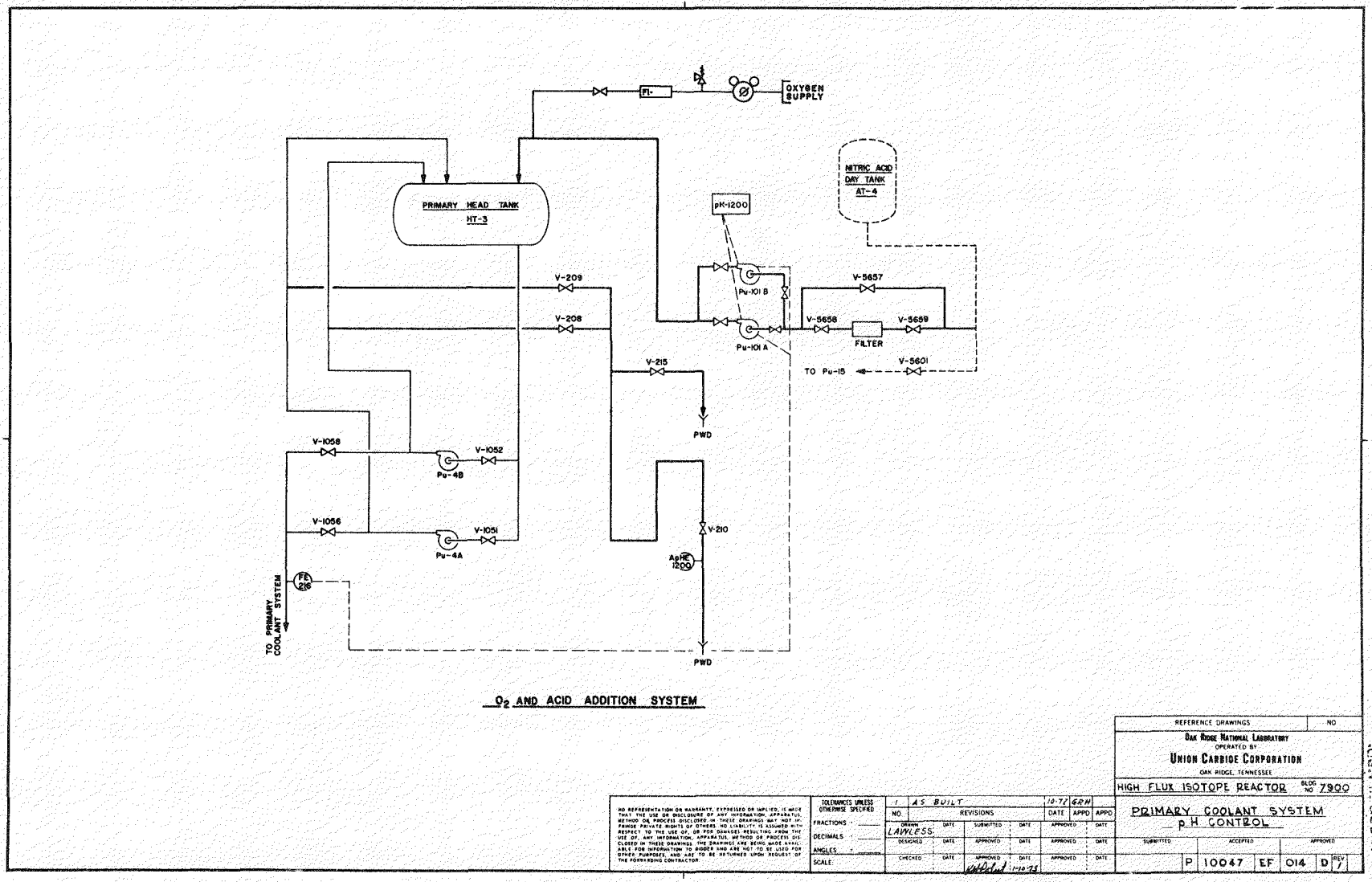


Fig. 6.4. Primary coolant system pH control.

Place the System into Service. NOTE: This procedure assumes that primary system cleanup flow has been established.

1. Establish flow (to pH probe ApHE-1200) of approximately 1 gph as indicated on FI-1200 by opening the following valves:
   a. V-208,
   b. V-209, and
   c. V-210.
2. Place the acid pump into service by opening the following valves:
   a. V-5659,
   b. V-5658, and
   c. V-5656.
3. Close V-5657 which bypasses the filter upstream of the acid pump.
4. Refer to Section 3.2.4 of this manual for operation of pH controller ApHRC-1200.

Remove the System from Service

1. Trip the chemical feed pump breaker located on ApHC-1200 panel.
2. Valve the pump out by closing V-5656 and V-5658.
3. Close V-215, V-210, V-208, and V-209 on the pH probe supply lines.

6.1.7 Switching primary pump-heat exchangers during operation

Introduction

Occasionally it is necessary to change pump-heat exchanger cells while the reactor is at power. This operation can be readily

performed, but it is essential to closely control the primary temperatures and secondary coolant flow to prevent a reactor shutdown. Normally three steps are involved: (1) establish secondary flow through all four heat exchangers; (2) start circulation through the primary pump to be placed in service and stop circulation through the primary pump being removed from service; and (3) stop secondary flow through the heat exchanger being removed from service.

The following detailed procedures assume the reactor system is in normal full power operation with a secondary water valve closed on the spare heat exchanger and the discharge valve closed on the spare circulating pump.

Establish secondary coolant flow through spare heat exchanger

1. Note the secondary coolant ΔP across the three operating heat exchangers as indicated on PDI-302.
2. Increase the total secondary coolant flow to the heat exchangers approximately 1,000 gpm by opening FCV-377.
3. When the ΔP as indicated on PDI-302 starts to increase, start to open the secondary coolant block valve on the spare heat exchanger. Try to maintain the original ΔP on PDI-302.
4. Repeat steps 2 and 3 above until the secondary coolant block valves on the spare heat exchanger are wide open. (Total secondary coolant flow to the heat exchangers will increase approximately 33 1/3% when the fourth exchanger is placed on line.)
5. Adjust FCV-377 as required to bring FCV-377A into the mid-position of its control range.

Switch primary coolant pumps

1. Check seal water conditions at the spare pump before it is started.
2. Start spare primary coolant pump. NOTE: The discharge block valve must be closed and the supply valve open when the pump is started.
3. Open discharge valve a small amount on spare primary coolant pump. Hold valve actuating switch in "open" position for approximately 2 s and then return it to the "intermediate" position.
4. Continue to open the discharge valve in small increments. Between valve movements wait until the flux reset modules stop "buzzing."
5. As the discharge valve of the spare pump is being opened, note the primary coolant strainer ΔP signal as recorded on PDR-103. When this ΔP signal increases (an indication that the primary coolant flow is increasing), partially close the discharge valve of the primary coolant pump being removed from service to reduce the PDR-103 signal to its original value.
6. Repeat steps 4 and 5 above until the discharge valve of the pump being placed in service is completely open and the discharge valve of the pump being removed from service is completely closed.
7. Stop the motor on the primary coolant pump removed from service.
8. Turn off power to the pony motor on the pump removed from

service and turn on power to the pony motor on the pump placed in service.

Stop secondary coolant flow through spare heat exchanger

1. Note the secondary coolant ΔP across the heat exchangers as indicated on PDI-302.
2. Slowly close one of the secondary coolant block valves on the heat exchanger being removed from service.
3. When the ΔP as indicated on PDI-302 starts to increase, partially close the main secondary flow control valve FCV-377. Try to maintain the original ΔP on PDI-302.
4. Repeat steps 2 and 3 above until the secondary coolant valve on the spare heat exchanger is completely closed.
5. Adjust FCV-377 as required to bring FCV-377A into the mid-position of its control range.

6.2. Reactor Cleanup System

6.2.1 References

Drawings:

1546-01-M-5502 Secondary Coolant Water - Engineering Flow Diagram

1546-01-M-5509 Section through Primary Loop Tunnel

1546-01-M-5512 Piping Arrangement Plan Process Equipment Ground Floor

1546-01-M-5513 Piping Arrangement Plan Process Equipment First Floor

1546-01-M-5514 Piping Arrangement Plan and Sections of Demineralizer Ground Floor

1546-01-M-5517 Piping Arrangement Plan and Sections of Demineralizer and Deaerator First Floor

1546-01-M-5534 Primary Coolant Low Pressure System - Engineering Flow Diagram

1546-01-I-4003 Primary Coolant Cleanup Instrumentation

Section 6 of HFIR Description Manual

Singmaster & Breyer Specifications: Section 64, Low Pressure System

6.2.2 Introduction

A sidestream of approximately 150 gpm is continuously bled from the high pressure loop, cleaned up, and returned to the loop by the pressurizer pumps. This sidestream flows first into a deaerator which removes dissolved gases from the water. The water then flows through a prefilter and into demineralizers which remove dissolved contaminants. The now purified water is filtered again and collected in a head tank where makeup water is added, if required, before the pressurizer pumps inject it back into the high pressure system (see Figs. 6.5 and 6.6).

6.2.3 Precautions

It is possible for extremely high radiation levels to exist inside the deaerator and filter cells. These areas should always be carefully monitored before entering. If they are entered while the reactor is operating, continuous radiation checks should be made since the background can increase quickly and without warning to a very high level in the event of a fuel meltdown.

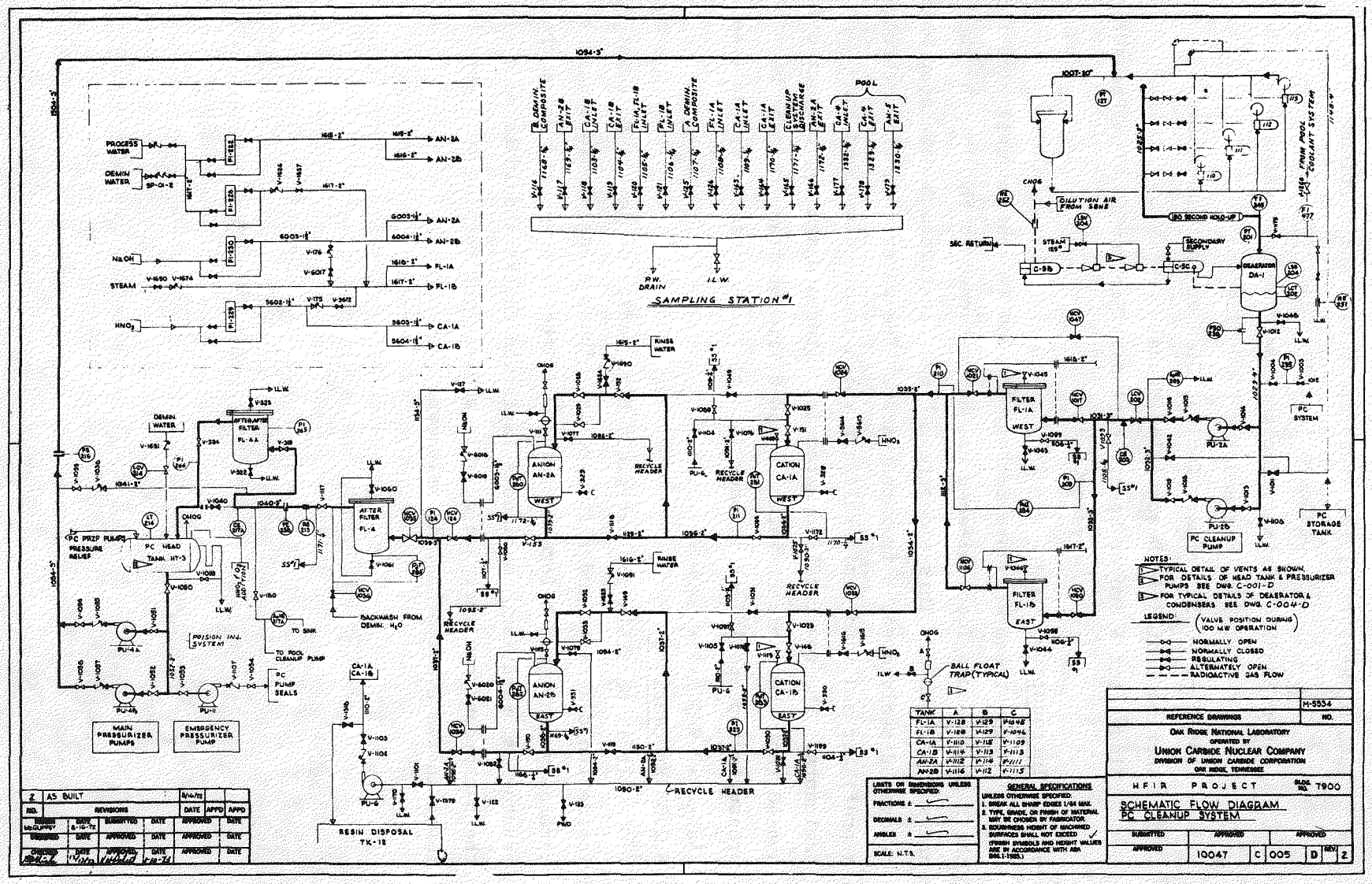


Fig. 6.5. Primary coolant cleanup system.

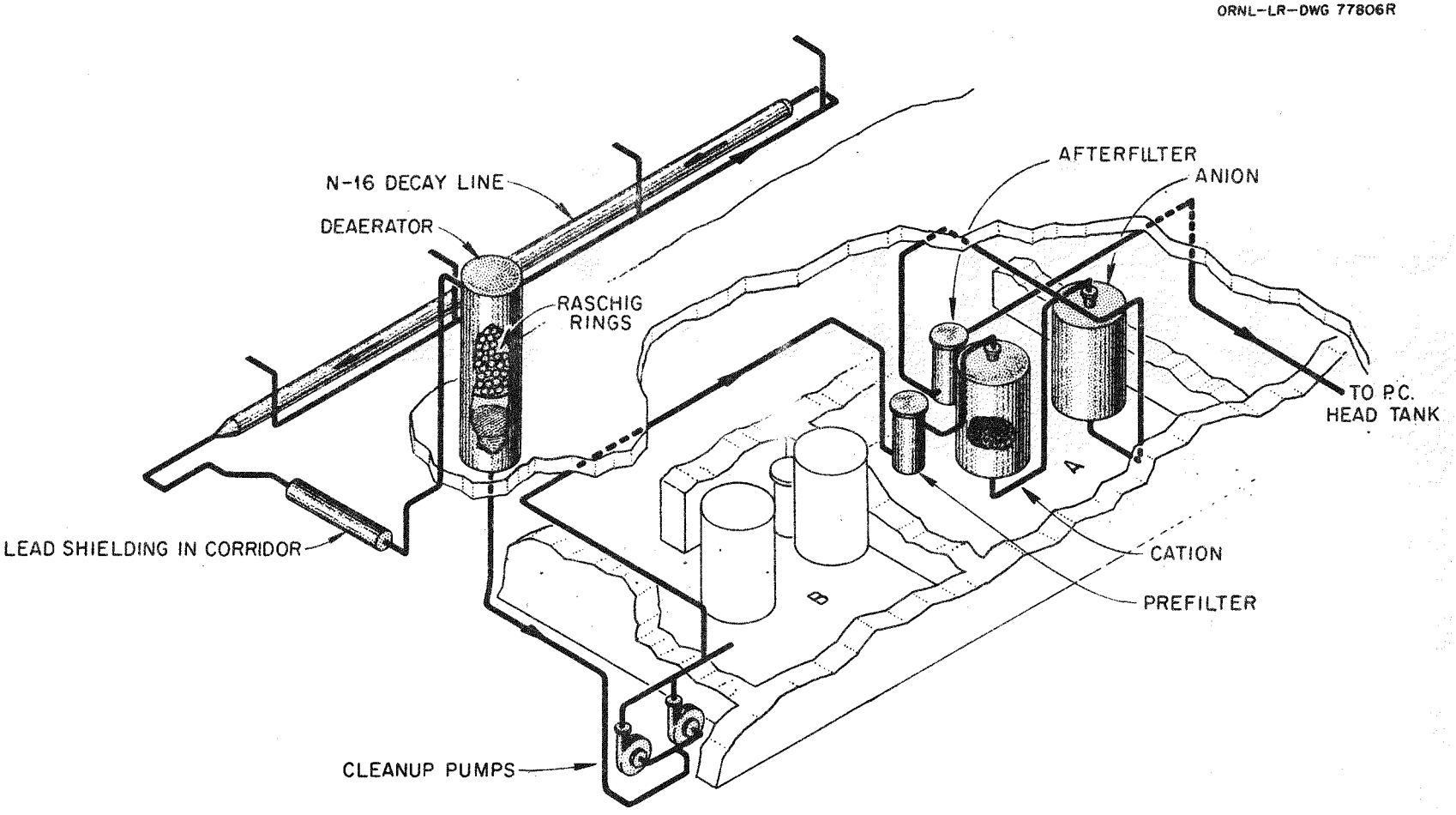


Fig. 6.6. Primary coolant cleanup system.

Acid and caustic regeneration solutions must be handled with care. Goggles or face shields must be worn when there is any danger of a chemical splash (such as when breaking into a line to change line blinds.) The 5% solutions will not burn the skin immediately, but they will cause irritation if not promptly washed off. The solutions are extremely irritating to the eyes and all normal precautions must be taken to prevent splashes into the eyes.

Regenerative effluent solutions can contain large amounts of radioactivity. Valving arrangements must be carefully checked to make sure these solutions go to the ILW system. If sampling is necessary, the radiation level must be carefully monitored. Proper care must be exercised to prevent spilling radioactive materials. Before regenerating any demineralizer unit, both inlet and exit line blinds must be positioned to prevent any acid or caustic from entering the process system. These solutions are extremely corrosive to some components in the system and all precautions must be taken to prevent their entry.

6.2.4 Place system in "normal" operation

Equipment in the primary cleanup system should be placed in operation in the following sequence:

1. Place the deaerator in operating condition (assuming the cleanup system is empty with all valves closed and the primary system is filled but not pressurized):
   a. Turn on the cooling water to the vacuum-system condensers.
      (1) Open cooling water supply valve V-1476 to the precondenser.
      (2) Open cooling water supply valve V-1507 to the aftercondenser.

b. Establish cooling water exit flow from the condensers.
   (1) Open V-1438 from the aftercondenser.
   (2) Partially open V-1439 from the precondenser.

c. Open the vent to the CHOG system from the after-condenser, V-133.

d. Open the steam supply valves to the jet ejectors.
   (1) V-3104 to the low vacuum ejector.
   (2) V-3103 to the high vacuum ejector.

NOTE: The system pressure will not begin to fall until enough steam has condensed to fill the barometric legs of the condensers. Wait until maximum vacuum is established before proceeding.

a. Fill the deaerator to normal operating level. (The primary system can be open to the pool rather than pressurized while performing this operation; that is, the vessel hatch or the primary pool equalizing valve can be open.)
   (1) Place PRC-127 in "manual" mode of operation and close the automatic letdown valves PCV-127-4, -5, -6, and -7.
   (2) Place the HS-127 switch in the "unblock" position to open block valves PCV-127-1A, -2A, -3A, -4A, and PCV-127-8A, -9A, -10A, and -11A.
   (3) Fill the deaerator by slowly opening the automatic letdown valves with PRC-127 until a level of approximately 75% of full scale is indicated on level indicator LI-202.

2. Start the primary cleanup pump: (This procedure will apply to the "A" pump. Valve numbers for the "B" pump are indicated in parenthesis. Either or both pumps can be run.)
   a. Open V-1012 in the outlet line from the deaerator.
   b. Open pump suction valve, V-1014 (V-1013).
   c. Start the pump with the "start" switch in the control room.
   d. Observe the pump-discharge pressure gauge, PI-207 (PI-208). It should indicate approximately 140 psig. If it does not, bleed air from the pump vent until normal pressure is achieved, then close the vent tightly.

   NOTE: The pump must be started before being bled. The pump suction is at a negative pressure due to the deaerator vacuum, so opening the vent before starting the pump will admit air into the system. A low level in the deaerator vessel will automatically stop the cleanup pump. It will start automatically (if the switch is in the "start" mode) when the level rises, but an above normal water level should be maintained by opening the letdown valves as required during subsequent operations.

   e. Open pump discharge valve, V-1016 (V-1019).
3. Primary cleanup filters: (This procedure will apply to the west of "A" filter. Valve numbers for the "B" filter are indicated in parenthesis. Either or both filters can be used.)
   a. Open filter-inlet valve HCV-1017 (HCV-1020) with the

pneumatic switch located on the outside north wall of the demineralizer cells.

b. Bleed air from the filter.

(1) Open vent valves HCV-1090 (HCV-1091), V-1045 (V-1046), and V-128 to the OHOG system.

c. When gas stops venting, open the filter-exit valve HCV-1021 (HCV-1106).

4. Place the demineralizers in service:

a. Open the cation-inlet valves, HCV-1024, V-1025, and V-156 to "A" unit (HCV-1022, V-1023, and V-148 to "B" unit).

b. Open the cation vent valves to the OHOG system, V-1109 and V-1110 on "A" unit (V-1113 and V-1114 on "B" unit).

c. When gas has stopped venting from the cation beds, open the cation exit and anion inlet valves, V-1026, V-152, and V-1028 on "A" unit (V-1030, V-149, and V-1032 on "B" unit).

d. Open the anion vent valves to the OHOG system, V-1111 and V-1112 on "A" unit (V-1115 and V-1116 on "B" unit).

e. When gas has stopped venting from the anion beds, open the anion-exit valves, V-153 and HCV-124 on the "A" unit (V-150 and HCV-1034 on the "B" unit).

5. Put the after-filters in service:

a. Open FL-4 inlet valve, HCV-1035.

b. Open vent valve V-1060 for one minute, then close it.

c. Open FL-4 exit valve, V-1117.

d. Open FL-4A inlet valve, V-319.

e. Open vent valve V-323 for one minute, then close it.

f. Open FL-4A exit valve, V324.

6. Final checks and adjustment of the system: (After normal flow, approximately 150 gpm, has been established in the cleanup system, the following checks and adjustments should be made.)

   a. Check the deaerator level. It should be between 15 and 60% full.

   b. Adjust the secondary coolant flow to the deaerator condensers by throttling V-1439 until a temperature rise of 13°F is obtained across the after-condenser. Observe TI-243 and TI-244 for inlet- and exit-cooling-water temperature, respectively.

   c. Valve in pH monitor on the discharge of the cleanup pumps.

      (1) Open inlet valve V-1397 to pH cell ApHE-203.

      (2) Open the exit valve, V-1396, from ApHE-203.

   d. Check the pressure drop across the primary-cleanup filter which is on stream. If the pressure drop exceeds 25 psi, switch to the other filter and clean or backwash the dirty one. See Section 6.2.8, Filter Cleaning, for details of the cleaning operation.

   e. Sample the influent and effluent from each demineralizer bed and analyze as required for operating data.

   f. Check the pressure drop across the primary demineralizer after-filter by observing differential pressure gauge PdI-285. If the pressure drop exceeds 20 psi

with a flow rate of 150 gpm, backwash the filter. See Section 6.2.8 for details of the cleaning operation.

g. Valve in pH monitor on the discharge of the after-filter.

(1) Open the inlet valve, V-180, to pH cell ApHE-217A.

6.2.5 Shutdown of the primary cleanup loop

For short periods of shutdown (less than 24 h) the primary cleanup loop can be placed in "standby" condition by closing the high pressure system letdown valves, stopping the pressurizer pumps, and stopping the cleanup pumps. For prolonged shutdowns the steam should be turned off the deaerator ejectors as well. Before the cleanup loop is put back on stream after a shutdown, water should be recycled through the demineralizers or they should be rinsed down with demineralized water (see Section 6.2.7).

6.2.6 Bypassing equipment in the primary cleanup loop

When filters require cleaning, it is sometimes convenient to bypass the unit requiring attention and continue operation of the remainder of the cleanup loop. This can be done as follows:

1. West or "A" cleanup filter
   a. Open the filter-bypass valve, HCV-1047.
   b. Close the filter-inlet valve, HCV-1017.
   c. Close the filter-outlet valve, HCV-1021.
2. East of "B" cleanup filter
   a. Open the filter-bypass valve, HCV-1047.
   b. Close the filter-inlet valve, HCV-1020.
   c. Close the filter-outlet valve, HCV-1106.

6.2.7 Regeneration of primary demineralizers

NOTE: Operation of the acid and caustic supply systems is not covered in this procedure. See Section 10.5, Acid and Caustic Supplies.

(This procedure is written for the "A" unit with valve numbers for the "B" unit in parenthesis.)

1. Take the unit to be regenerated "off stream"
   a. Close the cation-inlet, air-operated valve, HCV-1024 (HCV-1022).
   b. Close the anion-outlet valve, HCV-124 (HCV-1034).
   c. Vent valves should remain open throughout the regeneration procedure.
2. Isolate the inlet side of the unit with the line blind
   a. Close the cation-inlet valve, V-1025 (V-1023).
   b. Make sure the acid-inlet valve, V-5614 (V-5616), is closed.
   c. Open the drain valves on each side of the inlet line blind, V-1182 (V-1180), V-1183 (V-1181), V-5632 (V-5634), V-5633 (V-5635).
   d. Change the line blind.
      (1) Carefully loosen the flange studs at the inlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
      (2) Rotate the blind so that the water inlet is blanked and the acid inlet is open.
      (3) Retighten the studs on the line-blind flanges.

e. Close all drain valves.

3. Isolate the outlet side of the unit with the line blind
   a. Close the anion-exit valve V-153 (V-150).
   b. Make sure the caustic-inlet valve, V-6019 (V-6021), is closed.
   c. Open the drain valves on each side of the outlet line blind, V-1184 (V-1187), V-1185 (V-1186), V-6026 (V-6028), V-6027 (V-6029).
   d. Change the line blind.
      (1) Carefully loosen the flange studs at the outlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
      (2) Rotate the blind so that the water outlet is blanked and the caustic inlet is open.
      (3) Retighten the studs on the line-blind flanges.
   e. Close all drain valves.
4. Backwash the cation bed
   a. Close the anion-inlet valves, V-1038 (V-1032) and V-1029 (V-1033).
   b. The normal-flow valve, V-152 (V-149), between the cation and anion beds, should be open.
   c. The cation bypass valve, V-1049 (V-1031), should be closed.
   d. The anion bypass valve, V-1118 (V-1119), should be closed.
   e. The cation-exit valve, V-1026 (V-1030), should be open.
   f. The cation-inlet valve, V-151 (V-148), should be open.
   g. The recycle-inlet valve, V-1104 (V-1105), should be closed.

h. Open the backwash-exit valve, V-1076 (V-1078).

i. Open V-1675 and V-1676 at the water rotometer, FI-222. (This meter and associated valves are located on the north, or operating, wall of the demineralizer cells.)

j. Open the water inlet valve, V-1624 (V-1625).

k. Open the process water supply valve, V-1636, to rotometer FI-222.

NOTE: The system is now pressurized with process water. Backwash flow is controlled with the drain valve to ensure that the column remains full of water at all times.

l. Slowly open drain valve V-122 to the ILW system. Observe rotometer FI-222 (located on the wall above the drain valve) an set the backwash flow at 75 gpm. As backwash flow is established, observe the reading on PdI-281 (PdI-283). The differential pressure should not exceed -2 psi at any time during the backwash.

m. Continue the backwash for 10 min and then close the following valves:

(1) Process water supply valve, V-1636.

(2) Drain valve, V-122 (as soon as V-1636 is closed).

(3) Backwash exit valve, V-1076 (V-1078).

(4) Cation exit valve, V-1026 (V-1030).

5. Regenerate the cation bed

a. Open the acid inlet valve, V-5614 (V-5616).

b. Open V-1075 (V-1081), to the common drain line.

c. Open V-5636 and V-5637 at the 5% acid rotometer, FI-229.

NOTE: This procedure assumes that the acid distribution system is in normal operation with pressure on the building header.

d. Slowly open the drain valve, V-122, to the ILW system. Observe rotometer FI-229 and set the acid flow rate at 30 gpm.

e. Continue acid injection for approximately 14 min (430 gal of 5% HNO_3) and then close the following valves:
   (1) Acid-rotometer valves, V-5636 and V-5637.
   (2) Drain valve, V-122.
   (3) Acid-inlet valve, V-5614 (V-5616).

6. Rinse the cation bed

a. Open the demineralized water valves, on each side of backflow preventer SP-01-2, in line 1615 to the water rotometer, FI-222.

b. Open the cation-bypass valve, V-1049 (V-1031).

c. Open the cation-inlet valve, V-1025 (V-1023).

NOTE: The cation bed is now pressurized with demineralized water. Observe the flow glasses in the vent system to make sure all air has been forced out of the column before continuing.

d. Slowly open drain valve V-122 to the ILW system. Observe rotometer, FI-222 and set the rinse rate at 35 gpm.

e. Rinse at 35 gpm for 16 min. During the rinse, open

line blind drain valves for 1 min to flush out regenerate solution.

f. Close ILW drain valve, V-122.

g. Set the final rinse flow rate at 50 gpm by opening process-waste drain valve V-123.

h. Rinse at 50 gpm for 30 min, then start sampling the effluent. Rinse until the effluent pH becomes constant.

i. When the rinse in completed, close the following valves:

(1) Demineralized-water supply valves, adjacent to backflow preventer, SP-1-2, in line 1615.

(2) Drain valve, V-123.

(3) Cation drain valve, V-1075 (V-1081).

(4) Cation inlet valve, V-1025 (V-1023).

(5) Cation bypass valve, V-1049 (V-1031).

7. Backwash the anion bed

a. Open the process water valve, V-1636, to water rotometer, FI-222.

b. Open the anion bypass valve, V-1118 (V-1119).

c. Open the anion backwash valve, V-1077 (V-1079).

d. Slowly open the drain valve, V-122, to the ILW system. Observe the backwash flow rate on rotometer FI-222. Set the backwash flow at 40 gpm. As backwash flow is established, observe the reading on PdI-280 (PdI-282). The differential pressure should not exceed -2 psi at any time during the backwash.

e. Continue to backwash the unit for 10 min and then close the following valves:

(1) Process water supply valve, V-1636.

(2) Anion bypass valve, V-1118 (V-1119).

(3) Anion backwash outlet valve, V-1077 (V-1079).

(4) ILW drain valve, V-122.

8. Regenerate the anion bed

a. Open valve V-6031 and V-6030 at the 5% caustic rotometer FI-230.

NOTE: This procedure assumes that the caustic distribution system is in normal operation with pressure on the building header.

b. Open the caustic inlet valve, V-6019 (V-6021).

c. Open the anion exit valve, V-153 (V-150).

d. Open the drain valve, V-1080 (V-1082), to the common drain header.

e. Slowly open V-122 to the ILW system. Observe the caustic flow on rotometer FI-230. Set the caustic flow rate at 30 gpm.

f. Continue the caustic flow for approximately 37 min or until 1,100 gal of 5% caustic has been injected, then close the following valves:

(1) Caustic rotometer valves, V-6031 and V-6030.

(2) Caustic inlet valve, V-6019 (V-6021).

(3) ILW-drain valve, V-122.

9. Rinse the anion bed

a. Open the valves in demineralized water line, 1615, to the water rotometer, FI-222.

b. Open the anion-inlet valve, V-1028 (V-1032).

c. Slowly open drain valve V-122 to the ILW system. Observe the rinse flow rate on FI-222. Set the initial rinse flow at 30 gpm.

d. Rinse at 30 gpm for 30 min, then increase the rinse flow:

(1) Close ILW valve, V-122.

(2) Slowly open process-waste-drain valve, V-123, until a flow rate of 90 gpm is observed on FI-222.

e. Rinse at 90 gpm for 20 min, then start checking the effluent pH periodically. During the rinse, open the line blind drain valves for 1 min to flush out the regenerate solution. Continue the rinse until the pH becomes constant and then close the following valves:

(1) Valves in the demineralized water line, 1615.

(2) V-1675, V-1676 at water rotometer FI-222.

(3) Process-waste-drain valve, V-123.

(4) Water-inlet valve, V-1624 (V-1625).

10. Recycle the cation and anion units

a. Open the recycle-inlet valve, V-1104 (V-1105), to the cation unit.

b. Open the cation-exit valve, V-1026 (V-1030).

c. Open the recycle-pump-inlet valve, V-1101.

d. Open the recycle-pump-outlet valve, V-1103.

e. V-1318, in the resin-transfer line, should already by closed.

f. Start the demineralizer-recycle pump, PU-6.

g. Continue recylcing until the anion effluent has a minimum resistance of 750,000 ohm-cm and a maximum pH of 7, then close the following valves; and stop the pump:
   (1) Recycle-pump inlet, V-1101.
   (2) Recycle-pump exit, V-1103.
   (3) Cation-recycle inlet, V-1104 (V-1105).
   (4) Anion drain, V-1080 (V-1082).

11. Return the cation-inlet line blind to "normal flow" position
   a. Open drain valves on each side of the inlet line blind V-1182 (V-1180), V-1183 (V-1181), V-5632 (V-5634), and V-5633 (V-5635).
   b. Change the line blind
      (1) Carefully loosen the flange studs at the inlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
      (2) Rotate the blind so that the acid inlet is blanked and the water inlet is open.
      (3) Retighten the studs on the line-blind flanges.
   c. Close all drain valves.

12. Return the anion-outlet line blind to "normal flow" position
   a. Close the anion-outlet valve, V-153 (V-150).
   b. Open the drain valves on each side of the outlet-line blind, V-1184 (V-1187), V-1185 (V-1186), V-6026 (V-6028), and V-6027 (V-6029).

c. Change the line blind.

(1) Carefully loosen the flange studs at the outlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(2) Rotate the blind so that the caustic inlet is blanked and the water outlet is open.

(3) Retighten the studs on the line-blind flanges.

d. Close all drain valves.

13. Put the regenerated unit "on stream"

a. Open the cation-inlet valve, HCV-1024 (HCV-1022).

b. Open cation-inlet valve, V-1025 (V-1023).

c. Open anion-exit valve, V-153 (V-150).

d. Open anion outlet, HCV-124 (HCV-1034).

NOTE: If the unit is not to be put in service immediately after regeneration, the above valves should remain closed. However, before the unit is put in service it should be recycled or rinsed until anion effluent water meets specifications.

6.2.8 Filter cleaning

Both the prefilters and the after-filter are designed to be cleaned by backwashing with water. The prefilters can also be backflushed with acid, caustic, or steam; but these are used only when a water backwash is not effective. Filters are cleaned as follows:

1. Backwash of prefilters. (This procedure is written for the "A" unit with valve numbers for the "B" unit in parentheses.)

a. Put a clean filter on stream per procedure 6.2.4.3, or bypass filters per procedure 6.2.6. R

b. Open filter-outlet valve, HCV-1021 (HCV-1106).

c. Open V-1043 (V-1044) to the ILW drain. If more backwash flow is desired, close demineralizer-inlet valves HCV-1022 and HCV-1024.

NOTE: It is very important that this valving arrangement not be used for longer than 1 min. This should be sufficient time to flush the filter without upsetting system flows excessively.

d. Close ILW-drain valve V-1043 (V-1044) and open demineralizer-inlet valves HCV-1022 and HCV-1024, if they were closed.

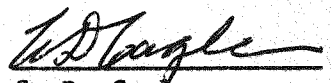
e. Put the cleaned filter in service per procedure 6.2.4.3. Valve out the other filter to check the pressure drop across the cleaned unit. If the pressure drop is less than 20 psi, it should be made the "standby" unit and the other filter returned to service. If pressure drop is greater than 25 psi, follow procedure 6.2.8.3. R

2. Backwash of after-filter with process water.

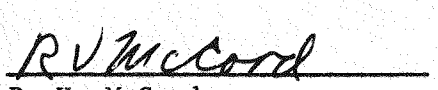
a. Turn the auxiliary pressurizer pump, PU-11, switch to "off."

b. Lower the operating pressurizer pump speed slowly to reduce the letdown flow rate to approximately 30 gpm.

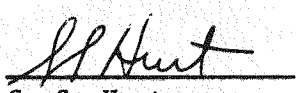
c. Place the demineralizer shutoff switch (located at pH-1200 panel) in "bypass."



C. D. Cagle
Technical Section



R. V. McCord
Reactor Operations Section



S. S. Hurt
Reactor Supervisor

d. Open V-1636, V-1675, and V-1676.

e. Close V-1117 and HCV-1035.

f. Open HCV-1036 and then open V-1061. Continue backwashing for 6 to 8 min at a flow rate of approximately 50 gpm as indicated by FI-222.

g. After completion of backwash, rinse with demineralized water by:

(1) Closing V-1636.

(2) Opening demineralized water supply valve.

Flush for 2 min.

h. Close the demineralized water supply valve as well as valves V-1675, V-1676, HCV-1036, and V-1061.

i. Open V-1117 and HCV-1035.

After the deaerator level returns to normal, raise the pressurizer pump speed back to normal and place PU-11 switch back in "remote control."

j. Place the demineralizer shutoff switch back in "normal."

3. Chemical cleaning of prefilters: (This procedure is written for the "A" unit with valve numbers of the "B" unit in parentheses.)

a. Put a clean filter on stream.

b. Isolate the filter inlet with the line blind.

(1) Make sure acid, V-5612, caustic, V-6017, and steam, V-1650, block valves are closed.

(2) Open drain valves on each side of the inlet-line blind, V-100 (V-110), V-101 (V-111), V-102

(V-108), and V-103 (V-109).

(3) Open drain valve V-1043 (V-1044).

(4) Change the line blind.

(a) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(b) Rotate the blind so that the water inlet is blanked and the chemical inlet is open.

(c) Retighten the studs on the line-blind flanges.

(5) Close the drain valves on the water inlet line (leave the drain valves open on the chemical inlet line).

c. Isolate the outlet of the filter line blind.

(1) Open the drain valves in the water line at the outlet line blind, V-104 (V-106) and V-105 (V-107).

(2) Change the line blind.

(a) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(b) Rotate the blind so that the water outlet is blanked and the chemical inlet is open.

(c) Retighten the studs on the line-blind flanges.

(3) Close all line blind drain valves.

d. Displace the water in the filter with steam.

(1) Close the vent valve, HCV-1090 (HCV-1091).

(2) Open filter drain valve, V-1043 (V-1044).

(3) Open the steam-inlet valve, V-1650. Allow steam to flow into the filter for not more than 5 min and then close the steam inlet valve, V-1650.

e. Fill the filter with cleaning solution.

(1) Fill the filter with caustic.

(a) Close the filter-drain valve, V-1043 (V-1044).

(b) Open the vent valve, HCV-1090 (HCV-1091).

(c) Pressurize the caustic supply system and open the caustic rotometer (FI-230) valves, V-6030 and V-6031.

(d) Open the caustic-inlet valve, V-6017.

(e) Observe caustic flow on FI-23. When it stops, the filter is full of caustic and valve V-6017 can be closed.

(f) Stop the caustic supply pumps and close the rotometer valves, V-6030 and V-6031.

(g) Allow the caustic to remain in the filter at least 1 h before proceeding to the next step.

(2) Displace caustic from the filter with steam.

(a) Close the vent valve, HCV-1090 (HCV-1091).

(b) Open the filter drain valve, V-1043 (V-1044).

(c) Open the steam inlet valve, V-1650. Allow

steam to flow into the filter for not more than 5 min and then close the steam inlet valve, V-1650.

(3) Fill the filter with acid.

(a) Close the filter-drain valve, V-1043 (V-1044).

(b) Open the vent valve, HCV-1090 (HCV-1091).

(c) Pressurize the acid supply system and open the acid rotometer (FI-229) valves, V-5636 and V-5637.

(d) Open the acid-inlet valve, V-5612.

(e) Observe acid flow on FI-229. When it stops, the filter is full of acid and valve V-5612 can be closed.

(f) Stop the acid supply pump and close V-5636 and V-5637.

(g) Allow the acid to remain in the filter at least 1 h before proceeding to the next step.

(4) Displace the chemical with steam.

(a) Open the filter-drain valve, V-1043 (V-1044).

(b) Close the filter-vent valve, HCV-1090 (HCV-1091).

(c) Open the steam-inlet valve, V-1650. Allow steam to flow into the filter for not more than 5 min and then close the steam-inlet valve, V-1650.

f. Rinse the chemical from the filter with demineralized water.

(1) Open the filter-drain valve, V-1043 (V-1044).

(2) Open the filter-vent valve, HCV-1090 (HCV-1091).

(3) Allow filter to drain for 5 min then close filter drain valve, V-1043 (V-1044).

(4) Open demineralized water valves V-1633, V-1634, and V-1627 at the rotometer FI-228. Allow the filter to fill with demineralized water until flow stops going through rotometer FI-228.

(5) Close demineralized water valve, V-1627.

(6) Open filter drain valve, V-1043 (V-1044) and allow filter to drain for approximately 5 min.

(7) Repeat fill and drain operation several times until the effluent pH approaches 7.0. Leave the filter full of demineralized water.

(8) Flush out the sample line to sample sink and the line blind drain valves.

(9) Close demineralized water valves V-1627, V-1634, and V-1633.

(10) Open line blind drain valves V-100 (V-110), V-101, (V-111), V-102 (V-108), V-103 (V-109), V-104 (V-106), and V-105 (V-107).

(11) Rotate both filter inlet and exit line blinds then close all line blind drain valves.

(12) Leak check line by opening HCV-1021 (HCV-1106).

(13) If there is no leak, close HCV-1021 (HCV-1106).

(14) Place filter in service when needed.

h. Check the pressure drop across the cleaned filter.

(1) Place the cleaned filter in service per procedure 6.2.4.4.

(2) Close the inlet valve of the filter which was in service.

(3) The bypass valve, HCV-1047, should already be closed.

(4) Observe the pressure drop across the cleaned filter. If it is less than 20 psi, the filter should be placed in "standby" by putting the alternate filter on the line and closing the inlet and exit valves of the cleaned filter. If the pressure drop is greater than 25 psi, repeat the chemical cleaning procedure.

6.2.9 Backwash the cation bed while system is in operation

The primary cleanup system cation beds can be backwashed while the system is in service. This procedure is as follows:

1. Reduce the primary cleanup flow rate to approximately 30 gpm by starting the auxiliary pressurizer pump, PU-11, and then reducing the speed of the main pressurizer pump until its output flow rate is zero.

2. Open ILW drain valve V-122.
   Open demineralized water valves V-1675 and V-1676. Make sure process water supply valve V-1636 is closed.
   Close HCV-1024 (HCV-1022) demineralizer inlet valve (this causes all cleanup flow to start filling the deaerator and eventually overflow to ILW).

Close anion inlet valve V-1028 (V-1032).

Open V-1624 (V-1625) and V-1076 (V-1078).

This starts the backwash. As backwash flow is established, observe the reading on differential pressure gauge PdI-281 (PdI-283). The differential presssure should not exceed -2 psi at any time during the backwash. Continue to backwash the column at approximately 75 gpm flow rate for 10 min.

NOTE: Since water is being taken from the primary head tank and none is being returned, the head tank will begin to make up. When this occurs the full 75 gpm backwash rate cannot be maintained. It may be necessary to close the head tank makeup valve temporarily during the backwash. The head tank level should be watched closely and the backwash terminated if the level drops to 50%.

3. Stop the backwash and return the system to normal service.

   Open the head tank makeup valve.

   Close V-122.

   Close demineralized water valves V-1675 and V-1676.

   Close V-1624 (V-1625).

   Close V-1076 (V-1078).

   Open V-1028 (V-1032).

   Open HCV-1024 (HCV-1022).

4. After the deaerator level returns to normal, increase the main pressurizer pump speed to normal and stop PU-11 and place it in "remote control."

5. Check the OHOG line above the counting room for β-γ radiation. If a significant amount is present, flush it out by

running water into the OHOG access in the reactor bay for approximately 5 min.

6.2.10 Resin disposal

The following procedure applies to both the primary cleanup system and the pool cleanup system. For related procedures, refer to the appropriate section of this manual.

1. Regenerate both columns of the demineralizer using the appropriate procedure. Do not place the demineralizer on recycle. The column for which resin is to be replaced should have two batches of chemicals run through it. There should be a short rinse between the two batches.
2. Arrange for a concrete cask to be lowered into the equipment hatch on the north side of the ground floor. Insert double plastic bags in the cask.
3. Arrange for a portable air compressor to be placed on the north side of the building adjacent to the equipment hatch.
4. Use the appropriate procedure to partially drain the column of water.
5. Remove the manhole cover from the column. Inspect the gasket for needed replacement.

   CAUTION: Health Physics coverage must be utilized for work being done in the demineralizer cell as well as while filling the cask with resin.
6. Keep an adequate amount of water flowing into the column while the pump suction line is being moved around in the resin to keep the pump and line from plugging.

7. As the cask fills with water and resin, syphon water off the top to the floor drain in the hatch area.
8. When the column is empty, stop the pump and the air compressor.
9. Inspect the screen in the bottom of the column to make sure it is not torn.

Replacement

1. Reverse the pump connection to pump new resin back through the same line to the demineralizer column.
2. Open the column drain valve to PWD.
3. Anchor the pump discharge line in the column or hold it so it won't come out of the column.
4. Mix sufficient amounts of water with the new resin to prevent plugging the pump and line.
5. Start the pump and continue pumping new resin and water into the column until the correct amount of resin is in the column (primary cation, 35 ft^3; primary anion, 60 ft^3; pool cation and anion, 50 ft^3 each.)
6. Disconnect and remove equipment. Replace the column manhole cover using a new gasket if needed.
7. Fill the column with process water and leak check with process water pressure (approximately 90 psi).
8. Regenerate the column twice using the appropriate procedure. Rinse between chemical injections.

6.3. Pool Coolant System

6.3.1 References

Drawings:

1546-01-M-5501 Engineering Flow Diagram - Pool Coolant

1546-01-M-5503 Process Equipment Arrangement - Ground Floor

1546-01-M-5504 Process Equipment Arrangement - First Floor

1546-01-M-5506 Piping Arrangement - Plan at Pools

1546-01-M-5512 Piping Arrangement Plan - Process Equipment - Ground Floor

1546-01-M-5513 Piping Arrangement Plan - Process Equipment - First Floor

1546-01-I-4404 Pool Coolant Instrumentation

Section 6 of HFIR Description Manual

Section 5.5 of HFIR Design Manual

Singmaster & Breyer Specifications - Section 71 Pool Cooling System

6.3.2 Introduction

Pool water absorbs heat from three sources: (1) radiation from the reactor, (2) high temperature primary system components, and (3) radioactive decay of stored fuel elements. This heat is transferred to the secondary coolant system by circulating the pool water through heat exchangers. Water for this cooling loop originates in the pool overflow. It is collected in scuppers and piped to a surge tank. Pool coolant pumps take water from the surge tank, force it through a filter and two parallel heat exchangers, and return it to the pools (see Figs. 6.7 and 6.8). Temperature of the pool water is maintained at approximately 95°F by a cooling flow rate of 1,000 gpm.

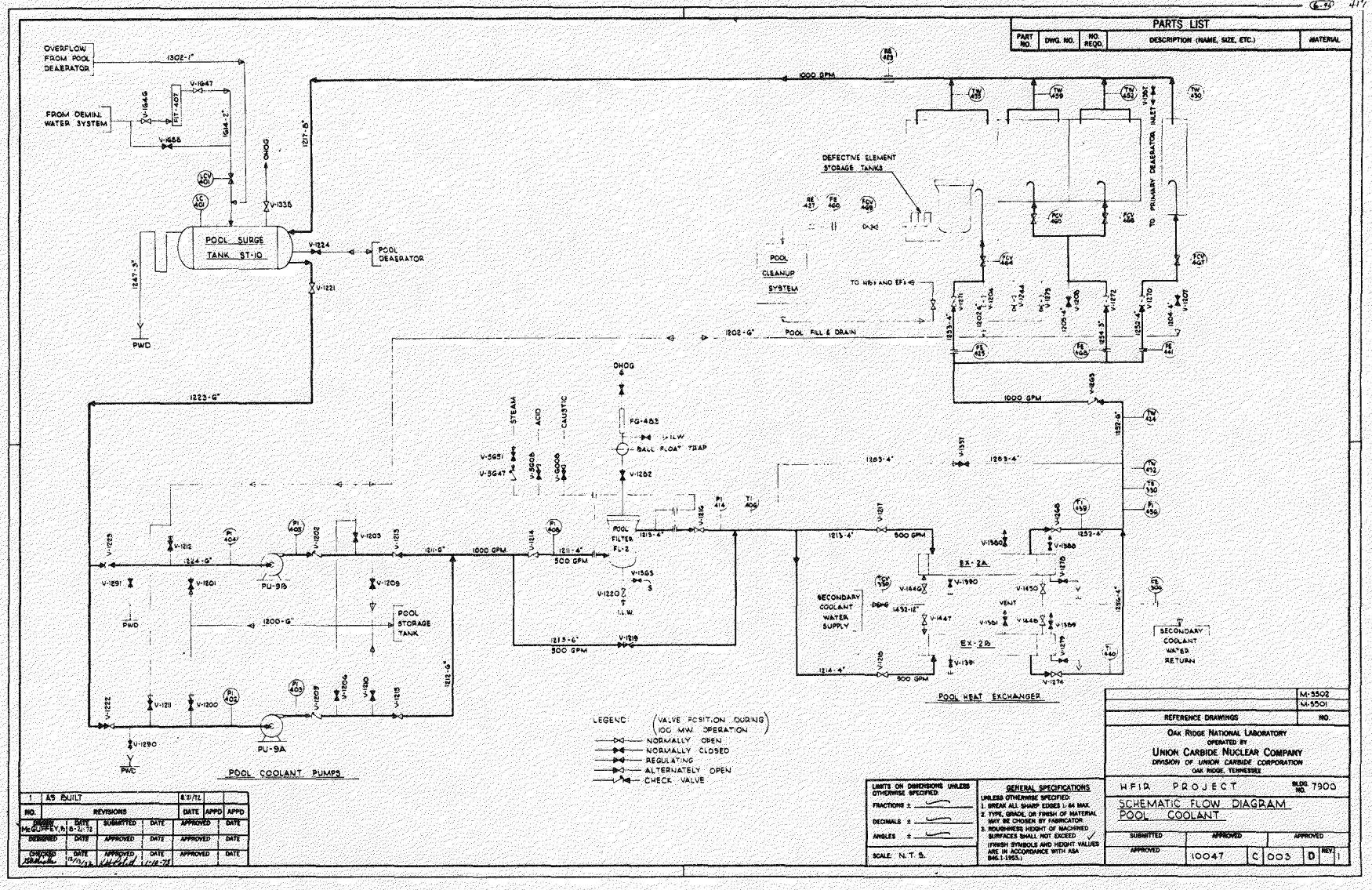


Fig. 6.7. Pool coolant system.

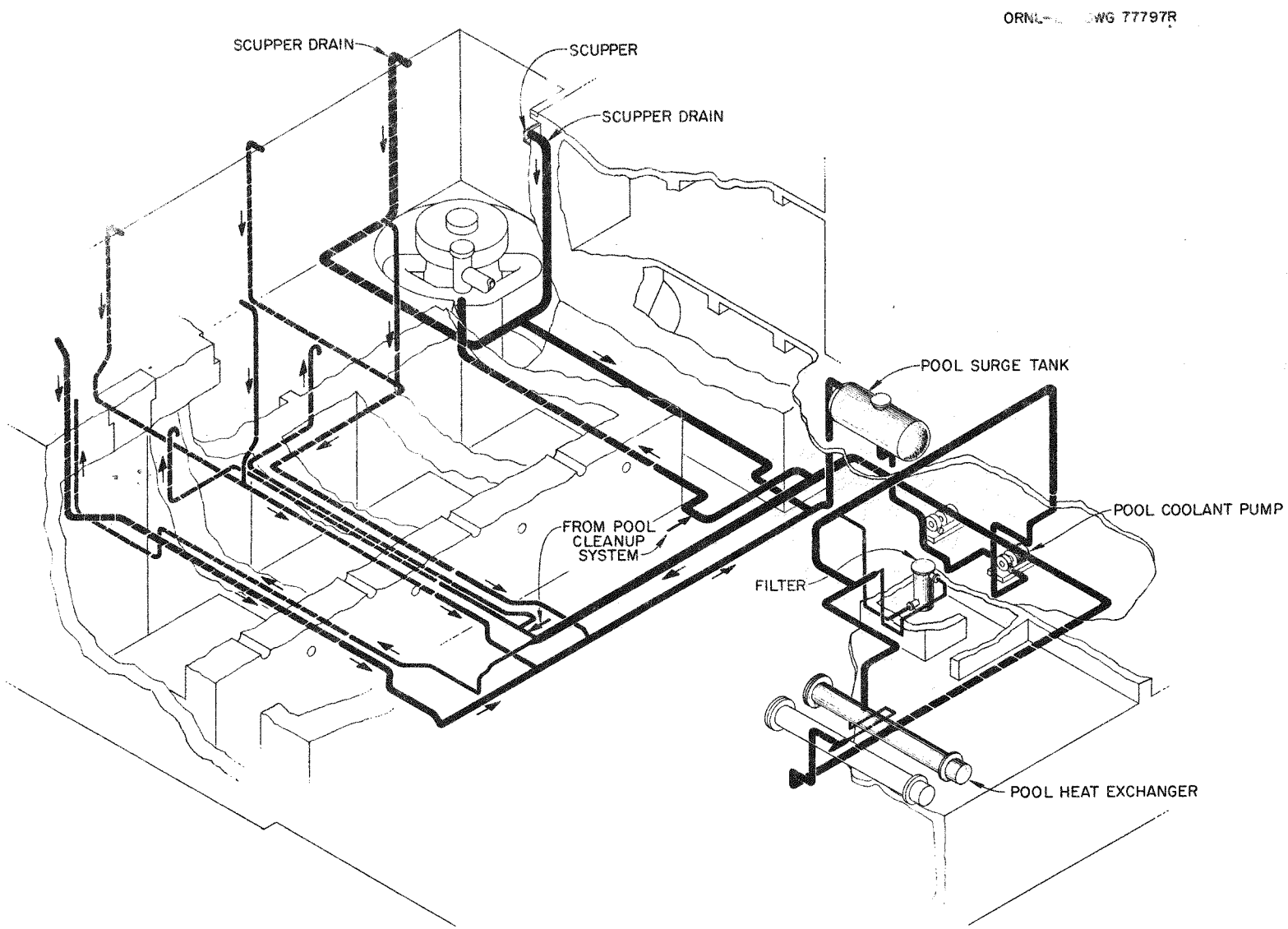


Fig. 6.8. Pool coolant system.

6.3.3 Precautions

Under normal conditions the pool water has a very low activity level. The only component of this system which will become hazardously radioactive is the cleanup filter, and it is located in a concrete cell. This cell must be carefully monitored before entering. Continuous monitoring is essential if personnel enter the cell while the pool coolant system is in operation.

6.3.4 Place system in "normal" operation

The pool coolant loop is placed in operation in the following manner:

1. Pool surge tank, 405-ST-10
   a. There are no valves in the lines between the pool scuppers and the surge tank. Any water which overflows the pool goes directly to the surge tank.
   b. Open the surge-tank vent to the OHOG system by opening V-1338.
   c. Place the automatic demineralized-water make-up system in operation.
      (1) Open demineralized-water valves V-1646 and V-1647 which are on each side of rotometer FIT-407.
      (2) V-1688, which bypasses the rotometer, should be closed.
      (3) The demineralized-water-supply system must be in normal operation (see Section 10.3., Demineralized Water Supply).
   d. Close V-1224, in the crosstie to the pool cleanup system.
   e. Open V-1221, in the exit line to the pool coolant pumps.

2. Pool coolant pumps, PU-9A and 9B. (Either pump may be used. This procedure applies to the "A" pump with equipment numbers for the "B" pump in parentheses.)
   a. Open inlet valve, V-1222 (V-1223), in the line from the pool surge tank.
   b. Start the pump motor.
   c. Observe the discharge pressure gauge, PI-403 (PI-405). Pressure should be approximately 90 psi; if not, bleed the air from the pump vent until normal pressure is observed.
   d. Open exit valve, V-1215 (V-1213), in the line to the pool-cleanup filter.
   e. All other valves in pump suction and discharge lines should be closed.
3. Pool cleanup filter, FL-2
   a. Open the inlet valve to the filter, V-1214.
   b. Open the vent to the OHOG system, valves V-1282 and V-1376. Observe the flow of gas from the filter in flow glass FG-483, located on the west wall of the filter cell.
   c. When gas has stopped venting from the unit, open exit valve, V-1216.
   d. All other valves around the filter, including bypass valve V-1219, should be closed.
4. Pool heat exchangers, EX-2A and 2B
   a. Open the inlet valves to both exchangers, V-1217 and V-1218.

b. Crack the vent valves, V-1380 and V-1381, until water appears, and then close tightly.

c. Open the exit valves, V-1268 and V-1274.

d. Open the secondary-coolant inlet valves, V-1470, V-1446, and V-1447, and open the exit valves V-1448, V-1450, and V-1469.

e. Place the pool-coolant exit-temperature controller TIC-330 in "auto" mode and set the control point at 90°F.

f. All drain and bypass valves should be closed.

5. Flow to the pools

a. Open the block valves to the individual pools; V-1271 to the reactor pool, V-1272 to the clean pools, and V-1270 to the critical pool. These valves are located overhead in the pipe tunnel on the ground floor.

b. Open automatic block valves, FCV-464, FCV-465, FCV-466, and FCV-467, with the switches in the control room.

c. Observe the flow indicators in the control room for flow to the various pools.

(1) FI-425 for flow to the reactor pool - 600 gpm.

(2) FI-468 for flow to the clean pools - >200 gpm.

d. If flows greater than the above are indicated to any pool, throttle the respective automatic control valve until the flow is reduced to the proper value.

e. If flows less than those specified in Section 5.c, above are indicated, slowly open bypass valve V-1219 around the pool cleanup filter until all flow indicators are above the specified setpoint.

f. Throttle the flow to each pool with the automatic flow-control valves until the proper flow rate is indicated to each pool.

6.3.5 Shutdown of pool coolant loop

During routine reactor shutdowns, the pool coolant system will usually remain in operation. However, if the water level is to be lowered in any pool, it will be convenient to stop circulation in the pool coolant pumps, PU-9A and -9B. It is not necessary to close any valves except those required for a fill or drain procedure as specified in Section 6.6.

6.3.6 Filter cleaning

The pool coolant filter should be cleaned when the pressure drop across it exceeds 80 psi. It is first cleaned by backwashing with pool coolant system water. If this is not effective, chemical cleaning methods must be used. Filter cleaning procedures are as follows:

Water Backwash

1. Bypass the filter.
   a. Open bypass valve, V-1219.
   b. Close inlet valve, V-1214.
2. Open V-1220 to the PWD drain. If more flow through the filter is desired, close the heat-exchanger-inlet valves, V-1217 and V-1218.

   NOTE: It is important that this valving arrangement not be for longer than 1 min. This should be sufficient time to flush the filter without upsetting pool system flows excessively.

3. Close PWD drain valve V-1220 and open heat-exchanger-inlet valves V-1217 and V-1218, if they are closed.
4. Open filter-inlet valve, V-1214.
5. Close filter-bypass valve, V-1219.
6. Check the pressure drop across the filter. If it is less than 50 psi, the filter can remain in service. If it is more than 50 psi, use the chemical-cleaning procedure.

Chemical Cleaning

1. Bypass filter.
   a. Open bypass valve, V-1219.
   b. Close filter-inlet valve, V-1214.
   c. Close filter-outlet valve, V-1216.
2. Isolate the inlet of the filter with the line blind.
   a. Make sure acid, V-5609, caustic, V-6009, and steam, V-5638, block valves are closed.
   b. Open the drain valves on each side of the inlet line blind, V-1323, V-1324, V-5624, V-5625.
   c. Change the line blind.
      (1) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
      (2) Rotate the blind so that the water inlet is blanked and the chemical inlet is open.
      (3) Retighten the studs on the line-blind flanges.
   d. Close all drain valves.
3. Isolate the outlet of the filter with the line blind.

a. Open the drain valves on each side of the outlet line blind, V-1325, V-1326, V-5624, and V-5625.

b. Change the line blind.

(1) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(2) Rotate the blind so that the water outlet is blanked and the chemical inlet is open.

(3) Retighten the studs on the line-blind flanges.

c. Close all drain valves.

4. Displace the water in the filter with steam.

a. Open drain valve, V-1220.

b. Close vent valve, V-1282.

c. Open steam-inlet valve, V-5638. Allow steam to flow into the filter for not more than 5 min and then close the steam-inlet valve, V-5638.

5. Fill the filter with caustic.

a. Close filter-drain valve, V-1220.

b. Open vent valve, V-1282.

c. Start the caustic pump and open the caustic rotometer valves, V-6014 and V-6015, at FI-472.

d. Open the caustic-inlet valve, V-6009.

e. Observe air venting from the filter through flow gauge FG-483. When air stops venting, the filter is full of caustic and V-6009 can be closed.

f. Stop the caustic pump and close the rotometer bypass valve, V-6042.

g. Allow caustic to remain in the filter at least 1 h.

h. Drain the caustic by opening V-1220.

6. Fill the filter with acid.

a. Close filter drain valve, V-1220.

b. Open vent valve, V-1282.

c. Start the acid pump and open the rotometer valves, V-5617 and V-5618, at FI-472.

d. Open the acid inlet valve, V-5609.

e. Observe air venting from the filter through flow gauge FG-483. When air stops venting, the filter is full of acid and V-5609 can be closed.

f. Stop the acid pump and close the rotometer valves, V-5617 and V-5618.

g. Allow acid to remain in the filter at least 1 h before proceeding to the next step.

7. Displace the chemicals with steam.

a. Open filter-drain valve, V-1220.

b. Close filter-vent valve, V-1282.

c. Open steam-inlet valve, V-5638. Allow steam to flow into the filter for <u>not more than 5 min</u> and then close the steam-inlet valve, V-5638.

8. Backwash the chmicals from the filter.

a. Close filter-drain valve, V-1220.

b. Open filter-vent valve, V-1282.

c. Switch the line blind on the <u>outlet</u> of filter.

(1) Open drain valves on each side of the outlet line blind, V-1325, V-1326, V-5624, and V-5625.

(2) Change the line blind (handle the pipe carefully; it may be hot).

(a) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(b) Rotate the blind so that the chemical inlet is blanked and the water outlet is open.

(c) Retighten the studs on the line-blind flanges.

(3) Close all drain valves.

d. Open the filter-outlet valve, V-1216. This will permit the filter to fill with water. Wait until air stops venting in flow gauge FG-480 before proceeding to the next step.

e. Open the filter drain, V-1220. This backwashes the filter with pool-coolant system water.

f. After backwashing the filter for 5 min, start sampling the effluent, via sample valve V-1363, and analyzing of pH. Continue the backwash until the effluent pH is essentially the same as the pool coolant system pH. Stop the backwash by closing drain valve V-1220 and outlet valve V-1216.

8. Return the filter to service.

a. Rotate the line blind on the filter inlet.

(1) Open the drain valves on each side of the inlet line blind, V-1323, V-1324, V-5623, and V-5624.

(2) Change the line blind.

(a) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(b) Rotate the blind so that the water inlet is open and the chemical inlet is closed.

(c) Retighten the studs on the line-blind flanges.

(3) Close all drain valves.

b. Open the filter-inlet valve, V-1214.

c. Open the filter-outlet valve, V-1216.

d. Close the filter-bypass valve, V-1219.

e. Check the pressure drop across the filter. It should be less than 20 psi.

6.4. Pool Cleanup System

6.4.1 References

Drawings:

1546-10-M-5501 Engineering Flow Diagram - Pool Coolant

1546-01-M-5503 Process Equipment Arrangement - Ground Floor

1546-01-M-5504 Process Equipment Arrangement - First Floor

1546-01-M-5506 Piping Arrangement - Plan at Pools

1546-01-M-5512 Piping Arrangement Plan - Process Equipment - Ground Floor

1546-01-M-5513 Piping Arrangement Plan - Process Equipment - First Floor

1546-01-I-4405 Pool Coolant Cleanup Instrumentation

Cochrane Drawing E-135173C - Schematic Flow Diagram - Pool Deaerator

Section 6 of HFIR Description Manual

Singmaster & Breyer Specifications - Section 71 Pool Cooling System

6.4.2 Introduction

Water for the pool cleanup loop flows at approximately 150 gpm from the defective fuel element storage tanks in the reactor pool. It is first degassed by the pool deaerator and is then filtered and demineralized. The purified water is returned to the clean pools. If the water removed from the reactor pool is hotter than 100°F, as will be the case when the defective fuel element station contains a recently irradiated element, the excess heat is removed by the pool deaerator (see Figs. 6.9 and 6.10).

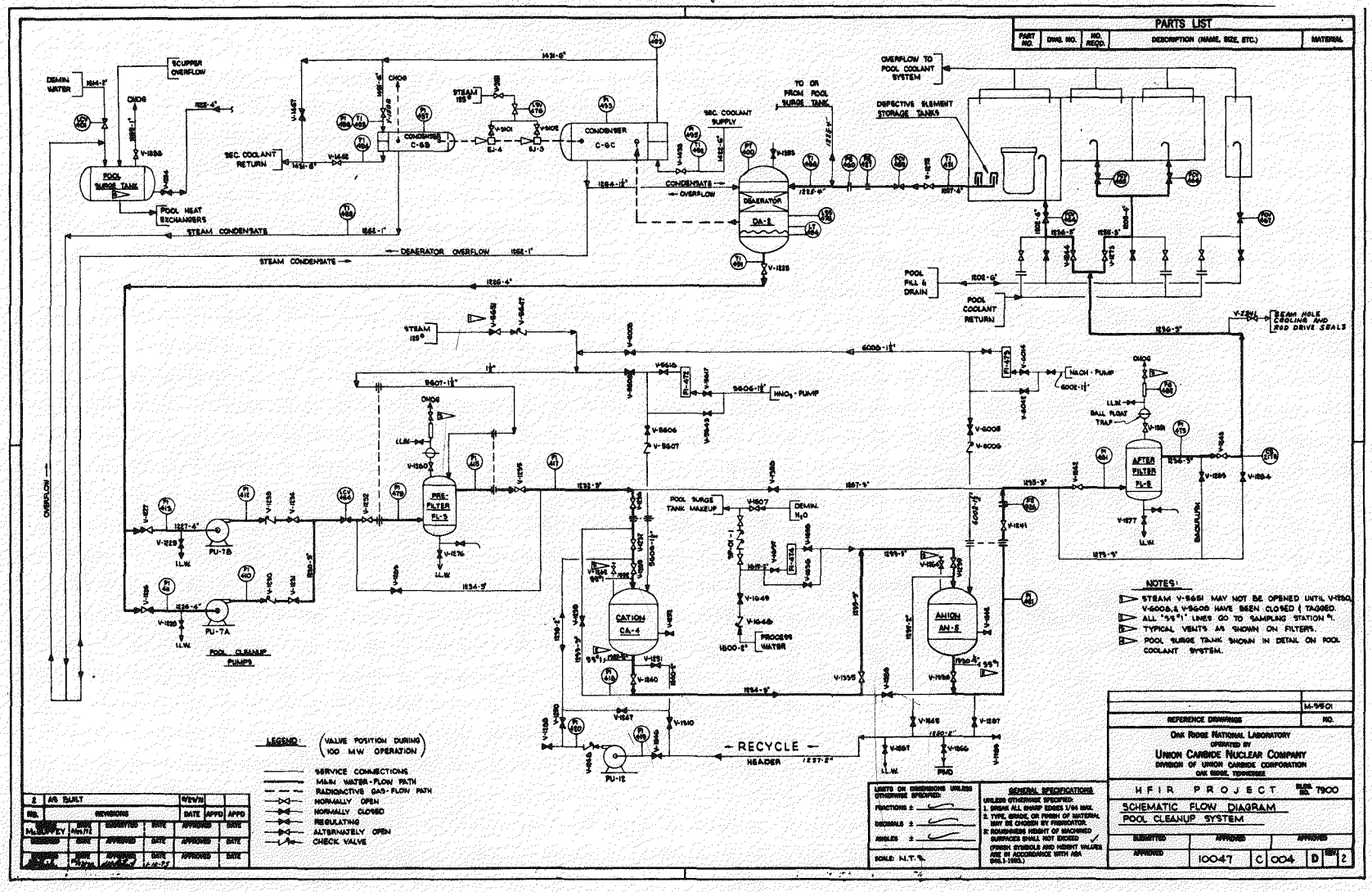


Fig. 6.9. Schematic flow diagram pool cleanup system.

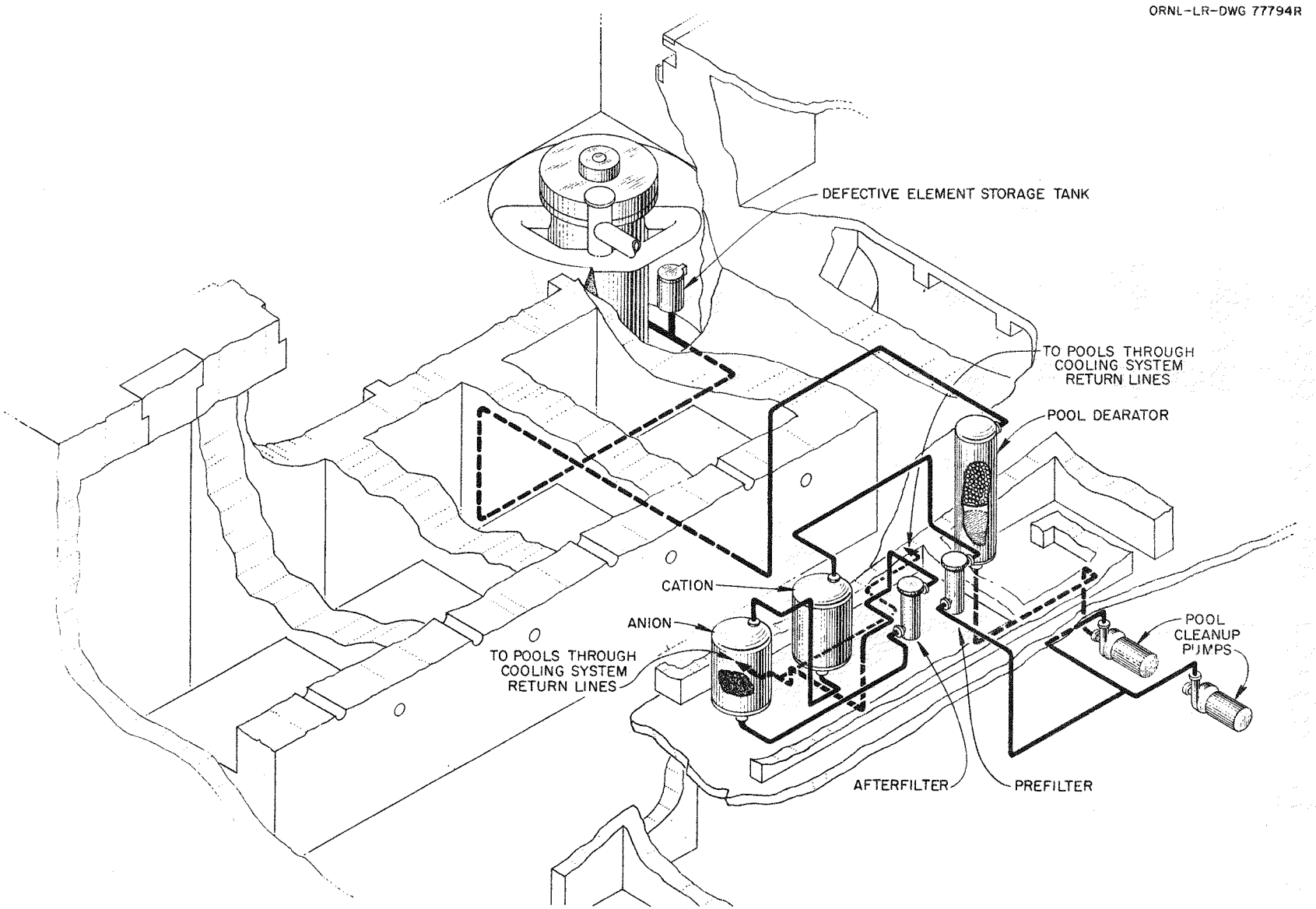


Fig. 6.10. Pool coolant cleanup system.

6.4.3 Precautions

Under most conditions, water in the pool cleanup loop contains very little radioactivity. However, the trace amounts of activity are concentrated by the filters and demineralizers so these units can become highly radioactive. The demineralizer cell must be carefully monitored before it is entered.

During the time a recently irradiated defective fuel element is stored in the defective fuel element storage tank, the entire pool cleanup system can become very highly radioactive. The deaerator will remove gases released by the defective element; so this equipment must be approached with caution. Under this condition, the demineralizer will also collect much more activity than is normally present.

Acid and caustic regeneration solutions must be handled with care. Goggles or face shields must be worn when there is any danger of a chemical splash (such as breaking into a line to change line blinds). The 5% solutions will not burn the skin immediately, but they will cause irritation if not promptly washed off. The solutions are extremely irritating to the eyes; all normal precautions must be taken to prevent splashes into the eyes.

Regenerative effluent solutions can contain large amounts of radioactivity. Valving arrangements must be carefully checked to make sure these solutions go to the ILW system. If sampling is necessary, the radiation level must be carefully monitored. Proper care must be exercised to prevent spilling radioactive materials. Before regenerating any demineralizer unit, both inlet and exit line blinds must be positioned to prevent any acid or caustic from entering the process system. These solutions are extremely corrosive to some components in the system, and all precautions must be taken to prevent their entry.

6.4.4 Placing the system in "normal" operation

Equipment in the pool cleanup system should be placed in operation in the following sequence:

1. Place the deaerator in operating condition (assuming the cleanup system is empty and all valves are closed).
   a. Turn on the cooling water to the vacuum system condensers.
      (1) Open the main valve, V-1433, to the condensers.
      (2) Open V-1508 to the after-condenser.
   b. Crack the vent valves to bleed air from the secondary side of the condensers and then close them tightly.
   c. Establish cooling water exit flow from the condensers.
      (1) Open V-1442 from the after-condenser.
      (2) Partially open V-1467 from the precondenser.
   d. Open the vent to the CHOG system from the after-condenser, V-1352.
   e. Open the steam supply valves to the jet ejectors.
      (1) V-3101 to the low vacuum ejector.
      (2) V-3102 to the high vacuum ejector.

      NOTE: The system pressure will not begin to fall until enough steam has condensed to fill the barometric legs of the condensers. Wait until maximum vacuum is established before proceeding. If the water level in the deaerator rises to the high level alarm point, the solenoid-operated steam supply valve to the jets will be automatically closed.
   f. Fill the deaerator to normal operating level.

(1) Open the block valve, V-1275, located in the pipe corridor in line 1254.

(2) From the control room, slowly open automatic-flow valve FCV-469 until a normal level appears on the deaerator water-level indicator.

2. Start the pool cleanup pump: (This procedure will apply to the "A" pump. Valve numbers for the "B" pump are indicated in parentheses. Either or both pumps can be run.)

a. Open V-1225 in the outlet line from the deaerator.

b. Open pump suction valve, V-1226 (V-1227).

c. Start the pump with the "start" switch in the control room.

d. Observe the pump-discharge pressure gauge. It should indicate approximately 140 psig. If not, bleed air from the pump vent until normal pressure is achieved, then close the vent tightly.

Operational Note: The pump must be started before being bled. The pump suction is at a negative pressure due to the deaerator vacuum, so opening the vent before starting the pump will admit air into the system. A low level in the deaerator vessel will automatically stop the demineralizer pump. It will start automatically (if the switch is in the "start" mode) when the level rises, but a normal water level must be maintained by opening FCV-469 as required during subsequent operations.

e. Open pump discharge valve, V-1231 (V-1234).

3. Pool demineralizer filter
   a. Open inlet valve, V-1232.
   b. Open the vent valves, V-1280 and V-1372, in line 1270.
   c. Observe air venting from the filter through flow gauge FG-480 which is located on the east wall of the demineralizer cell.
   d. When air stops venting, open exit valve V-1235.
4. Pool demineralizers
   a. Open inlet valves V-1236, V-1237, and V-1289 to the cation inlet.
   b. Open cation vent valves V-1262 and V-1263 to the OHOG system.
   c. Observe air venting from the cation bed through flow gauge FG-470 which is located on the east wall of the demineralizer cell.
   d. When air stops venting, open cation-exit valve, V-1240.
   e. Open anion inlet valves, V-1335 and V-1239.
   f. Open anion vent valves, V-1264 and V-1265, to the OHOG system.
   g. Observe air venting from the anion bed through flow gauge FG-471 which is located on the east wall of the demineralizer cell.
   h. When air stops venting, open anion-exit valves, V-1336 and V-1241.

   NOTE: This procedure assumes the demineralizers have been regenerated, rinsed down, and are ready for operation. See Section 6.4.7, Pool Demineralizer Regeneration, for details.

5. Pool demineralizer after-filter
   a. Open the inlet valve, V-1242, to the filter.
   b. Open the filter vent valves, V-1281 and V-1374, to the OHOG system.
   c. Observe air venting from the filter through flow gauge FG-482 which is located on the east wall of the demineralizer cell.
   d. When the air stops venting, open the filter exit valve, V-1243.
6. To establish normal flow in the cleanup system
   a. Open V-1273 in line 1255. This valve is located in the pipe corridor on the ground floor. It admits water from after-filter exit line 1236 to the clean pool.
   NOTE: The pool coolant system must be in normal operation, pumping water to and receiving it from all pools. If the pool coolant loop is not in normal operation, water from the cleanup loop must be returned to the reactor pool since that is its source. If water is to be returned to the reactor pool, open V-1244 in line 1236 instead of V-1273 in line 1255.
   b. Adjust FCV-469 from the control room until a flow of approximately 150 gpm to the deaerator is observed on flow indicator FI-460.
7. Final checks and adjustment of the system
   a. Check the deaerator level. It should be between 20% and 60%.
   b. Adjust the secondary coolant flow to the deaerator

condensers by throttling V-1467 until a temperature rise of approximately 12°F is obtained across the after-condenser. Observe TE-493 and TE-494 for inlet and exit temperatures, respectively.

c. Check the pressure drop across the pool demineralizer filter by observing pressure gauges PI-479 and PI-415. If the pressure drop is excessive with the flow rate of approximately 150 gpm, bypass the filter and clean it. See Section 6.4.8, Pool Filter Cleaning, for details of cleaning operation.

d. Sample the influent and effluent from each demineralizer bed and analyze as required for operating data.

e. Check the pressure drop across the pool demineralizer after-filter by observing pressure gauges PI-481 and PI-475. If the pressure drop exceeds 10 psi with a flow rate of approximately 150 gpm, bypass the filter and clean it. See Section 6.4.8, Pool Filter Cleaning, for details of cleaning operation.

6.4.5 Shutdown of pool cleanup loop

For short periods of shutdown (less than 24 h), the pool cleanup loop can be placed in "standby" condition by closing pool outlet valves, FCV-464 and V-1275, and then stopping the demineralizer pumps, PU-7A and -7B. To start up after a brief shutdown, the pumps are started first and then the pool outlet valves are opened.

6.4.6 Bypassing equipment in pool cleanup loop

When filters require cleaning or demineralizers require regeneration, it is sometimes convenient to bypass the unit requiring

attention and continue operation of the remainder of the cleanup loop. This can be done as follows:

1. Pool demineralizer prefilter
    a. Open bypass valve V-1283.
    b. Close inlet valve V-1232.
    c. Close exit valve V-1235.
2. Pool demineralizers (both cation and anion beds)
    a. Open bypass valve V-1358.
    b. Close inlet valve V-1236.
    c. Close exit valve V-1241.
3. Cation unit
    a. Open bypass valve V-1238.
    b. Close inlet valve V-1237.
    c. Close exit valve V-1240.
4. Anion unit
    a. Open bypass valve V-1286.
    b. Close inlet valve V-1335.
    c. Close exit valve V-1336.
5. Pool demineralizer after-filter
    a. Open bypass valve V-1284.
    b. Close inlet valve V-1242.
    c. Close exit valve V-1243.

The individual units can be put back on stream by reversing the bypass procedures. That is, by opening the inlet and exit valves and then closing the bypass valve.

6.4.7 Regeneration of pool demineralizers

Take the demineralizers "off stream"

NOTE: The pool cleanup loop must be shut down or the demineralizers bypassed during regeneration. See Section 6.3.5, or 6.3.6, Pool Cleanup System, for details.

1. Close cation-inlet valves V-1236 and V-1237.
2. Close anion-outlet valves V-1336 and V-1241.
3. Vent valves should remain open throughout the regeneration procedure.

Isolate the inlet side of the demineralizer with the line blind

1. Make sure the acid-inlet valve, V-5606, is closed.
2. Cation-bypass valve, V-1238, should already be closed.
3. Open the drain valves on each side of the inlet line blind, V-5631, V-5630, V-1334, and V-1333.
4. Change the line blind.
   a. Carefully loosen the flange studs at the inlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
   b. Rotate the blind so that the water inlet is blanked and the acid inlet is open.
   c. Retighten the studs on the line-blind flanges.
5. Close all drain valves.

Isolate the outlet side of the demineralizer with the line blind

1. Make sure the caustic inlet valve, V-6005, is closed.
2. Anion-bypass valve, V-1286, should already be closed.
3. Open the drain valves on each side of the outlet line blind, V-6024, V-6025, V-1331, and V-1332.

4. Change the line blind.
   a. Carefully loosen the flange studs at the outlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
   b. Rotate the blind so that the water outlet is blanked and the caustic inlet is open.
   c. Retighten the studs on the line-blind flanges.
5. Close all drain valves.

Backwash the cation bed

1. Open the process water supply valve, V-1649.
2. Open V-1637 and V-1638 around the water rotometer FI-474.
3. Close the anion-inlet valve V-1239.
4. Anion-inlet valve, V-1335, should already be open.
5. Cation-exit valve, V-1240, should already be open.
6. Open cation-backwash-exit valve V-1247.
7. Open cation-drain valve V-1310.
8. Slowly open V-1267 to the ILW system. Observe the flow on rotometer FI-474. Set the backwash flow rate at 118 gpm.
9. Continue the backwash for 10 min and then close the following valves:
   a. Process water supply, V-1649.
   b. ILW drain, V-1267.
   c. Cation exit, V-1240.
   d. Backwash exit, V-1247.

Regenerate the cation bed

1. Open V-5617 and V-5618 around the 5%-HNO_3 rotometer, FI-472.

2. Open acid-inlet valve V-5606.
3. Open cation-drain valve V-1251.
4. Slowly open drain valve V-1267 to the ILW system. Observe rotometer FI-472 (located on wall above drain valve) and set the acid flow rate at 30 gpm.
5. Continue acid injection for approximately 20 min at 30 gpm (615 gal of 5% HNO_3) and then close the following valves:
   a. Acid rotometer, V-5617 and V-5618.
   b. Drain, V-1267.
   c. Acid inlet, V-5606.

Rinse the cation bed

1. Open the demineralized water supply valves on each side of backflow preventer Sp-01-1 in line 1619.
2. Open cation-bypass valve V-1238.
3. Open cation-inlet valve V-1237.
4. Slowly open ILW drain valve V-1267. Observe the water rotometer FI-474 and set the initial rinse flow rate at 50 gpm.
5. Continue the initial rinse at 50 gpm for approximately 17 min (approximately 865 gal of water).
6. Close ILW drain valve V-1267.
7. Set the final rinse flow rate at 75 gpm by opening the process waste drain valve, V-1266, and observing the water rotometer FI-474.
8. Continue the rinse at 75 gpm for 30 min, then start sampling the bed effluent. Rinse until the effluent pH becomes constant.

9. When the rinse is completed, close the following valves:
   a. Demineralizer water supply valves on each side of backflow preventer Sp-01-1 in line 1619.
   b. Process waste drain, V-1266.
   c. Cation bypass, V-1238.
   d. Cation inlet, V-1237.
   e. Cation drain, V-1251 and V-1310.

Backwash the anion bed

1. Open the process-water valve, V-1649, to the water rotometer FI-474.
2. Open the anion-bypass valve, V-1286.
3. Open the anion-exit valve, V-1336.
4. Open the backwash-exit valve, V-1245.
5. Slowly open the drain valve, V-1267, to the ILW system. Set the backwash flow rate at 40 gpm.
6. Continue to backwash the unit for 10 min and then close the following valves:
   a. Process-water supply, V-1649.
   b. ILW drain, V-1267.
   c. Anion inlet, V-1335.
   d. Anion bypass, V-1286.
   e. Anion-backwash exit, V-1245.

Regenerate the anion bed

1. Open V-6014 and V-6015 around the 5%-caustic rotometer FI-473.
2. Open the caustic inlet valve, V-6005.
3. Open the anion-drain valve, V-1287.
4. Slowly open ILW drain valve, V-1267. Observe the caustic

rotometer FI-473 and set the caustic flow at 25 gpm.

5. Continue the caustic flow for approximately 37 min or until 915 gal of 5% caustic have been injected; then close the following valves:
   a. Caustic rotometer, V-6014 and V-6015.
   b. ILW drain, V-1267.
   c. Caustic inlet, V-6005.

Rinse the anion bed

1. Open the valves on each side of backflow preventer Sp-01-1 in the demineralizer water line, 1619, to water rotometer FI-474.
2. Open anion-inlet valve, V-1239.
3. Slowly open ILW drain valve V-1267. Observe the rinse flow on water rotometer FI-474. Set the initial rinse flow rate at 25 gpm.
4. Continue rinsing to the ILW at 25 gpm for approximately 35 min (865 gal of rinse water) and then increase the flow:
   a. Close ILW drain, V-1267.
   b. Slowly open the process-waste drain, V-1266, until a flow rate of 75 gpm is observed on FI-474.
5. Rinse at 75 gpm for 30 min then start checking the effluent pH periodically. Continue the rinse until the pH becomes constant and then close the following valves.
   a. Valves on each side of backflow preventer Sp-01-1 in demineralized-water line 1619.
   b. Process-waste drain, V-1266.
   c. V-1637 and V-1638 around water rotometer FI-474.

Recycle the cation and anion units

1. Open the recycle inlet, V-1250, to the cation unit.
2. Open the cation exit, V-1240.
3. Open the anion inlet, V-1335.
4. Open the pool demineralizer recycle pump (PU-12) suction valve, V-1246.
5. Start the demineralizer recycle pump, PU-12.
6. Continue recycling until the anion effluent has a minimum resistance of 750,000 ohm-cm and a maximum pH of 7, then close the following valves:
   a. Recycle pump-suction valve, V-1246.
   b. Recycle inlet valve, V-1250, to the cation unit.
   c. Anion drain valve, V-1287.

Return the cation inlet line blind to "normal flow" position

1. Block valves on each side of the inlet line blind should already be closed - check them.
2. Open the drain valves on each side of the line blind, V-1334, V-1333, V-5630, and V-5631.
3. Change the line blind.
   a. Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
   b. Rotate the blind so that the acid inlet is blanked and the water inlet is open.
   c. Retighten the studs on the line-blind flanges.
   d. Close all drain valves.

Return the anion outlet lind blind to "normal flow" position

1. Close the anion-exit valve, V-1336.
2. Open the drain valves on each side of the outlet line

blind, V-1331, V-1332, V-6024, and V-6025.

3. Change the line blind.
   a. Carefully loosen the flange studs at the outlet line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
   b. Rotate the blind so that the caustic outlet is blanked and the water inlet is open.
4. Close all drain valves.

Put the regenerated unit "on stream"

1. Open the cation-inlet valves, V-1236 and V-1237.
2. Open the anion-outlet valves, V-1336 and V-1241.

   NOTE: If the unit is not to be put in service immediately after regeneration, the above valves should remain closed. However, before the unit is put in service, it should be recycled until the effluent water meets specifications.

6.4.8 Filter Cleaning

Both the prefilter and the after-filter are designed to be cleaned by backwashing with system water. The prefilter can also be backflushed with acid, caustic, or steam; but these are used only when a water backwash is not effective. Filters are cleaned as follows:

Prefilter

1. Bypass the filter per procedure 6.4.6.1.
2. Open exit valve, V-1235.
3. Open V-1276 to the ILW drain. If more flow through the filter is desired, close demineralizer-inlet valve, V-1236.

   NOTE: It is very important that this valving arrangement

not be used for longer than 1 min. This should be sufficient time to flush the filter without upsetting system flows excessively.

4. Close the ILW drain valve, V-1276, and open the demineralizer-inlet valve, V-1236, if it was closed.
5. Open the filter inlet, V-1232.
6. Close the filter bypass, V-1283.
7. Check the pressure drop across the filter. If it is less than 20 psi, the filter can remain in service; if it is more than 20 psi, follow the procedure for chemical cleaning.

After-filter

1. Bypass the filter per procedure 6.4.6.5.
2. Open the backwash-inlet valve, V-1286.
3. Open the backwash-outlet valve, V-1271, to the ILW drain.
4. Continue the backwash for no longer than 5 min and then put the filter in service:
   a. Close the ILW drain, V-1271.
   b. Close the backwash valve, V-1286.
   c. Open the filter-inlet valve, V-1242.
   d. Open the filter-outlet valve, V-1243.
   e. Close the filter-bypass valve, V-1284.
5. Check the pressure drop across the filter. If it is less than 10 psi, the filter can remain in service. If it is greater than 10 psi, repeat the backwash procedure.

Chemical cleaning of the prefilter

1. Bypass the filter per procedure 6.4.6.1.

2. Isolate the filter inlet with the line blind.
   a. Make sure the acid, V-5608, caustic, V-6008, and steam, V-5651, block valves are closed.
   b. Open the drain valves on each side of the inlet line blind, V-1327, V-1328, V-5627, and V-5628.
   c. Change the line blind.
      (1) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
      (2) Rotate the blind so that the water inlet is blanked and the chemical inlet is open.
      (3) Retighten the studs on the line-blind flanges.
   d. Close all drain valves.
3. Isolate the outlet of the filter with the line blind.
   a. Open the drain valves on each side of the outlet line blind, V-1329, V-1330, and V-5629.
   b. Change the line blind.
      (1) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.
      (2) Rotate the blind so that the water outlet is blanked and the chemical inlet is open.
      (3) Retighten the studs on the line-blind flanges.
   c. Close all drain valves.

4. Displace the water in the filter with steam.
   a. Open the drain valve, V-1276.
   b. Close the vent valve, V-1280.
   c. Open the steam inlet V-5651. Allow steam to flow into the filter for not more than 5 min and then close the steam inlet V-5651.
5. Fill the filter with caustic.
   a. Close the filter-drain valve, V-1276.
   b. Open the vent valve, V-1280.
   c. Start the caustic pump and open valves V-6014 and V-6015 at caustic rotometer FI-473.
   d. Open the caustic inlet valve, V-6008.
   e. Observe air venting from the filter through flow gauge FG-480. When the air stops venting, the filter is full of caustic and V-6008 can be closed.
   f. Stop the caustic pump and close the rotometer valves V-6014 and V-6015.
   g. Allow the caustic to remain in the filter at least 1 h before proceeding to the next step.
6. Fill the filter with acid.
   a. Close the filter drain valve, V-1276.
   b. Open the vent valve, V-1280.
   c. Start the acid pump and open valves V-5617 and V-5618 at acid rotometer FI-472.
   d. Open the acid inlet valve, V-5608.
   e. Observe air venting from the filter through flow gauge FG-480. When air stops venting, the filter is full of acid and V-5608 can be closed.

f. Stop the acid pump and close the rotometer valves, V-5617 and V-5618.

g. Allow the acid to remain in the filter at least 1 h before proceeding to the next step.

7. Displace the chemical with steam.

a. Open the filter-drain valve, V-1276.

b. Close the filter-vent valve, V-1280.

c. Open the steam-inlet valve, V-5651. Allow steam to flow into the filter for not more than 5 min and then close the steam-inlet valve, V-5651.

8. Backwash the chemical from the filter.

a. Close the filter drain valve, V-1276.

b. Open the filter-vent valve, V-1280.

c. Switch the line blind on the filter outlet.

(1) Open the drain valves on each side of the outlet line blind, V-1329, V-1330, and V-5629.

(2) Rotate the line blind (handle the pipe carefully; it may be hot).

(a) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(b) Rotate the blind so that the chemical inlet is blanked and the water outlet is open.

(c) Retighten the studs on the line-blind flanges.

(3) Close all drain valves.

d. Open the filter-outlet valve, V-1235. This will permit the filter to fill with water. Wait until the air stops venting in flow gauge FG-480 before proceeding to the next step.

e. Open the filter-drain valve, V-1276. This backwashes the filter with pool cleanup system water.

f. After backwashing the filter for 5 min, start sampling the effluent, via sample valve V-1385, and analyzing for pH. When the pH drops below 7.0, discontinue the backwash by closing drain valve V-1276 and outlet valve V-1235.

9. Return the filter to service.

a. Rotate the line blind on the filter inlet.

(1) Open the drain valves on each side of the inlet line blind, V-1327, V-1328, V-5627,and V-5628.

(2) Change the line blind.

(a) Carefully loosen the flange studs at the line blind. If any leakage of water under pressure is observed, retighten the studs and check the valving.

(b) Rotate the blind so that the water inlet is open and the chemical inlet is closed.

(c) Retighten the studs on the line-blind flanges.

(3) Close all drain valves.

b. Open the filter-inlet valve, V-1232.

c. Open the filter-outlet valve, V-1235.

d. Close the filter bypass valve, V-1283.

e. Check the pressure drop across the filter. If it is less than 20 psi, the filter can remain in service. If it is more than 25 psi, repeat the procedure "Chemical Cleaning of Prefilter," Section 6.4.8.

6.5. Secondary Coolant Systems

6.5.1 References

Drawings:

1546-05-E-2118 Elementary Control Diagrams - Process Water System

1546-I-4007 Instrument Application Diagram - Secondary Coolant System

1546-M-5502 Engineering Flow Diagram - Secondary Coolant System

1546-U-7147 Flow Diagram - Chemical Treatment System

Singmaster & Breyer Specifications: Section 66 Secondary Coolant System
Section 49 Cooling Tower
Section 81 Chemical Treatment

6.5.2 Introduction

The plant heat load from the primary and pool heat exchangers, the air conditioning systems and other auxiliary equipment is absorbed by the secondary coolant system which includes the cooling tower, the cooling tower pumps and the coolant loop piping. Heat loads of the

reactor coolant and pool coolant loops are transferred to the secondary coolant system through the secondary side of their respective heat exchangers. The secondary system circulates approximately 26,000 gpm of cooling water through the process equipment and over a cooling tower which has a maximum design capacity of 380 x 10^6 Btu/h at an average on-tower water temperature of 115°F. Cooling water is pumped from the tower basin through the shell side of the primary exchangers and through the tube side of the pool exchangers.

Of the 380,000,000 Btu/h normal load on the cooling tower, 350,000,000 Btu/h comes from the reactor primary loop, 10,000,000 Btu/h from the pool loop, 8,000,000 Btu/h from the air conditioning, 3,000,000 Btu/h from other auxiliary loads, and 9,000,000 Btu/h tower capacity is reserved for future loads. The coolant loop is designed for reactor operations at 100 MW with provision for future expansion to permit operation at 125 MW (see Figs. 6.11 and 6.12).

6.5.3 Precautions

The principle hazards associated with the secondary system involve the chemicals used to treat the water. These chemicals are very toxic and the following precautions should be strictly observed.

Biocides. Various biocides, such as sodium hyperchlorite and commercial preparations, are used to control microorganisms in the secondary water. All of these chemicals have the common property of being poisonous to both microorganisms and people. Contact with the skin, eyes, and clothing should be prevented. In case of contact, immediately flush with large amounts of water. Avoid breathing dust or solution spray. The liquids are flammable and should not be exposed to open flames or excessive heat.

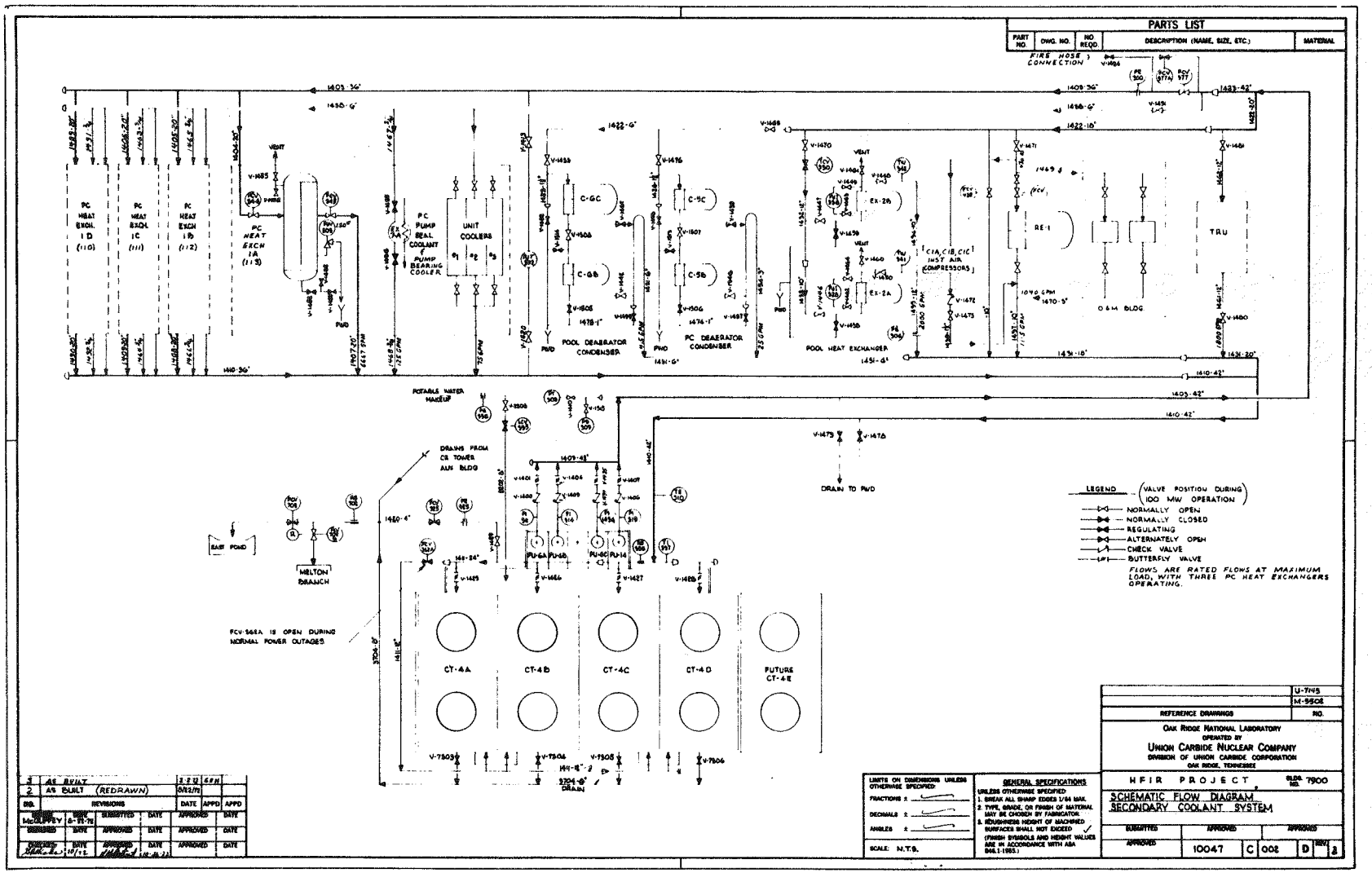


Fig. 6.11. Schematic flow diagram secondary coolant system.

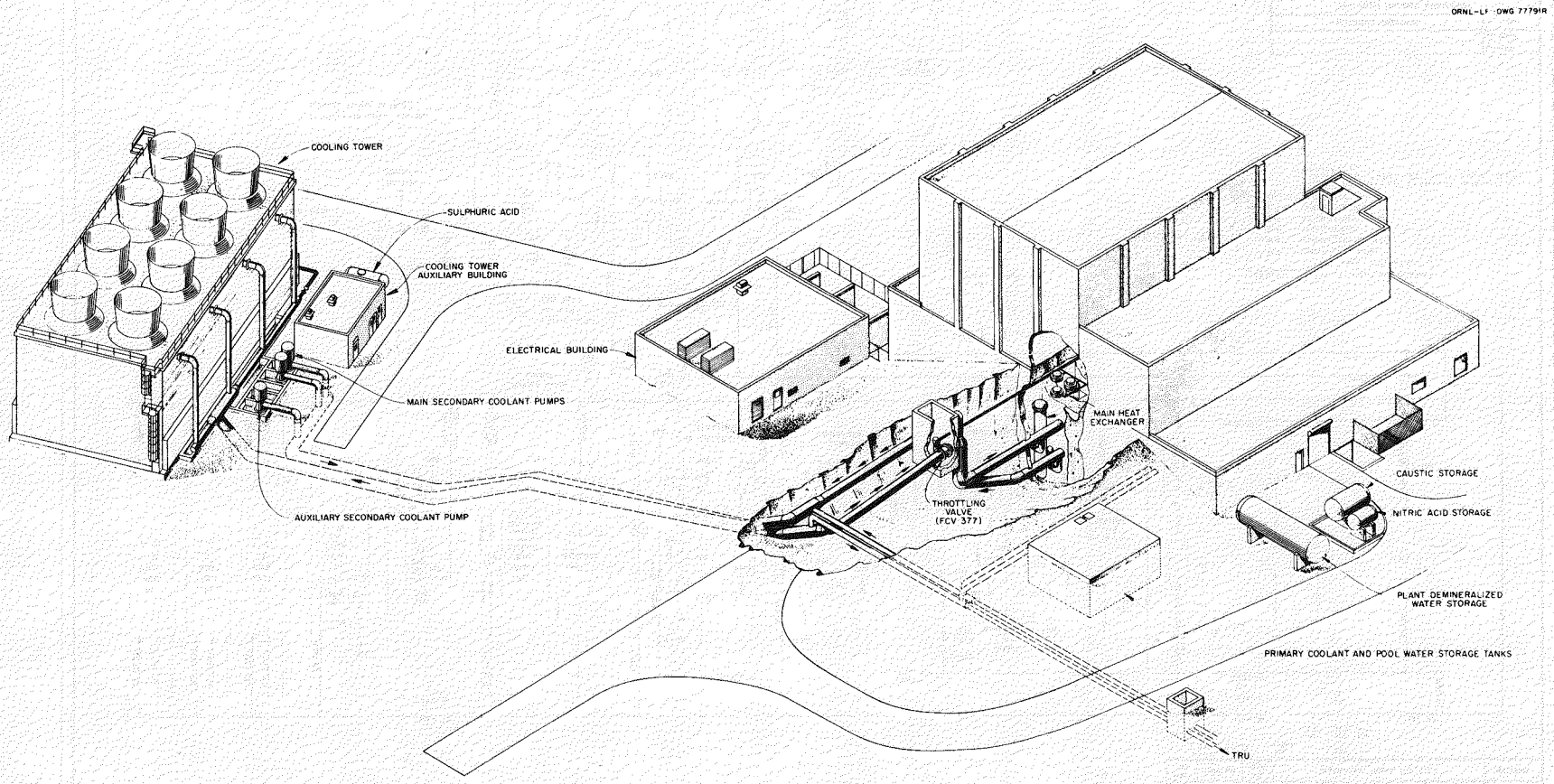


Fig. 6.12. Secondary coolant system.

Corrosion inhibitors. The corrosion inhibitors protect metals in the system from corrosion. They cause local irritation of mucous membranes and skin. They produce harmful effects if swallowed or inhaled. In case of contact with the skin, flush the area with water; for eyes, flush with water for at least 15 min and get medical attention.

Sulfuric acid. Concentrated sulfuric acid is used to control the pH of the secondary system. This material is extremely corrosive to human tissue. Avoid contact with skin, eyes, and clothing. Do not breathe fumes. In case of contact, immediately flush with water and get medical attention.

Secondary flow through primary heat exchangers. Due to the possibility of tube rupture from vibrations caused by excessive secondary flow, a limit of 6,000 gpm through each heat exchanger has been established. The total permisible secondary flow rate through three heat exchangers is 18,000 gpm. If, during adverse weather conditions, it is not possible to restrict the flow rate to these values, the reactor power should be lowered.

6.5.4 To circulate secondary water

NOTE: This procedure assumes that the secondary coolant system has been filled and has received its preoperational cleaning.

1. Open the weir gates from each tower basin to allow water to flow into the pump flume.
2. Make sure manual block valves V-2208 and V-2207, in process water makeup line 2202, are open.
3. Open the main circulating-pump-discharge butterfly valves, V-1401, V-1435, and V-1404.

4. Open the auxiliary-pump-discharge butterfly valve, V-1407.
5. Set the controller for automatic-flow-control valve FCV-377 in "manual" mode and open the valve.

   NOTE: As indicated in the standby checks, the controller for FCV-377A must be placed in "auto" mode before starting the reactor.
6. Open the butterfly valves in the risers to the individual tower cells, V-1425, V-1426, V-1427, and V-1428.
7. Start the main circulating pumps.
   a. Place selector switch SS-4 (located in the control room) in position to choose the third pump as a spare.
   b. Manually start each circulating pump with its start switch in the control room.
   c. Check the secondary flow to the main heat exchangers on FI-300 in the control room. It should indicate a maximum of 18,000 gpm when three heat exchangers are valved in or 6,000 gpm per heat exchanger.

6.5.5 Adjust blowdown flow

1. Open manual valve V-1429 in blowdown line 1420.
2. Set the blowdown controller for a concentration ratio wanted and place it in "cascade" mode.

   NOTE: This controller changes the blowdown flow in relation to the makeup water flow rate to hold a set concentration cycle.

6.5.6 Chemical Treatment

1. pH control
   a. Open outlet valve V-5802 from the H_2SO_4 storage tank.

b. Open the H_2SO_4 metering pump inlet valves, V-5804 and V-5806.

c. Open the H_2SO_4 metering pump exit valves, V-5805 and V-5807.

d. Open the acid mixer acid-inlet valve, V-5808.

e. Open the valves at the backflow preventer on water inlet line 2208 to the acid mixer.

f. Open the water-supply valve, V-2209, in line 2203.

g. Adjust the water flow to the acid mixer to 50 gpm, as indicated on rotometer FI-320, with valve V-2212.

h. Set the control point of secondary coolant pH controller ApH-C-331 and place the controller in "auto" mode.

i. Start both of the H_2SO_4 metering pumps, 05-415-PU-1A and -1B, with the local "start" switches.

j. Check the pH of the secondary water with a portable pH meter and compare the result with the automatic monitors.

6.5.7 Deicing of cooling tower

In subfreezing weather, ice tends to form on the louvers at the base of the cooling tower. If this ice is permitted to accumulate unchecked, structural damage to the cooling tower can result. Therefore, it is essential that the cooling tower be checked for ice at least twice per shift in subfreezing weather. If ice formations appear to be increasing, the cooling tower fans should be periodically reversed.

The following procedure should be used for reversing the fans:

1. Both fans in a cooling-tower cell should be reversed at the same time. Select the cell which is to be deiced first and turn very slowly both its fan mode switches (located on process panel board in the control room) to "run" mode. Fans will stop when switching from "auto" to "run."
2. Press the "slow-reverse" pushbuttons of fans to be reversed. NOTE: A time delay of two minutes is built into the circuit before the motors can be reversed. This gives the fan blades time to stop.
   Allow fans to run in reverse until the cell louvers are deiced.
   Inspect tower to make sure ice has melted.
3. Return the fans to normal operation by turning the mode switch to "auto." There is a two minute time delay in the circuit before normal operation is resumed.
   CAUTION: Wait for normal operation of the fans to resume before proceeding with the reversal of other fans.
4. If other cooling-tower cells require deicing, proceed as in steps 1, 2, and 3 above.

6.6 Fill and Drain Systems

6.6.1 References

Drawings:

1546-01-M-5501 Engineering Flow Diagram - Pool Coolant

1546-01-M-5512 Piping Arrangement Plan - Ground Floor

1546-01-M-5514 Piping Arrangement Plan - Ground Floor

1546-01-M-5534 Primary Coolant Low Pressure System Flow Diagram

1546-01-M-5541 Primary Coolant High Pressure System Flow Diagram

1546-05-U-7113 Utility Plan Yard Piping

Signmaster & Breyer Specifications: Section 71 Pool Coolant System

6.6.2 Introduction

It is necessary to be able to lower the water safely in any (or all) of the pools for maintenance or experiment installation. A 55,000-gal underground storage tank and the associated piping, valves, and pumps has been provided for this operation. Underground storage space is also provided for 20,000 gal of primary water in the event this system should ever need to be drained. Separate lines and pumps are provided for the primary system water.

6.6.3 Precautions

It is essential that sufficient water shielding be maintained above radioactive materials stored in the pools. When water is being drained from the pools or the primary system, the water level must be

monitored by an observer at the poolside. The clean and critical pools can be drained only to the 835-ft level directly, but the reactor pool can be drained almost completely if the valves are not properly set. The radiation level should be checked closely during a draining operation and before any entry is made into a drained pool.

6.6.4 Drain water from pool to storage tank

1. Set the valves at the pool coolant pump manifolds. (Select the pump not in service. This procedure will apply to the "A" pump with valve numbers for the "B" pump in parentheses.)
   a. Open V-1211 (V-1212) from pool drain line to pump suction.
   b. Open V-1210 (V-1209) discharge valve in line to storage tank.
2. Set the valves in the pipe tunnel on the ground floor.
   a. To drain the reactor pool:
      (1) Open V-1204.
      (2) Close V-1244, V-1271, and FCV-464.
   b. To drain the clean pools:
      (1) Open V-1208.
      (2) Close V-1273, V-1272, FCV-465, and FCV-466.
   c. To drain the critical pool:
      (1) Open V-1207.
      (2) Close V-1270 and FCV-467.
3. Open the flow control valve from the pool to be drained (valve controls are in the control room).
   a. Open FCV-464 to drain the reactor pool.

b. Open FCV-465 to drain the west clean pool.

c. Open FCV-466 to drain the east clean pool.

d. Open FCV-467 to drain the critical pool.

4. Start the pool coolant pump which has been valved as a drain pump in step 1.

5. Closely observe both the pool water level and radiation level as the water drops.

6. When water reaches the desired level, stop the drain pump, close the automatic flow control valve, and return all other valves to their normal positions.

6.6.5 Fill pools from storage tanks

1. Set the valves at the pool pump manifold. (Select the pump not in service. This procedure will apply to the "A" pump with valve numbers for the "B" pump in parentheses.)

a. Open V-1200 (V-1201) in the suction line from the storage tank.

b. Open V-1206 (V-1203) in the pool fill and drain line.

2. Set the valves in the pipe tunnel on the ground floor.

a. To fill the reactor pool:

(1) Open V-1204.

(2) Close V-1244, V-1271, and FCV-464.

b. To fill the clean pools:

(1) Open V-1208.

(2) Close V-1273, V-1272, FCV-465, and FCV-466.

c. To fill the critical pool:

(1) Open V-1207.

(2) Close V-1270 and FCV-467.

3. Start the pool coolant pump which has been valved as a fill pump in step 1.
4. Open the flow control valve from the pool to be filled (valve controls are in the control room).
   a. Open FCV-464 to fill the reactor pool.
   b. Open FCV-465 to fill the west clean pool.
   c. Open FCV-466 to fill the east clean pool.
   d. Open FCV-467 to fill the critical pool.
5. Observe the pool water level as it rises.
6. When water reaches the desired level, stop the fill pump, close the flow control valve, and return all other valves to their normal positions.

6.6.6 Drain reactor system to storage tank

NOTE: This procedure is extremely dangerous since an irradiated fuel element could be exposed. The valves involved are locked to prevent unauthorized tampering. The required administrative approvals must be obtained before draining the reactor system.

1. Set the valves at the primary cleanup pumps. (Either pump can be used. This procedure is for the "A" pump with valve numbers for "B" pump in parentheses.)
   a. Open V-1042, in the line to the storage tank.
   b. Open V-1016 (V-1019) pump-discharge valve.
   c. Open V-1014 (V-1013) pump-suction valve.
   d. Unlock and open HCV-1003, located in the pipe tunnel, and V-1004 on the suction manifold of the pumps.

   NOTE: These valves are in line 1012 which connects

directly to line 1000, the exit water line from the reactor vessel.

2. Station an observer at poolside to monitor both water level and radiation level in the reactor vessel.
3. Start the cleanup pump which was valved as a primary drain pump in Step 1.
4. When water drops to the desired level in the reactor vessel, stop the drain pump.
5. Close and relock HCV-1003 and V-1004.
6. Return other valves to their normal positions.

6.6.7 Fill reactor system from storage tank

1. Set the valves at the primary cleanup pumps. (Either pump can be used. This procedure is for the "A" pump with valve numbers for "B" pump in parentheses.)
2. Fill the deaerator to >50% full, then close its outlet valve, V-1012.
3. Open V-1041, in the line from the storage tank.
4. Open V-1014 (V-1013) pump-suction valve.
5. Open V-1016 (V-1019) pump-discharge valve.
6. Add water to the primary system through the primary cleanup loop.
   a. Start the cleanup pump.
   b. Place the cleanup loop filters and demineralizers in service or bypass them per Section 6.2.
   c. Start a pressurizer pump and add water to the primary system after the level starts rising in the primary head tank. Keep the level in the head tank above the

setpoint of the demineralized water makeup system. The head tank and pressurizer pumps can be bypassed and water added directly to the primary tank by:

(1) Closing the head tank inlet valve, V-1040.

(2) Opening the pressurizer pump bypass valve, V-1039.

7. When sufficient water has been added to the primary system, stop the pumps and return all valves to normal position.

6.7. Miscellaneous Heat Exchanger Maintenance Procedure

6.7.1 Drain and fill secondary and/or primary side of the primary heat exchangers

1. PRECAUTIONS: During reactor operation the heat-exchanger cells are extremely radioactive. They can be entered only when the heat exchanger and pump are valved out of the system or when the reactor is shutdown. The heat exchangers cells must be carefully monitored for radiation before entry. Precautions should also be taken to prevent contamination on floors and equipment.
2. Isolate the heat exchanger-pump combination
   a. Close the motor operated block valve in the primary inlet water line to the heat exchanger with the manual switch in the control room.
      (1) FCV-140 to "A" unit, Cell 113
      (2) FCV-142 to "B" unit, Cell 112
      (3) FCV-144 to "C" unit, Cell 111
      (4) FCV-550 to "D" unit, Cell 110

b. Close the motor operated block valve in the primary pump outlet line with the manual switch in the control room.
   (1) FCV-149 from "A" unit, Cell 113
   (2) FCV-151 from "B" unit, Cell 112
   (3) FCV-153 from "C" unit, Cell 111
   (4) FCV-551 from "D" unit, Cell 110

c. Close the air operated pressure equalizing valve in the 3/4-in. bypass lines around the heat exchanger inlet block valve with the manual switch in the control room.
   (1) HCV-180-A to "A" unit, Cell 113
   (2) FCV-181-A to "B" unit, Cell 112
   (3) FCV-182-A to "C" unit, Cell 111
   (4) FCV-583-A to "D" unit, Cell 110

d. Stop the seal water flow to the pump.
   (1) Close the two Autoclave flow regulating valves in the seal feed line from the main pressurizer pump, located near the cell entrance.
      (a) HV-164 and HV-164-A to the "A" unit, Cell 113
      (b) HV-165 and HV-165-A to the "B" unit, Cell 112
      (c) HV-166 and HV-166-A to the "C" unit, Cell 111
      (d) HV-557 and HV-557-A to the "D" unit, Cell 110
   (2) Block the seal water flow path from emergency pressurizer pump PU-11 by closing the block valves on each side of the seal inlet-water rotometer.
      (a) V-1066 and V-1067 to the "A" unit, Cell 113
      (b) V-1064 and V-1065 to the "B" unit, Cell 112
      (c) V-1062 and V-1063 to the "C" unit, Cell 111
      (d) V-196 and V-197 to the "D" unit, Cell 110

3. Drain the secondary side of the heat exchanger to the process waste sump.

   a. Close the secondary isolation valves to the heat exchanger.

      (1) FCV-344 and 345 for the "A" unit, Cell 113

      (2) FCV-346 and 347 for the "B" unit, Cell 112

      (3) FCV-348 and 349 for the "C" unit, Cell 111

      (4) FCV-552 and 553 for the "D" unit, Cell 110

   b. Make sure the shell drain valve, at the bottom of the heat exchanger which empties onto the floor, is closed.

      (1) V-1482 for the "A" unit, Cell 113

      (2) V-1484 for the "B" unit, Cell 112

      (3) V-1486 for the "C" unit, Cell 111

      (4) V-1531 for the "D" unit, Cell 110

   c. Open the two shell drain valves at the bottom of the heat exchanger which empty into the closed line to the process waste sump.

      (1) V-1452* and V-1483 for the "A" unit, Cell 113

      (2) V-1453* and V-1485 for the "B" unit, Cell 112

      (3) V-1454* and V-1487 for the "C" unit, Cell 111

      (4) V-1530* and V-1532 for the "D" unit, Cell 110

      NOTE: Valves marked with an asterisk (*) may be operated from the upper grating level by a lazy rod which extends down to the valve at the bottom of the heat exchanger.

   d. Slowly open the shell vent valve located at the upper grating level.

      (1) V-1455 for the "A" unit, Cell 113

      (2) V-1456 for the "B" unit, Cell 112

      (3) V-1457 for the "C" unit, Cell 111

      (4) V-1528 for the "D" unit, Cell 110

e. The secondary side should now drain. Note that the process waste sump will fill and jet empty, at intervals, as the heat exchanger drains.

4. Refill the secondary side of the primary heat exchangers

a. Make sure the shell drain valves, at the bottom of the heat exchanger, are closed.

(1) V-1452, V-1482, and V-1483 on the "A" unit, Cell 113

(2) V-1453, V-1484, and V-1485 on the "B" unit, Cell 112

(3) V-1454, V-1486, and V-1487 on the "C" unit, Cell 111

(4) V-1530, V-1531, and V-1532 on the "D" unit, Cell 110

b. Partially open the heat exchanger secondary cooling-water-inlet block valve with the manual switch in the control room.

(1) FCV-344 to the "A" unit, Cell 113

(2) FCV-346 to the "B" unit, Cell 112

(3) FCV-348 to the "C" unit, Cell 111

(4) FCV-552 to the "D" unit, Cell 110

c. As the shell fills with secondary water, vent the air from the heat exchanger by cracking the vent valve until all the air is displaced and water appears. Then close the vent valve tightly. Do not stand in front of the vent valve while venting.

(1) V-1455 for the "A" unit, Cell 113

(2) V-1456 for the "B" unit, Cell 112

(3) V-1457 for the "C" unit, Cell 111

(4) V-1528 for the "D" unit, Cell 110

5. Drain the primary side of the primary heat exchangers

PRECAUTIONS: High pressure water must be handled with care. When draining or venting high pressure equipment, never stand in front of an outlet. Always open valves slowly. It should always be assumed that the high pressure water is contaminated. Proper radiation and contamination precautions must be taken.

a. Observe precautions in Step 1 above.

b. Isolate the heat-exchanger-pump combination, to be drained, per procedures in Steps 2a through 2d above.

c. Slowly open the pump bowl drain-vent valves (two valves in series.)

(1) V-1137 and V-1137-A for "A" unit, Cell 113

(2) V-1135 and V-1135-A for "B" unit, Cell 112

(3) V-1011 and V-1011-A for "C" unit, Cell 111

(4) V-203 and V-203-A for "D" unit, Cell 110

d. Slowly open the heat exchanger inlet plenum vent valves (two valves in series) located in 1-in. line at the top of the heat exchanger.

(1) V-1194 and V-1194-A for "A" unit, Cell 113

(2) V-1195 and V-1195-A for "B" unit, Cell 112

(3) V-1196 and V-1196-A for "C" unit, Cell 111

(4) V-189 and V-189-A for "D" unit, Cell 110

e. Slowly open the heat exchanger head drain valve located just above the head bolt flange near the grating level.

(1) V-1071 for "A" unit, Cell 113

(2) V-1072 for "B" unit, Cell 112

(3) V-1073 for "C" unit, Cell 111

(4) V-204 for "D" unit, Cell 110

Primary water will now drain from the unit between the top of the heat exchanger tube bundle and the pump exit line block valve, via the collection funnel and flow to the process waste sump.

6. Refill the primary (tube) side of the primary heat exchangers

a. Close the pump bowl drain-vent valves.

(1) V-1137 and V-1137-A for "A" unit, Cell 113

(2) V-1135 and V-1135-A for "B" unit, Cell 112

(3) V-1011 and V-1011-A for "C" unit, Cell 111

(4) V-203 and V-203-A for "D" unit, Cell 110

b. Open the seal water flow regulating valves in the seal feed supply line.

(a) HV-164 and HV-164-A to "A" unit, Cell 113

(b) HV-165 and HV-165-A to "B" unit, Cell 112

(c) HV-166 and HV-166-A to "C" unit, Cell 111

(d) HV-557 and HV-557-A to "D" unit, Cell 110

c. Open the block valves on each side of the seal inlet-water rotometer.

(1) V-1066 and V-1067 to the "A" unit, Cell 113

(2) V-1064 and V-1065 to the "B" unit, Cell 112

(3) V-1062 and V-1063 to the "C" unit, Cell 111

(4) V-196 and V-197 to the "D" unit, Cell 110

d. As seal water fills the heat exchanger head, vent the air from the tube bundle through the head drain valve until water appears in the collection funnel; then close the drain valve tightly.
   (1) V-1071 for the "A" unit, Cell 113
   (2) V-1072 for the "B" unit, Cell 112
   (3) V-1073 for the "C" unit, Cell 111
   (4) V-204 for the "D" unit, Cell 110

e. As the heat exchanger head continues to fill, vent the air from the inlet plenum through the vent valves at the top of the head until water appears in the collection funnel; then close the vent valves tightly.
   (1) V-1194 and V-1194-A for "A" unit, Cell 113
   (2) V-1195 and V-1195-A for "B" unit, Cell 112
   (3) V-1196 and V-1196-A for "C" unit, Cell 111
   (4) V-189 and V-189-A for "D" unit, Cell 110

f. Open the pump bowl drain-vent and vent air from the pump suction line and pump bowl until water appears in the collection funnel; then close the valves tightly.
   (1) V-1137 and V-1137-A for "A" unit, Cell 113
   (2) V-1135 and V-1135-A for "B" unit, Cell 112
   (3) V-1011 and V-1011-A for "C" unit, Cell 111
   (4) V-203 and V-203-A for "D" unit, Cell 110

g. Open the air operated pressure equalizing valve with the manual switch in the control room.
   (1) HCV-180-A to "A" unit, Cell 113
   (2) HCV-181-A to "B" unit, Cell 112

(3) HCV-182-A to "C" unit, Cell 111

(4) HCV-153-A to "D" unit, Cell 110

Adjust the seal feed flow and place the heat exchanger-pump combination in "standby" per normal procedure.

6.8. Hot Water Injection System

6.8.1 References

Drawings:

I-43930	Flow Diagram
P-43953	Piping Layout
D-49137	Flow Diagram

6.8.2 Introduction

The hot water injection system is used to test the response of the safety system by spraying hot water on the temperature sensors and observing the trip response in the control room (see Fig. 6.13).

6.8.3 Place the system into service

1. Open the following valves:
   a. HV-8
   b. HV-1126-C2
   c. HCV-1126-C1
   d. HCV-1126-A
2. Start the pressurizer pump and adjust speed so that the discharge pressure is approximately 100 psi.
3. Slowly open HV-6 until all the air is vented from HV-8. Close HV-8.

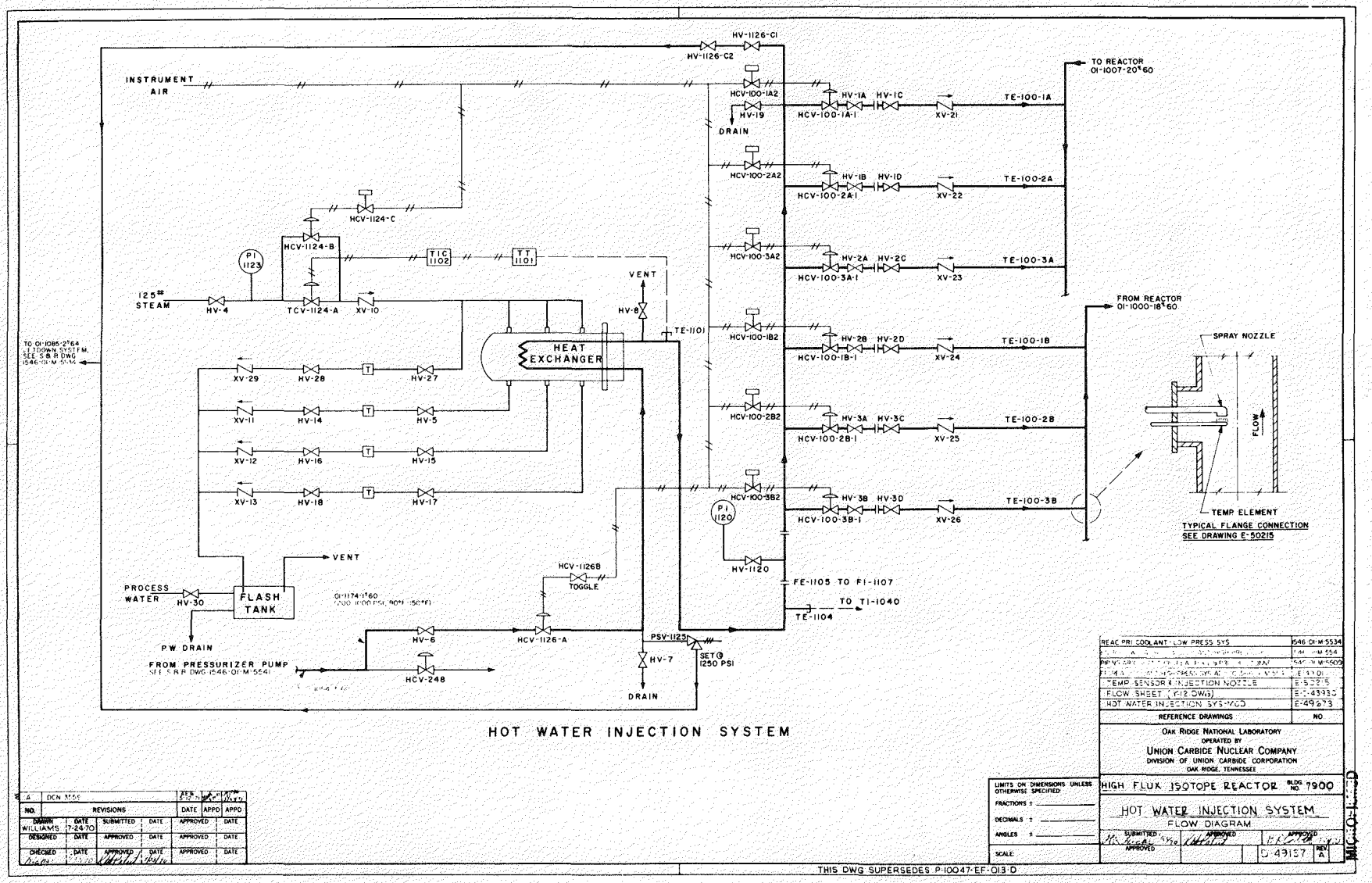


Fig. 6.13. Hot water injection system.

4. Close HV-1126-C1 and HV-1126-C2.
5. Open the following valves.
   a. HV-1A
   b. HV-1C
   c. HV-1B
   d. HV-1D
   e. HV-2A
   f. HV-2C
   g. HV-2B
   h. HV-2D
   i. HV-3A
   j. HV-3C
   k. HV-3B
   l. HV-3D
6. Drain steam from the heat exchanger by opening the following valves:
   a. HV-27
   b. HV-28
   c. HV-5
   d. HV-14
   e. HV-15
   f. HV-16
   g. HV-17
   h. HV-18
   i. HV-31 (Allow all water to drain from the strainer.)
7. Establish steam flow by slowly cracking open HV-4 until only steam is emitted from HV-31.

8. Close HV-31 and slowly open HV-4 until 125 psig in indicated on pressure indicator PI-1123.

   Allow at least 15 min for warmup.

Temperature indicator controller, TIC-1102, will then control the temperature of the exit water from the heat exchanger at 220°F. the system is now ready for operation as outlined in Section 3.1.3.

6.8.4 Remove the system from service

1. Close the following valves
   a. HV-4
   b. HV-6
   c. HV-1C
   d. HV-1D
   e. HV-2C
   f. HV-2D
   g. HV-3C
   h. HV-3D
2. To drain the system, open the following valves in the order listed:
   a. HV-8
   b. HV-1126-C1
   c. HV-1126-C2

7. CONTAINMENT: HEATING, VENTILATING, AND AIR CONDITIONING

7.1. SBHE System

7.1.1 References

Drawings:

1546-01-E-2115	Elementary Control Diagrams
1546-01-E-2114	Annunciators
1546-05-H&V-3001	Air Flow Diagrams
1546-05-H&V-3026	Building 7900 Equipment Schedule
1546-05-H&V-3052	Exhaust Stack Breeching and Fans
1546-05-H&V-3054	Filter Pit Details
RC-11-10-9	Instrument Application

Singmaster & Breyer Specifications:
- 59 Charcoal-Bed Filters
- 67 SBHE System and Exhaust Stack Breeching
- 100 Exhaust Stack
- 101 Heating, Ventilation, and Air Conditioning

7.1.2 Introduction

Containment of radioactive gases and vapors from a major reactor accident or a small-pipe rupture is provided by the SBHE system. Air is removed from potentially contaminated rooms in such a manner that all leakage is from clean areas to contaminated areas. This air is then filtered to remove radioactive contamination before being discharged through the exhaust stack (see Figs. 7.1, 7.2, 7.3, 7.4, and 7.5).

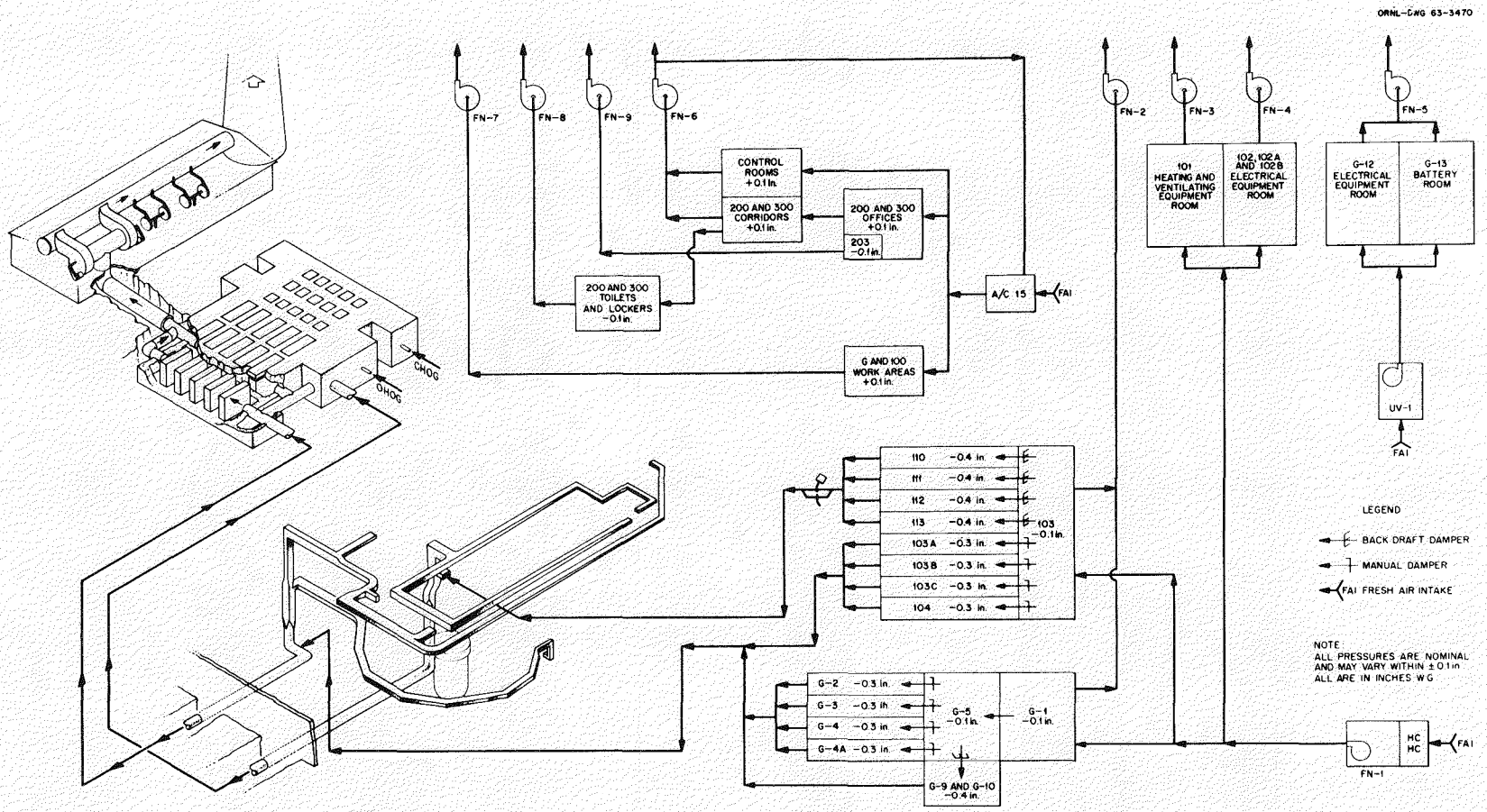


Fig. 7.1. Special building hot exhaust system.

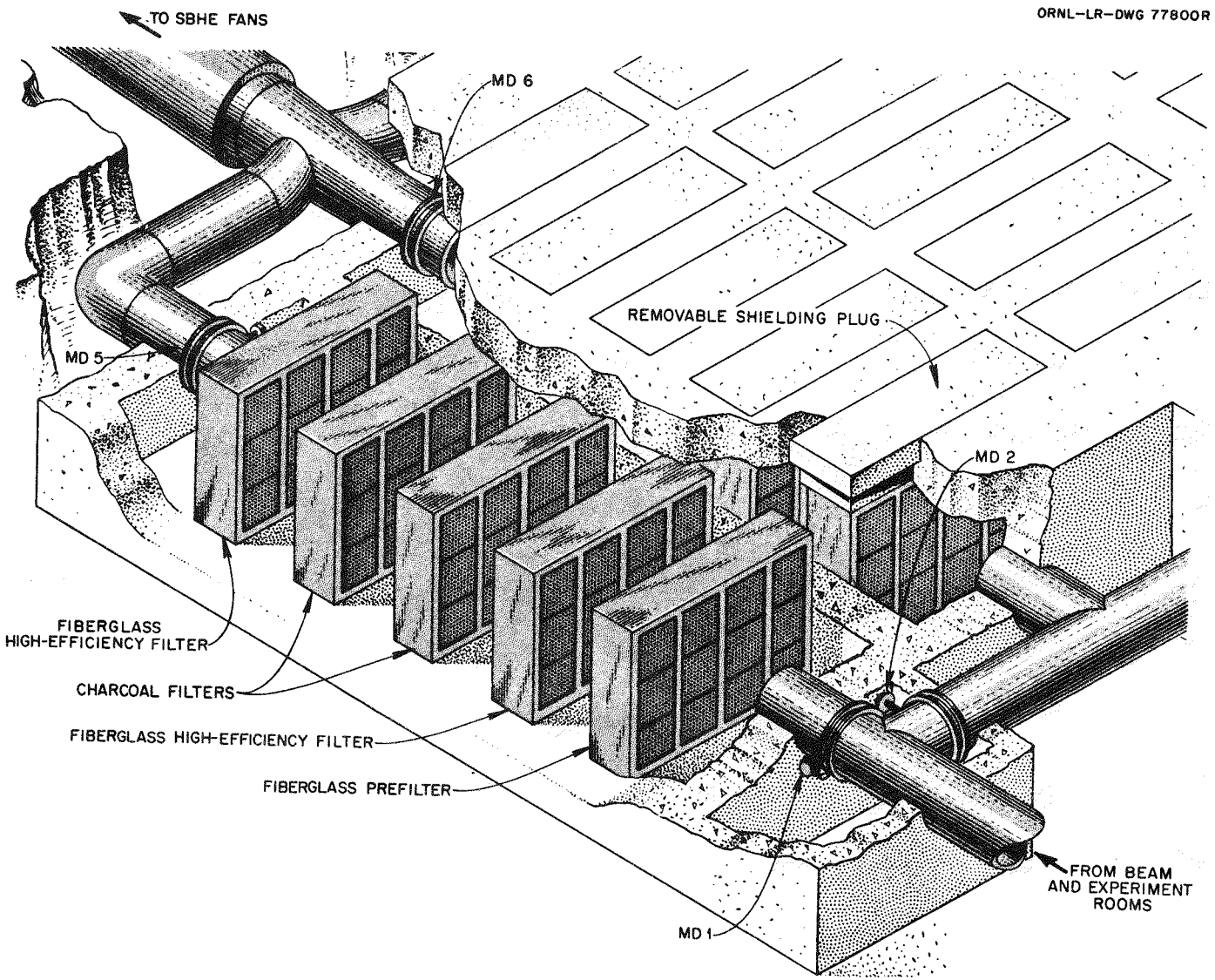


Fig. 7.2. Special building hot exhaust filter pit.

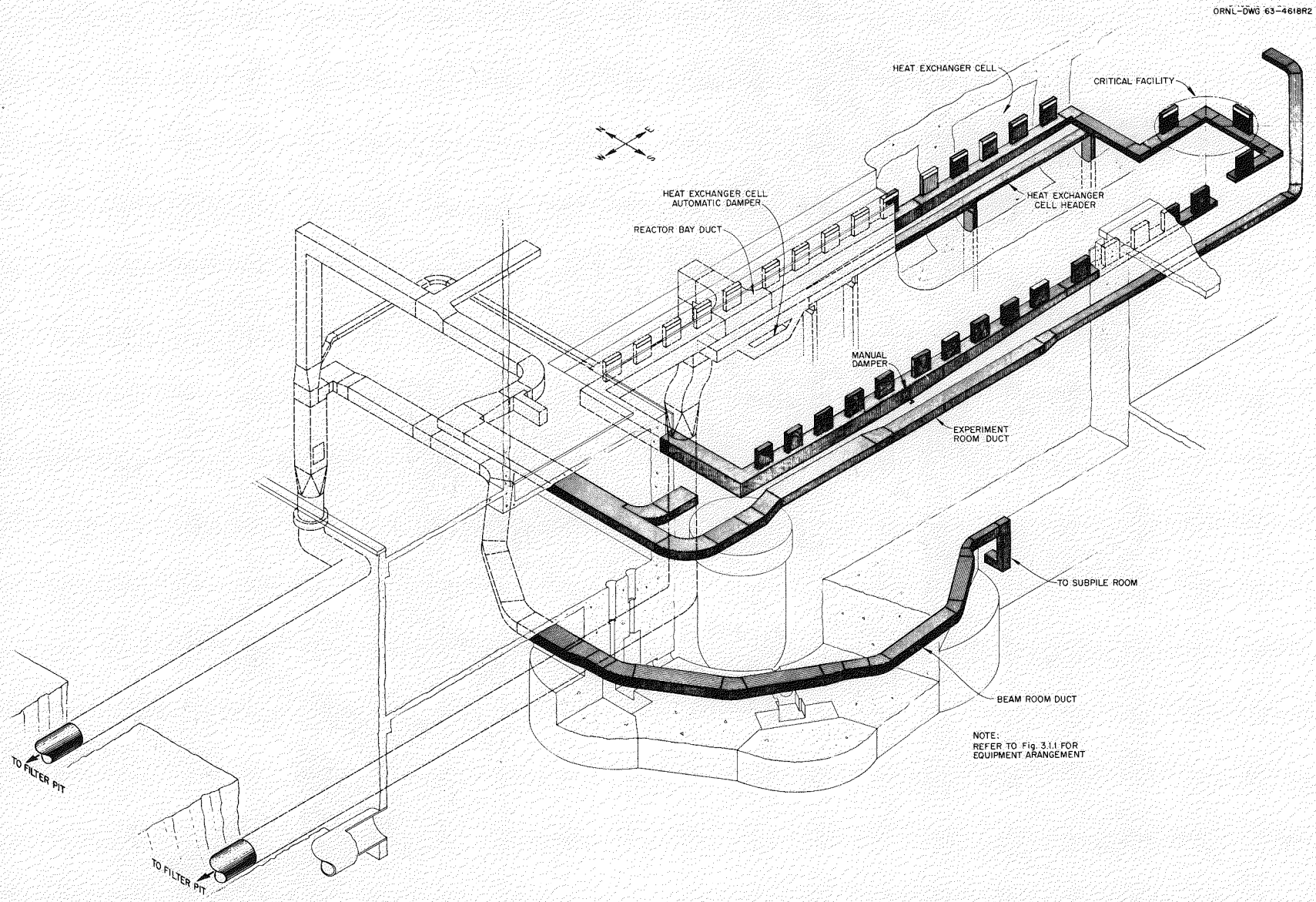


Fig. 7.3. Special building hot exhaust ducts.

ORNL-DWG 63-1698R3

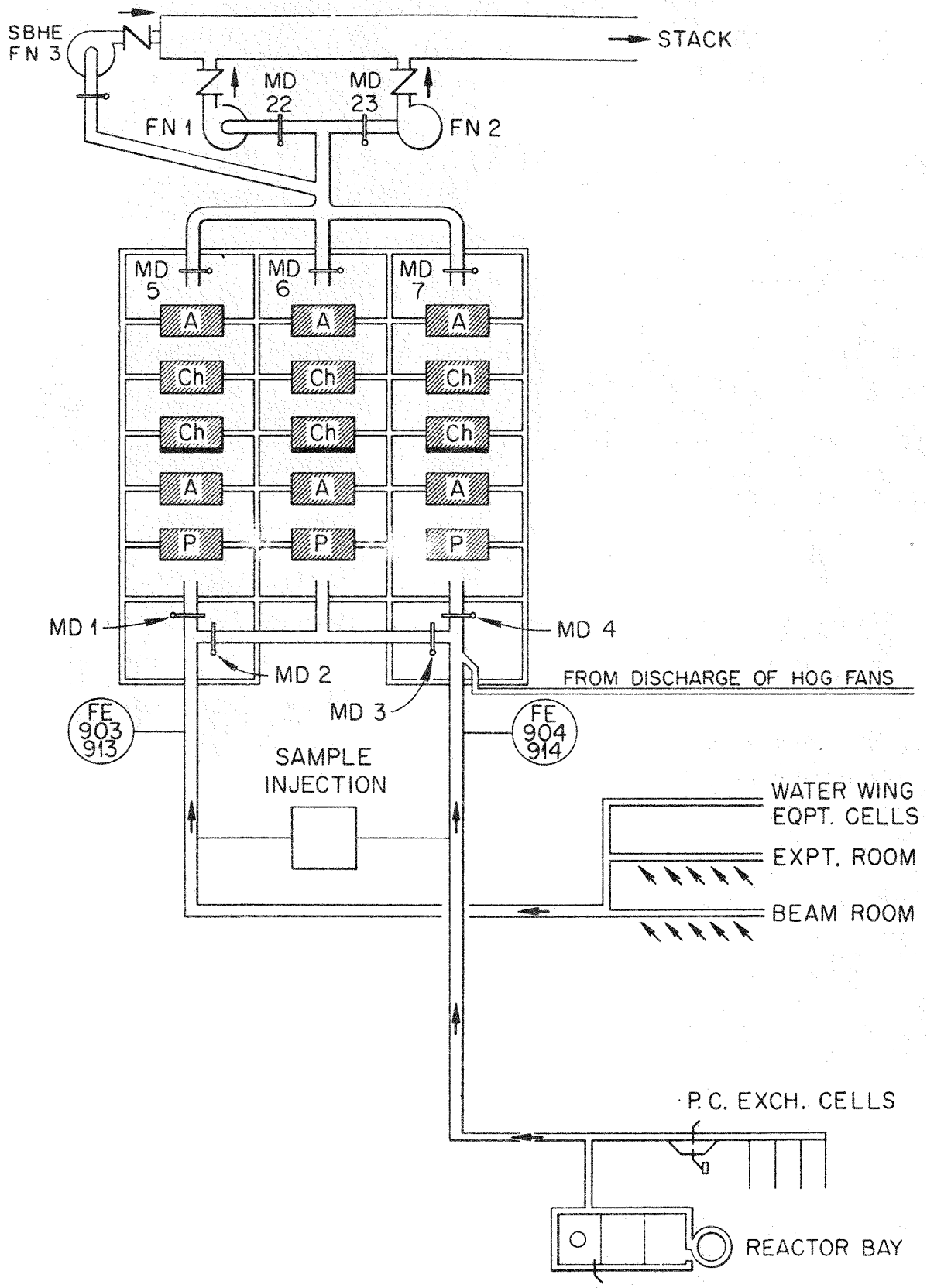


Fig. 7.4. Special building hot exhaust system.

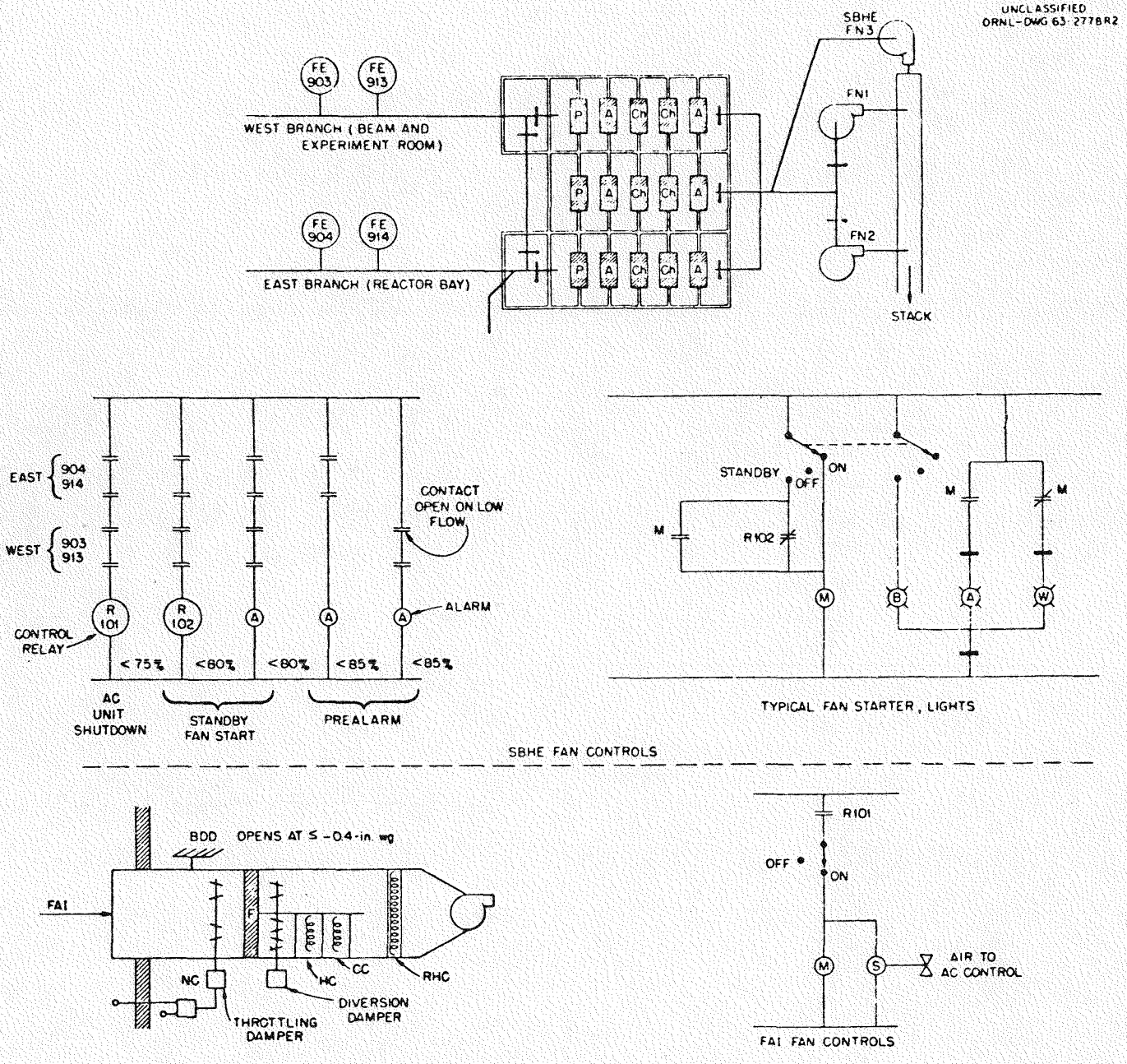


Fig. 7.5. SBHE fan controls.

7.1.3 Precautions

1. The SBHE system must not be removed from service while the reactor is operating or while a spent fuel element is being handled.
2. Since the SBHE system provides building containment, the reactor must be shut down and no irradiated fuel handled upon loss of system reliability; (one fan operating and one in standby backed up by a diesel generator).

7.1.4 Normal operation

Flow through each branch of the system is maintained at approximately 13,000 scfm by one of the three SBHE fans. Normally, SBHE fan 3 is in operation while the other two, FN-1 and -2, are on standby.

Suction by the SBHE fan and modulation of the fresh-air-intake dampers by electro-pneumatic switches maintain negative pressure inside the containment areas of the reactor building (Table 7.1).

7.1.5 Operating procedures

To place the SBHE system in service

1. Open dampers MD-4 on the inlet side and MD-7 on the exit side of the east SBHE filter compartment.
2. Open dampers MD-1 on the inlet side and MD-5 on the exit side of the west SBHE filter compartment.
3. Close dampers MD-6 on the exit side and MD-2 and MD-3 on the inlet side of the center SBHE filter compartment.
4. Open dampers MD-22 on the suction side of FN-1 and MD-23 on the suction side of FN-2.
5. Close the breakers for FN-1 and FN-2 in MCC "H" and MCC "G," respectively. Close the breaker for SBHE fan No. 3

Table 7.1. Flow indicator and switch tabulation

Flow switch	Indicator*	Sensor location	Normal flow (scfm)	Switch setpoint (scfm)	Action
FS-914B-1	914A & B	East duct	8,500	7,225 (85% flow)	Alarm
FS-914A-1				6,800 (80% flow)	Standby fan starts
FS-914A-2				6,375 (75% flow)	Shuts down AC-2, 5, 10 & 14
FS-904B-1	904A & B	East duct	8,500	7,225 (85% flow)	Alarm
FS-904A-1				6,800 (80% flow)	Standby fan starts
FS-904A-2				6,375 (75% flow)	Shuts down AC-2, 5, 10 & 14
FS-903B-1	903A & B	West duct	8,500	7,225 (85% flow)	Alarm
FS-903A-1				6,800 (80% flow)	Standby fan starts
FS-903A-2				6,375 (75% flow)	Shuts down AC-2, 5, 10 & 14
FS-913B-1	913A & B	West duct	8,500	7,225 (85% flow)	Alarm
FS-913A-1				6,800 (80% flow)	Standby fan starts
FS-913A-2				6,375 (75% flow)	Shuts down AC-2, 5, 10 & 14

*All "A" indicators are located in the fan shed; all "B" indicators are located in the control room.

6. Turn FN-1 control switch to the "standby" position. The fan should start.
7. Turn FN-2 control switch to the "standby" position and turn FN-1 control switch to the "off" position. FN-2 should start.
8. Turn the SBHE fan No. 3 on and when it reaches full speed, turn FN-2 off.
9. Turn either or both of fans FN-1 and FN-2 control switches to the "standby" position. (Only one fan must be in the standby condition during reactor operation. However, unless maintenance is being performed on one fan, it is desirable to operate with both in the standby condition.)

The SBHE system is now in normal operating condition. All pressure and flow indicators in the fan shed and in the reactor building should be observed for normal operating conditions.

Routine checks, shift, daily, and weekly. Checks on the SBHE system are performed routinely by roving operators on a shift, daily and weekly basis. They are incorporated in the master checklist for the HFIR reactor.

1. Shift Checks
   a. Listen for any unusal noises in the fan shed which would indicate bearing failure, belt slippage, or fan shaft misalignment. Report any unusual vibrations.
   b. Check fan bearing and motor casing temperatures by feel. Report any unusually hot motors.
   c. Report any oil or grease accumulations near the fans.
   d. Observe that at least one fan control switch is in the "standby" position.

e. Record the stack $\beta-\gamma$ particulate activity, the stack α particulate activity, the HFIR duct $\beta-\gamma$ particulate activity, the stack iodine and inert gas activity, and the stack high-level activity readings. These instruments are located in the main control room on the gaseous-waste panel. If there are any readings above the normal levels, report them to the shift supervisor.

2. Daily Checks

a. Record duct-flow-indicator readings in the fan shed and in the control room. Compare the readings obtained at each location. Report any variations.

b. Record the pressure drops across the individual SBHE filters. The pressure indicators are located in the fan shed. If readings indicate dirty filters, see page 7-14 for compartment switching procedures.

Table 7.2. Filter ΔP tabulation

PdI	Filter location	Normal ΔP (in. H_2O)	Maximum ΔP (in. H_2O)
1, 2, and 3	Prefilters in west, center, and east filter banks	0.09	0.20
4, 5, and 6	Absolute filters in west, center, and east filter banks	1.10	3.30
7, 8, and 9	Charcoal filters in west, center, and east filter banks	3.60	>3.60
10, 11, and 12	Absolute filters in west, center, and east filter banks	1.10	1.60

c. Record building negative pressures from the indicators in the control room. Report any significant variations from normal conditions.

Table 7.3. Building ΔP tabulation

PdI	Area being monitored	Normal ΔP (in. H_2O)
900	Reactor bay	-0.30
901	Beam room	-0.30
902	Experiment bay	-0.30

d. Observe the FAI damper-positions. If any are out of normal operating range, report this to the shift supervisor.

Switch fans between standby and run. Optimum performance from the SBHE fans is best obtained by switching the standby and operating fans periodically. CAUTION: This operation should normally be done while the reactor is shutdown, while no fuel movements are being made, and under the supervision of the shift engineer.

1. When reactor is shutdown:

   A check on the "standby-start" feature of the SBHE fans should be made during the switching operation.

   a. Establish two-way communication between the fan shed and the main control.

   b. Make sure that the standby fan control switch is in the "standby" position.

c. Turn the operating fan control switch to the "off" position. Simultaneously, two annunciators in the control room should alarm. They are "Beam and Experiment SBHE Low Flow" and "Reactor Bay SBHE Low Flow." Almost immediately another annunciator, "SBHE Low Flow," should alarm; and the standby fan should start. When the standby fan starts, the three alarms should clear. Lights on the gaseous waste panel in the control room should indicate the operating condition of the fans. A white "off" light should indicate which fan was turned off. The amber "on" light for the standby fan should be burning.

d. Turn the fan control switch for the fan now operating to the "on" position.

e. Turn the fan control switch for the fan just removed from service to the "standby" position. Check the lights on the gaseous waste panel for proper indications. One amber "on" light and one blue "standby" light should be burning.

2. Switching fans while the reactor is in operation. (This procedure is to be used only if there are indications that the operating unit is malfunctioning.)

a. Turn the control switch of the standby fan to "run."

b. When an increase in flow indicates the second fan is running, turn the first fan to "off," wait until it stops, then switch it to "standby."

Switch the center filter compartment into service. When switching either of the two SBHE systems to the center filter compartment, it is important that the two compartments be paralleled before removing the original compartment from service. This assures uninterrupted service while the switching is being done.

1. Open damper MD-6 on the exit side of the center filter compartment.
2. Open damper MD-2 on the inlet side of the center compartment if flow through the west SBHE system is being transferred to the center. Open MD-3 if flow through the east SBHE sytem is being transferred to the center. This makes the two compartments parallel. The compartment being removed from service may now be isolated.
3. Close MD-5 on the exit side and MD-1 on the inlet side of the west compartment if it is being removed from service. If the east compartment is being removed from service, close MD-7 on the exit side and MD-4 on the inlet side of the filters.
4. Throttle the center compartment inlet damper enough to keep the FAI dampers in the reactor building within their normal operating range. See Section 7.1.5 for the appropriate procedures.

Remove the SBHE system from service. CAUTION: The reactor must be shutdown and no fuel movements may be made while the system is out of service.

1. Place the standby fan control switch in the "off" position.
2. Place the operating fan control switch in the "off" position.

7.1.6 Action on an outage of normal power

The east SBHE fan (FN-2) is connected to the No. 1 normal-emergency power distribution system through MCC "G." When a normal-power interruption occurs, the fan will restart when the No. 1 normal-emergency system switchgear transfers the load to the diesel generator.

Similarly, the west SBHE fan (FN-1) is connected to the No. 2 normal-emergency power distribution system through MCC "H." It will restart as soon as the No. 2 normal-emergency system switchgear transfers the load to the diesel generator (no time delay).

7.1.7 Action on loss of flow in the SBHE ducts

Conditions which may cause a loss of air flow in the ducts are:

1. filter plugging,
2. fan failure, and
3. diesel-generator failure during an outage of normal power.

In the event a loss of flow occurs, operation of the system takes place in the following manner:

A slight drop (to <85%) in air flow in either duct will cause one of both of the flow switches (FS-903-B1 in the west duct, and FS-913-B1 in the east duct) to open and actuate an audible and visual alarm in the control room. A greater loss in air flow (<80%) in either duct will cause one or more of four flow switches (FS-903-A1 and FS-913-A1 in the east duct and FS-904-A1 and FS-914-A1 in the west duct) to open, start the standby fan through relay R-102, and simultaneously sound an alarm in the control room. On a further decrease in air flow (<75%), flow switches (FS-903-A2 and FS-913-A2 in the east duct and FS-904-A2 and FS-914-A2 in the west duct) will, through relay R-101, shut down air conditioning units AC-2, AC-5, AC-10, and AC-14 which are the fresh-air-intake units in the three containment areas. The recirculating units will continue to operate. When normal flow is restored, the air conditioning units will restart automatically.

8. EMERGENCY PROCEDURES

8.1. Emergency Equipment

8.1.1 Diesel Electric Generation and Distribution System References

Drawings:

1546-01-E-2007, -2008 Normal-Emergency and Fail-Free System

1546-01-E-2009 Instrument Power

Singmaster & Breyer Specifications: 107 Electrical Work, Diesel Generators and Normal-Emergency Switchgear, Cable, Batteries and Battery Chargers

8.1.1.1 Load testing and the diesel-generators. One per week, each diesel-generator is started and operated for 30 min under 30% load using the building lighting system as the load. This test may be performed with the reactor in operation.

a. Close the generator "test loading" circuit breaker located on the control panel of the diesel-generator being tested.

b. Place the "engine test - automatic - stop - hand crank" selector switch in the "engine test" position. Record the time required for the diesel engine to start.

c. When the diesel engine is at full speed, check and record the general output voltage.

d. Place the building lighting load switch in the test position.

e. Allow the diesel-generator to run for 30 min while observing the unit for proper operation. Record the output

current from the generator. Note any unusual noises or vibrations.

f. Return the building lighting load toggle switch to the normal position.

g. Stop the diesel engine by placing the control switch in the "stop" position. When the diesel stops, return the switch to the "automatic" position.

h. Reset the fuel rack solenoid and confirm with the control room that the "misoperation" alarm has cleared.

i. Test the other diesel-generator by repeating steps a through h.

8.1.1.2 Testing the normal-emergency systems. A complete operational test of the normal-emergency systems is made every three months. The purpose of this test is to ensure the integrity of the related components in the systems. The test can be performed only under specified conditions. These conditions are:

a. The reactor must be shut down.

b. Experiments on the normal-emergency systems bus ducts must be able to withstand short power outages (approximately 60 s).

c. The normal-emergency systems must be in use with their usual connected load.

A. Normal-emergency system No. 1

1. Open the 480-V normal-emergency system feeder breaker at substation No. 3 and note that:
   a. All feeder breakers in normal-emergency switchgear No. 1 trip except the feeder to MCC "G" at the fan shed.
   b. A trip impulse is applied to the diesel "test loading" circuit breaker.
   c. Diesel-generator No. 1 starts.
   d. The automatic transfer switch transfers to the emergency position.
   e. Normal-emergency switchgear No. 1 feeder breakers close in sequence. Loads are transferred to the No. 1 diesel-generator at the following time intervals:

0 seconds	feeder to MCC "G" (Fan House)
10 seconds	feeder to TRU
20 seconds	feeder to MCC "J" (Electrical Building)
20 seconds	feeder to MCC "D" (Room G-12)
30 seconds	feeder to MCC "E" (Basement North)
40 seconds	feeder to the 225-amp bus duct in the south side of the experiment area

   f. PU-11, the auxiliary pressurizer pump, and PU-14, the auxiliary cooling tower pump (slow-speed winding), automatically start. The cooling tower bypass valve, FCV-362B, opens automatically upon startup of PU-14.
2. Close the 480-V normal-emergency feeder breaker in substation No. 3 and note that, after 60 s, the load returns to the normal-power system.

3. Stop the No. 1 diesel engine by placing its control switch in the "stop" position. Return the switch to the "automatic" position.
4. Reset the fuel rack solenoid.
5. Stop pumps PU-11 and PU-14.
6. Make sure FCV-362B closed automatically.

B. Normal-emergency system No. 2

1. Open the 480-V normal-emergency system feeder breaker in substation No. 4 and note that:
   a. All feeder breakers in normal-emergency switchgear No. 2 trip except the feeder to MCC "H."
   b. A trip impulse is applied to the diesel "test loading" circuit breaker.
   c. Diesel-generator No. 2 starts.
   d. The automatic transfer switch transfers to the emergency position.
   e. Normal-emergency switchgear No. 2 feeder breakers close in sequence. Loads are transferred to the No. 2 diesel-generator at the following time intervals:

0 seconds	feeder to MCC "H" (Fan House)
10 seconds	feeder to TRU
20 seconds	feeder to MCC "F" (Electrical Building)
30 seconds	feeder to the 225-amp bus duct in the west side of the experiment area

2. Close the 480-V normal-emergency feeder breaker in substation No. 4 and note that, after 60 s, the load returns to the normal-power system.

3. Check the proper operation of the two solenoid valves which prevent air being applied to the diesel starters while the deisel is running. (A test valve is installed in each parallel line for this purpose.)
4. Stop the No. 2 diesel engine by placing its control switch in the "stop" position. Return the switch to the "automatic" position.
5. Reset the fuel rack solenoid.

C. Return to normal operation after a normal-power outage.

After a normal power outage has been experienced, the normal-emergency systems must be returned to standby condition. This consists mainly of stopping the diesel-generators and making sure they are readied for any subsequent emergency.

1. Stop each diesel-generator by turning its control switch to the "stop" position.
2. After the diesel has stopped, return the control switch to the "automatic" position.
3. Check the fuel oil level in both fuel oil day tanks. If the level is less than 50% full, manually start the appropriate fuel oil pumps and refill the tanks.
4. Check the fuel oil level in the underground storage tank. Make arrangements to refill it if necessary.
5. Check the operation of the No. 1 diesel-generator starter-battery charger. If needed, set the timer on the charger to charge at the freshening rate for a period of time sufficient to completely recharge the batteries.
6. Check the air pressure in the No. 2 diesel generator starter-air receiver. If it is less than 200 psig, manually start the air compressor and run it until the

receiver pressure is at least 225 psig. Place the air compressor control switch back in the "automatic" position.

7. Reset the fuel rack solenoid valves on each diesel.

8.1.1.3 Place "pony motor battery spare charger" in service - to charge switchgear battery. To be used if switchgear charger fails. CAUTION: Do not disconnect ± cables from battery (2#2) which are connected directly from the battery to dc panel "P-22." (If the dc circuit is interrupted, circuit No. 6 in panel "P-22" will be de-energized and this will cause the reactor to be shut down!)

1. Disconnect faulty switchgear charger:
   a. Trip ac breaker.
   b. Trip dc output breaker.
   c. Trip ac supply breaker to charger transformer (breaker in MCC "J" or MCC "F"; see sketch 1, Rev. A).
   d. Open door of charger. Disconnect dc ± output leads from charger (these are identified in the charger) which continue to the battery.
   e. Pull these leads (+ and -) out of the charger cabinet.
2. Place "spare pony motor charger" in service.
   a. Connect + lead from "spare charger" to the + lead removed from switchgear charger. Connect - lead from "spare charger" to the - lead removed from switchgear charger (see 1.5 above). Insulate these connections.
   b. Plug ac input to "spare charger" into special receptacle provided (identified on receptacle).

c. Turn ac switch on "spare charger" to "on" position - note red light on front of "spare charger."

d. NOW - close dc breaker on front of "spare charger."

e. NOTE: Voltmeter and ammeter on "spare charger."

f. Adjust float voltage to 129 V.

g. Adjust equalize voltage to 147 V.

h. Ammeter indicates load amps plus charge amps.

3. "Pony motor spare charger" is now in service.

4. Note the following:

a. Annunciator "HI-15" will indicate "switchgear battery trouble." This is to be expected, with the normal charger out of service.

b. The following visual monitors should be used to check operation of the "spare charger" once every 4 hr.

	Device	Location	Condition
(1)	Voltmeter	Spare charger	Float or equal. volts
(2)	Ammeter	Spare charger	Load + charge amps
(3)	Red indicating lamp	Spare charger	Charger energized

5. Do not permit battery voltage to drop below 105 V dc.

6. Initiate action to repair "normal switchgear batter charger" immediately.

8.1.2 Battery Powered Pony Motors

References

Drawings:

1546-01-E-2120 Elementary Control Diagram, Process Water Equipment

ORNL Specifications:

M-500-E-2 Specification for Primary Coolant Pumps; Section 11, dc Pony Motor

Introduction. In order to ensure the high degree of reliability that is required of the HFIR emergency cooling system, a program of routine testing has been set up whereby a separate pony motor is tested during each refueling shutdown. This program ensures that all four pony motors are performance tested during any four-month period.

1. Pony Motor Test

   a. After the reactor has been shut down, continue circulating primary water with the main ac motors for one hour and until the primary coolant outlet temperature is equal to the pool water temperature.

   b. Establish shutdown status to the primary coolant system as outlined in Section 6.1.5. CAUTION: Flow from at least two reliable pony motors must be maintained until the irradiated fuel element is removed from the reactor. The pony motor battery being tested is not considered reliable during the test or until the batteries are fully recharged.

   c. The reactor vessel may now be opened for refueling work since little mixing of pool and primary coolant water will occur at pony motor flow rate.

   d. Open the circuit breaker between the battery charger and the battery of the pony motor being tested. This is done by turning the ac power switch on the charger to the "off" position.

e. Allow the pony motor to run on power from the battery for a period of at least two hours. Do not allow the battery voltage to drop below 105 V. Record the following data initially and every 20 min thereafter:

1. Pony motor current
2. Battery current
3. Battery voltage
4. Primary collant flow rate

f. At the end of the testing period, stop the pony motor and return ac power to the battery charger. Set the charger at its freshening charge rate until the battery is fully recharged.

8.1.2.2 Place "pony motor spare battery charger" in service

1. "Spare charger" may be substituted for either 1E, 1F, 1G, or 1H charger.
2. Disconnect faulty charger:
   a. Trip ac breaker on front of charger.
   b. Open door and trip dc output breaker.
   c. Disconnect the ac supply to the charger by removing the plug from the ac receptable below the metering cabinet.
   d. Open the door to the associated metering cabinet. Disconnect the + and - leads from the charger at the + and - terminals in the metering cabinet. TAPE THE ENDS OF THESE LEADS.

      NOTE: This is required to isolate the faulty charger from the system and to prevent the battery and/or the connected "spare charger" from energizing the dc output terminals of the faulty charger.

3. Place the "spare charger" in service.

   a. Connect the + lead from the "spare charger" to the + terminal of the metering cabinet. Connect the - lead from the "spare charger" to the - terminal of the metering cabinet (see 2.d above).

   b. Plug ac input to "spare charger" into receptacle under charger (either NE No. 1 or NE No. 2).

   c. Turn ac switch on "spare charger" to "on" position - note red light on front of "spare charger."

   d. NOW - close dc breaker on front of the "spare charger."

   e. NOTE: Voltmeter and ammeter on "spare charger."

      (1) Float voltage = 134 V.

      *(2) Equalize voltage = 140 V.

      (3) Ammeter indicates battery charge amps plus pony motor amps.

      (4) Red indicating light - charger energized.

4. "Spare charger" is now in service.

5. Note the following:

   a. Annunciator "HI" will indicate trouble in the charger that has been replaced. This condition is normal - under the circumstances.

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*To check equalize voltage (if desired), turn timer knob clockwise to any position off "0." After checking float and equalize voltages (see slotted adjustment screws on front of spare charger), return charger to float condition by turning timer knob counterclockwise to "0."

b. The "1E" annunciators Hi and Lo pony motor current will be in service. Use test pushbutton to verify operation.

c. The following VISUAL monitors should be used to check operation of the "spare charger" once every 4 h.

	Device	Location	Condition
(1)	Voltmeter	Spare charger	Float or equal. volts
(2)	Ammeter	Spare charger	Pony motor + charging amps
(3)	Red indicating light	Spare charger	Charger energized
(4)	Ammeter	Metering cabinet	Battery charge amps
(5)	dc millivolt	Metering	Black pointer should be between 2 red pointers. Left red pointer is set at 120 V dc charger output. Push P.B. to reset black pointer.

6. Do not permit battery voltage to drop below 105 V dc.

8.1.3 Instruments batteries

References

Drawings:

1546-04-E-2007 One Line Diagram, Normal-Emergency System No. 1 and Fail-Free System

Singmaster & Breyer Specifications: 107 Electrical Work, Diesel Generators and Normal-Emergency Switchgear, Cable, Batteries and Battery Chargers

Introduction. The instrument batteries are designed to supply dc power to the nuclear instrumentation for a period of two hours with the chargers not in operation. There are six banks of batteries which have a total of three outputs at -32 V, three outputs at +32 V, and/or three outputs at 64 V. The six battery chargers are designed to supply 50 amperes each continuously at 32 V dc.

Part of the energy stored in the instrument batteries is used during the time interval between the loss of normal power and the assuming of the load by the diesel-generator. This time interval is usually less than 60 s. In the event the diesel engine fails to start, all essential nuclear instrumentation is operated from the batteries.

Recharging the batteries after a normal-power outage. Upon resumption of normal power, the batteries, if discharged, must be recharged to their normal capacity. This takes place automatically. However, the charge rate can be increased by operating the chargers at their freshening charge rate. This is done in the following manner:

1. Set the timer on each of the six instrument battery chargers so that they will charge at the freshening rate an amount of time sufficient to completely recharge the batteries.
2. Check the liquid level in each cell of each bank of batteries.

8.1.4 Auxiliary Pressure Pump

References

Drawings:

1546-01-E-2120 Elementary Control Diagram, Process Water Equipment

Singmaster & Breyer Specifications: 41 Primary Feed Pump

Introduction. The auxiliary pressurizer pump automatically starts upon loss of flow from the main pressurizer pumps and/or upon the transfer of load to diesel-generator No. 1 during a normal-power outage. Upon return of normal power, the pump continues to run so that primary coolant pump seal water flow may be maintained until the main pressurizer pump can be restarted.

Testing the pump. The pump is tested during each refueling shutdown in the following manner. (The reactor must have cooled down and the primary coolant system should be ready for depressurization.)

1. Stop the operating pressurizer pump. As the flow drops, the auxiliary pressurizer pump should start.
2. Observe the water flow on the flow indicators at the heat exchanger cell entrances (FI-158, -159, -160, and -558).

8.1.5 Auxiliary Cooling Tower Pump

References

Drawings:

1546-I-4007 Instrument Application Diagram, Secondary Cooling System

Singmaster & Breyer Specification: 50 Cooling Tower Vertical Centrifugal Pumps

Introduction. The auxiliary cooling tower pump (slow speed drive) is provided to remove heat produced by the reactor during 10-MW operation. This pump is equipped with a dual winding motor. The high speed winding drives the pump during reactor shutdowns and produces 6,000 gpm. It is operated from the normal-power system.

The slow speed winding drives the pump during normal-power outages and is supplied power from the No. 1 normal-emergency system. Its capacity is approximately 3000 gpm.

Operation of the pump. Operation of the emergency drive of the auxiliary cooling tower pump is automatic. In the event of a normal-power outage, the slow speed winding of the motor is energized by an auxiliary contact in the normal-emergency switchgear No. 1 and supplied power from diesel-generator No. 1. Upon return of normal power, a time-delay relay allows the pump to continue to run while restarting the main cooling tower pumps.

Testing the operation of the pump. The slow speed winding of the auxiliary cooling tower pump drive is tested during the routine testing of the normal-emergency systems (see Section 8.1.1).

8.2. Fire Protection Systems

8.2.1 References

Drawings:

1546-01-E-2079, -2080, -2081, -2082	Fire Alarm Interconnection Diagrams
1546-05-E-2083	Fire Alarm Interconnection Diagrams
1546-01-E-2084	Fire Alarm Block Diagram

Singmaster & Breyer Specifications:

70	Fire Protection
170	Electrical Specifications, Fire Alarm System

8.2.2 Introduction

The HFIR is protected from fire by three similar fire-alarm systems: master box No. 1 serves the cooling tower, the cooling-tower

equipment building (these two structures utilize a dry-pipe sprinkler system), and the electrical building; master box No. 2 serves the reactor building (a preaction sprinkler system); master box No. 3 serves the office and maintenance building (a wet-pipe system).

Heat-actuated devices, operated on either rate-of-rise or fixed temperatures, are placed appropriately in all rooms (maximum separation between the detectors is 50 ft). These detectors sound a coded fire alarm on the ORNL system when tripped by excessive heat. All alarms are given by repeater bells in the HFIR area and a reactor building fire alarm also causes an annunciator alarm in the control room. The systems are battery powered; a self-monitoring device initiates a trouble alarm upon open circuits, grounds, and battery-charger failure.

8.2.3 Cooling tower, cooling tower equipment building, and electrical building fire alarms (master box 1, Code 843)

Indication of a fire alarm in this area will be recieved from the plant-wide fire-alarm system or from a horn in the local area. The "no fire" lights on the zone control panel will go out. When this occurs:

1. The control-room operator will announce over the public-address system that there is a fire alarm at the cooling-tower area. He will also monitor the cooling tower fan indicator lights on the process panel. If the fans are turned off by the fire alarm, he will notify the shift supervisor and await further instructions.
2. The roving operator and the shift supervisor will attempt to determine the extent and location of the fire while

waiting for the ORNL Fire Department to arrive. Attempts should be made to bring the fire under control using portable extinguishers. Care should be taken if the fire is in the electrical building or in the switchgear room of the cooling-tower equipment building because of high-voltage danger. Only CO_2 extinguishers should be used on electrical fires - do not use water.

3. In the event the cooling-tower fans are shut down, relays R-60 and R-61 must be reset before the fans can be restarted. These relays are located on the south wall inside the cooling-tower equipment building. A "bypass" button may be actuated to allow the relays to be reset and fans restarted in the event there is no fire.

8.2.4 Reactor building fire alarm (master box No. 2, Code 842)

A fire in the reactor building is annunciated on panel "HI" in the control room. Simultaneously the local alarm horn in the zone affected will sound, and the "no fire" lights on the zone panel will go out. Master boxes No. 2 and 4 will be tripped, and plant-wide coded alarm 842 will sound. Air conditioner AC-15 and ventilation fan FN-1 will shut down. Action taken is as follows:

1. The control-room operator will announce over the public-address system that there is a fire in the reactor building.
2. The roving operator and the shift supervisor will enter the reactor building and attempt to locate the fire using the local horn and zone panel lights as guides. If personnel hazards are involved, the shift supervisor will

instruct the control-room operator to shut the reactor down and evacuate the building.

3. After the area has been warned adequately, the local alarm horn may be silenced.
4. After the fire is put out or a false alarm is determined, the alarm reset on control panel No. 2, located in the fire alarm equipment room, may be reset. Fan FN-1 and air conditioner AC-15 must be restarted. If the zone 1 alarm (ground floor) was tripped, UV-1 must also be restarted. CAUTION: Each time the fire alarm reset button on a control panel is pushed, there will be a trouble alarm on the plant-wide fire-alarm system.

8.2.5 Office and maintenance building fire alarm (master box No. 3, Code 841.

Should a fire alarm from the office and maintenance building occur during the night shift or on a weekend, the roving operator and shift supervisor should go immediately to the building and investigate the alarm. A fire alarm will occur only from a manual box or from the flow switch in the sprinkler system.

During the normal work day (8:00-4:30) the occupants of the office and maintenance building will take care of the situation.

8.2.6 Master box No. 4 trouble bell (Code 8422)

An indication will be given by the trouble bell at the local station control panel and the zone 2 control panel and from the plant-wide call (8422) for master box No. 4. (All trouble indications for the Laboratory are four-digit alarms to distinguish them from the three-digit true fire alarm.) Since there is no "trouble" light on

the box, only the bell will indicate which station is causing the trouble.

1. The control-room operator should listen to intercom station 19 (chemical room at the cooling tower) and to station 11 (entrance to the pool demineralizer corridor). In this way the location of the trouble bell can be determined.
2. The control-room operator will announce over the public-address system that there is fire alarm trouble in the identified zone.
3. The roving operator of shift supervisor should meet the fire captain and direct him to the scene of the troubled station.

8.3 Emergency and Abnormal Operating Procedures

8.3.1 Evacuation Procedures for Reactor Operating Personnel

8.3.1.1 Organization of emergency personnel. During emergency situations, the Reactor Supervisor will serve as the Local Emergency Director at the HFIR, the Shift Engineer will serve as the Alternate Local Emergency Director, and the Laboratory Shift Supervisor will serve as the ORNL Emergency Director.

8.3.1.2 Laboratory evacuation - an emergency outside the HFIR area. If an emergency requiring a plant-wide evacuation occurs outside the HFIR area, the following steps should be taken:

1. Confirm that a true evacuation condition exists by calling the Laboratory Shift Supervisor (4-6606, 6-6646, or 4-7102). If the situation so warrants, instructions will be issued

by the ORNL Emergency Director.

2. Shut the reactor down, remove the console key switch, de-energize one secondary pump, and sound the evacuation alarm.
3. Announce the situation over the public-address system by stating: "This is a plant-wide evacuation. Evacuate the building. You will receive further orders over the Laboratory-wide public-address system." (Repeat the announcement one time.)
4. Take the emergency package and leave the building via the west exit of the first floor, and go to the assembly area.
5. Reactivate the HFIR evacuation horn from the office building.
6. Assist any emergency crews as needed.
7. Inform the Reactor Supervisor and/or other HFIR supervision of the status of the situation (either before leaving or from the office building).
8. After the emergency situation is over and there is no further threat to the health and/or safety or personnel, the all-clear signal will be given.

8.3.1.3 A local area evacuation - an emergency outside the HFIR area. If an emergency requiring a local area evacuation occurs from a source outside the HFIR area, the control desk operator will be notified by the Laboratory Shift Supervisor or other responsible individuals for a local area evacuation. If this type of situation occurs, execute the same evacuation procedure as outlined above; however, the public-address announcement

should be: "This is an emergency outside the HFIR. Evacuate the building."

8.3.1.4 A building evacuation - an emergency in the HFIR building

1. A Total Reactor Building Evacuation

   If an emergency occurs in the reactor building requiring a total building evacuation, execute the same evacuation procedure as outlined previously; however, the public-address announcement should be: "This is a reactor building emergency. Evacuate the building immediately and proceed to the assembly point near the parking lot." Also:

   a. The Local Emergency Director will evaluate the magnitude of the emergency and notify the Laboratory Emergency Control Center (911). If the situation is sufficiently serious, recommendations should be made to the Center concerning possible evacuation of areas adjacent to the HFIR complex.

   b. The local emergency crew should attempt to combat the emergency condition until relieved by higher authority.

   c. After the situation is under control and there is no further threat to the health and/or safety of personnel, the all-clear signal will be given. However, do not re-enter any building without approval by the Health Physicist and/or the Emergency Director (ORNL or local).

2. A Partial Reactor Building Evacuation

   The containment facilities at the HFIR have been designed to minimize the spread of contamination inside the building as

well a outside in the event of an accidental release of radioactivity. This type design permits evacuation of local areas or zones of the building in case of a release. If a zone of a building requires evacuation, execute the same evacuation procedure as outlined previously; however, the public-address announcement should be: "This is an experiment room emergency. Evacuate the experiment room immediately and proceed to the assembly point near the parking lot."

8.3.1.5 Emergencies due to natural causes. If an emergency situation develops at the reactor complex due to natural causes (such as tornados, earthquakes, etc.) follow the same reactor shutdown and evacuation procedures as outlined previously.

8.3.1.6 Emergencies due to civil disturbances, bomb threats, and/or terrorist activities. Should civil disturbances present any conceivable threat to the safe operation of this reactor facility, shut down the reactor and follow the same evacuation procedures as previously outlined.

In the event of a bomb threat, reactor operating personnel should perform the following:

1. Shut down the reactor (as outlined previously).
2. Notify the Emergency Control Center (911).
3. Proceed with the building evacuation (as outlined previously).

In regard to the activity of terrorists, should such individuals penetrate ORNL security and/or the reactor operating crew becomes aware of their presence, perform the following:

1. Shut down the reactor, if possible.
2. Initiate a building evacuation signal.
3. Notify the Emergency Control Center (911), if possible.
4. Actuate the fire alarm, if possible.
5. Try to remain calm; proceed in a seemingly cooperative but delaying manner.
6. Relay any messages or demands made by the terrorists.

8.3.1.7 An Emergency Due to Personnel Injury or Illness. It is quite possible that someone may be injured during an emergency situation which involves a building evacuation necessitated by excessively high contamination levels. Should such a condition develop, perform the following:

1. Execute the same reactor shutdown and evacuation procedures as outlined previously.
2. Administer first aid as needed and as practical. If treatment of the victim involves re-entry into the reactor building (e.g., the victim found during a post-evacuation search), utilize the respirators and/or radiation-monitoring equipment, as needed.
3. Notify the rescue crews and assist them as required.

8.3.2 HFIR Emergency Operating Instructions

8.3.2.1 HFIR emergency operating instruction No. 1 - inadvertent criticality during refueling

1. Symptoms:
   a. Possible alarms
      (1) Five-second period
      (2) Rate trip (20 MW/s)
      (3) Reverse
      (4) Level trip

b. Parameter changes

(1) Increase in count rate

(2) Reactor period remains positive during fuel insertion and does not become infinite after fuel is seated

2. Possible causes:

a. Control rods not seated during insertion of fuel elements

b. Control plates inadvertently left out of vessel during refueling

3. Automatic action:

None

4. Immediate operator actions:

a. Stop insertion of fuel immediately and remove the element from the vessel.

5. Follow-up actions:

a. Stop all reactor operations and notify the Reactor Supervisor.

b. Have the Health Physicist check radiation dosimeters of the operators.

c. Notify Laboratory Emergency Director (911).

8.3.2.2. HFIR emergency operating procedure No. 2 - loss of shutdown cooling during power outage

1. Symptoms:

a. Possible alarms

(1) Pony motor current low

(2) Pony motor current high

(3) Low low flow

b. Parameter changes

(1) Loss of pony motor current indication

(2) A loss of primary flow

2. Possible causes:
   a. Pony motor current loss
      (1) Battery troubles
      (2) Open circuit between batteries and pony motors
      (3) Breakers inside battery room open
   b. Pony motor current high
      (1) Overloaded motors
      (2) Ground fault in motors
3. Automatic actions:
   a. Reactor will shut down from low-low-flow trip.
4. Immediate operator actions:
   a. If diesel-generator power remains available, keep system pressurized with PU-11 auxiliary pressurizer pump.
   b. Turn letdown block valve control switch to the "block" position but do not allow the system pressure to exceed 800 psig as indicated on PRC-127.
   c. Locate cause of pump failure and make temporary repairs to one pony motor as quickly as possible.
   d. Make sure auxiliary secondary pump, PU-14, is operating.
5. Follow-up action:
   a. Stabilize after-heat removal by having at least one pony motor pump, one secondary pump, and one pressurizer pump operating as long as the fuel remains in the reactor.

8.3.2.3 HFIR emergency operating instruction No. 3 - handling of a dropped, irradiated fuel element. In the event a fuel element being removed from the reactor is dropped to the pool floor in a horizontal position, the fuel plates would become overheated and melt to some degree if not uprighted within about 4 1/2 minutes. If the element can be uprighted to at least a 10° angle within this time, melting can be prevented.

1. Symptoms:
   a. Possible alarms
      (1) Reactor bay CAM and monitron alarms (if melting occurs)
   b. Parameter changes
      (1) Loss of fuel plate cladding
2. Possible causes:
   a. Improper attachment of tool to fuel element
   b. Failed lifting tool
3. Automatic actions:
   a. Evacuation horns (if melting occurs)
4. Immediate operator actions:
   a. Use the readily available fuel uprighting tool to raise the top end of the element to at least a 10° angle and completely upright if possible.
   b. If not possible to completely upright the element, secure it at some angle greater than 10° with the floor.
   c. If it is not possible to upright the element and evidence of boiling is noted, evacuate the building immediately.
5. Follow-up actions:
   a. Report accident to the Laboratory Emergency Crew (911).
   b. Notify supervision.

8.3.2.4 HFIR emergency operating instruction No. 4 - loss of coolant accident. A major leak that develops rapidly may result in the melting of the aluminum fuel cladding and/or generate steam in sufficient quantity to present a major problem. Such a situation is considered a loss-of-coolant accident (LOCA). If a LOCA occurs, especially one resulting from a major break in the

inlet line in the pipe tunnel, the reactor will scram and the primary pumps may pump water from the vessel into the pipe tunnel during coastdown. The pony motors will continue to pump water from the system.

1. Symptoms:
   a. Possible alarms
      (1) Reactor pressure low
      (2) Low-low-flow trip
      (3) Radiation instruments
      (4) FFED
      (5) Reactor vessel ΔP low
      (6) Process water systems not OK
      (7) Head tank makeup
   b. Parameter changes
      (1) Rapid decrease in reactor pressure
      (2) Rapid loss of cooling flow
      (3) Head tank makeup
      (4) Increased pressurizer pump output flow, decrease in clean-up flow
2. Possible cause:

   Piping failure large enough to cause loss of system flow and pressure. The most serious case could be such a break occurring in the inlet line located in the pipe tunnel.
3. Automatic actions:
   a. Reactor scram
   b. Primary pump shutdown
   c. Letdown block valve closure
   d. Reactor vessel water makeup through 2-in. line from pool
   e. Standby pressurizer pump start

4. Immediate operator actions
   a. Determine location of pipe break and attempt to isolate leak.
   b. If possible, use fire hoses to keep reactor pool filled.
   c. Shut off all but one pony motor. CAUTION: Leave one operating; isolate other cells.
   d. Evacuate building if necessary.
5. Follow-up actions:
   a. Continue to monitor situation when possible and attempt to prevent core damage.
   b. Notify Laboratory Emergency Director (911).
   c. Notify supervision.

8.3.2.5 HFIR emergency operating instruction No. 5 - high radiation level in reactor building

1. Symptoms:
   a. Possible alarms
      (1) Building radiation >5 R/h
      (2) Radiation instruments
      (3) Stack ionization chamber high level
      (4) Stack activity
      (5) Stack iodine-inert gas radiation high
      (6) Primary deaerator off-gas radiation high
      (7) Cladding failure
      (8) Primary coolant radiation high, 90 mR/h
      (9) FFED
   b. Parameter changes
      (1) Possible fluctuations of the servo system indicators
      (2) Much higher than normal radiation levels

2. Possible causes:
   a. Failure of fuel element cladding
   b. Failure of target cladding
   c. Failure of an experiment
   d. Accident while refueling
3. Automatic actions:
   a. If the problem is caused by the loss of the fuel element cladding, the reactor will scram and radiation block valves will close.
   b. Building evacuation may be initiated by the FRCAS.
4. Immediate operator actions:
   a. Shut the reactor down if necessary.
   b. Initiate building evacuation if necessary.
   c. Determine source of high activity and correct, if possible.
5. Follow-up actions:
   a. Ensure that the reactor has been shut down and is in a safe condition.
   b. Ensure adequate after-heat removal.
   c. Serve as the Local Emergency Squad and assist any rescue crews, as applicable.
   d. Notify the Reactor Supervisor.

8.3.2.6 HFIR emergency operating instruction No. 6 - rapid loss of pool water

1. Symptoms:
   a. Possible alarms
      (1) West clean pool water level low
      (2) East clean pool water level low
      (3) Reactor pool water level low
      (4) Pool surge tank level low

b. Parameter changes

(1) Decrease in pool water level

(2) Increase in radiation level over pool and in experiment room

(3) Decrease in pool coolant flow

2. Possible causes:

a. Failure of the ball valve during a changeout of a rod drive mechanism

b. Failure of a beam tube facility or piping

c. A major break in the pool wall

d. Improper valving

3. Automatic action:

a. Radiation alarms will be initiated locally and in the control room.

4. Immediate operator actions:

a. If radiation levels are excessive, initiate building (or partial building) evacuation procedures.

b. If there is a major loss of water during normal operation, shut down and secure the reactor.

c. Utilize available fire hoses to keep water in the pool, if possible.

d. Attempt to stop loss of water, if possible.

5. Follow-up actions:

a. Notify the Reactor Supervisor and/or other HFIR supervision.

b. Ensure adequate afterheat removal.

c. If the reactor is shut down, complete the Shutdown Checklist.

d. If makeup water cannot be added to the pool rapidly enough to control or raise the level, allow the makeup water to continue flowing into the pool and then instruct those performing this work to evacuate the building.

e. Notify Laboratory Emergency Director (911).

8.3.2.7 HFIR emergency operating instruction No. 7 - stuck control rods

1. Symptoms:

   a. Possible alarms

      (1) 2/3 insert error

      (2) 1.1 N_F

      (3) Reverse

   b. Parameter change

      Selsyn indicators do not show repositioning of control rods when the operator attempts to move the rods.

2. Possible causes:

   a. Servo and shim drive motor troubles

   b. Damage to control plates or bearing tracks

   c. Obstruction at track-bearing interface

3. Automatic action:

   None

4. Immediate operator actions:

   a. Shut down the reactor with operable control rods.

   b. If all control rods are stuck, the poison injection system may have to be used to effect a shutdown.

   c. Attempt to insert the stuck rods from the subpile room using the hand-operated crank.

5. Follow-up actions:
   a. Notify the Reactor Supervisor.
   b. Ensure adequate after-heat removal.
   c. Ensure that all system and readouts are stabilized.
   d. Prepare to remove the fuel element after adequate cool-down and water cleanup.

8.3.3 HFIR Abnormal Operating Instructions

8.3.3.1 HFIR abnormal operating instruction No. 1 - loss of primary containment. Containment is required for all modes of operation and during movement of irradiated fuel. The specifications are: (1) in-leakage, (2) a minimum of 6000 scfm, (3) one SBHE fan on and one in standby, and (4) one operable letdown block valve for each heat exchanger in operation.

1. Symptoms:
   a. Possible alarms
      (1) Reactor bay ΔP low
      (2) East and/or west SBHE low flow
      (3) SBHE standby fan on
   b. Parameter change
      (1) Decrease in flow rate through the SBHE system
2. Possible Causes:
   a. Failure of the SBHE fans and/or filtering system
   b. A major breach in the containment building
   c. Improper valving at filter pit
3. Automatic action:
   a. Standby fans in the SBHE system energize and FAI air conditioners stop.

4. Operator action:
   a. If the loss of flow cannot be restored immediately, shut the reactor down or stop irradiated fuel movement.
5. Follow-up actions:
   a. Notify the Reactor Supervisor.
   b. Complete the Shutdown Checklist.
   c. Investigate the problem.
   d. Initiate corrective action, as applicable.

8.3.3.2 HFIR abnormal operating instruction No. 2 - loss of one primary coolant pump

1. Symptoms:
   a. Possible alarms
      (1) Reactor vessel ΔP low
      (2) Process water systems not OK
      (3) Vibration switch
   b. Parameter changes
      (1) Decrease in primary flow rate
      (2) Decrease in reactor power
2. Possible causes:
   a. Electrical disturbance
   b. Pump vibration
   c. Pump control circuit problems
3. Automatic action:
   a. Reactor power setback
   b. Increase in primary inlet temperature
4. Operator actions:
   a. Verify power setback.
   b. Check pump motor load current to determine which pump stopped. Try restarting it one time.

5. Follow-up actions:
   a. If pump cannot be restarted, switch to standby pump-heat exchanger and return reactor to full power.

Loss of two or more primary coolant pumps. NOTE: Reactor power level should be reduced automatically to correspond to the lower flow rate. A scram from high inlet temperature (to pump failures) or from low pressure (complete power outage) may result if automatic features are slow to operate.

1. Symptoms:
   a. Possible alarms
      (1) Reactor vessel ΔP low
      (2) Process water system not OK
      (3) High inlet temperatures
   b. Parameter change
      (1) Decrease in reactor power level
      (2) Decrease in servo demand
      (3) Increase in primary inlet temperature
      (4) Possible decrease of system pressure
2. Possible causes:
   a. Electrical disturbance or loss
3. Automatic actions:
   a. Reactor power setback
   b. Reactor scram
4. Operator actions:
   a. Verify power setback or scram.
   b. If pump loss is caused by a power outage, use the "AUTO Process Start" to restart them when power is available. If possible, restart the reactor using the restart check sheet.

c. If a minor electrical disturbance caused loss of two pumps, restart them and return the reactor to full power operation.

d. If reactor cannot be restarted, ensure afterheat removal is adequate.

5. Follow-up actions:

a. Report occurrence to the Reactor Supervisor.

8.3.3.3 HFIR abnormal operating instruction No. 3 - loss of reactor primary coolant - small leaks. NOTE: If the leak rate does not exceed 90 gpm (the plant demineralizer's makeup-water capacity), the leak is considered small. Leaks of this magnitude should present few problems with the operation of the reactor depending on the specific location of the leak.

1. Symptoms:

a. Possible alarm

(1) Head tank makeup

b. Parameter change

(1) Low flow in the primary cleanup system

(2) Makeup to head tank

2. Possible Causes:

a. Failure of piping or valves in the primary coolant system

b. Misvalving

c. Leaking rod-drive seals

d. Heat exchanger tube leak

3. Automatic action:

a. Demineralized water is automatically made up to the head tank.

4. Operator action:

a. Monitor the frequency of the makeup to the head tank.

5. Follow-up actions:
   a. Determine the source of the leak and isolate it, if possible.
   b. Valve out the leaky heat exchanger.
   c. Notify the Reactor Supervisor and/or other HIFR supervision.
   d. Depending on the magnitude, the nature, and/or location of the leak, prepare to shut down the reactor.
   e. If the reactor is shut down, ensure adequate afterheat removal and complete the Shutdown Checklist.

Medium leaks. NOTE: Any leak rate in excess of 90 gpm, but less than one causing a low pressure alarm, is considered a medium size leak. This can be determined by the head-tank makeup indicator driving full scale and remaining without receiving a low pressure alarm.

1. Symptoms:
   a. Possible alarms
      (1) Head tank makeup
      (2) Demineralized water pressure low
      (3) Primary coolant head tank level low, No. 1
      (4) Reactor primary water head tank level low, No. 2
      (5) Cell flooded
   b. Parameter changes
      (1) Increase in makeup flow rate
      (2) Decrease in cleanup flow rate
2. Possible Causes:
   a. Failure of piping or valve in the primary coolant system
   b. Heat exchanger tube leak
   c. Misvalving
   d. Leaking rod-drive seals

3. Automatic action:

   a. Demineralized water makeup to the head tank.

4. Operator action:

   If the head-tank makeup level indicator cannot be maintained on scale and leak cannot be isolated, shut down the reactor.

5. Follow-up actions:

   a. Ensure adequate after-heat removal.

   b. Depressurize the primary system.

   c. Notify the Reactor Supervisor.

   d. Complete the Shutdown Checklist.

Large leaks (but NO loss of coolant accident). NOTE: Any leak from the reactor primary system that results in a low pressure alarm and/or low pressure scram is considered a large size break.

1. Symptoms:

   a. Possible alarms

      (1) Reactor pressure low

      (2) Head tank makeup

      (3) Low pressure trip

      (4) Demineralized water pressure low

      (5) Primary coolant head tank level low, No. 1

      (6) Primary coolant head tank level low, No. 2

      (7) Process water systems not OK (if primary pumps de-energize at 400 psig)

      (8) Reactor ΔP low

      (9) Cell flooded

   b. Parameter changes

      (1) Decrease in reactor pressure

      (2) Loss of letdown flow

      (3) Reactor scram

2. Possible cause:

   Failure of piping, component, etc.

3. Automatic actions:

   a. The standby pressurizer pump is energized at 700 psig.

   b. A 1.1 Ø/flow fast reverse may be initiated if the flow rate decreases.

   c. The reactor scrams at 600 psig.

   d. The primary pumps are de-energized at 400 psig.

4. Operator actions

   a. Ensure that the reactor power level has been reduced either by the fast reverse or a scram.

   b. Ensure adequate after-heat removal.

5. Follow-up actions:

   a. Ensure all systems are stabilized.

   b. Ensure after-heat removal.

   c. Complete the Shutdown Checklist.

   d. Investigate the cause of the leak.

   e. Notify the Reactor Supervisor.

8.3.3.4 HFIR abnormal operating instruction No. 4 - loss of steam

1. Symptoms:

   a. Possible alarm

      (1) High pressure steam low (120 psig)

   b. Parameter changes

      (1) Pool cleanup flow decreases, if pump de-energizes due to low deaerator level.

2. Possible Causes:

   a. Loss of steam supply from ORNL's steam plant

3. Automatic action:

   If deaerator level decreases, the cleanup pump is de-energized.

4. Operator actions:
   a. Verify the loss of steam.
   b. Notify the steam plant personnel, if necessary.
5. Follow-up actions:
   a. During freezing weather (<32°F), if the steam outage is suspected to last for an hour or less:
      (1) Shut down the fresh air intake units in the reactor bay, beam room, and experiment room.
      (2) De-energize exhaust fans FN-7, FN-8, and FN-9 in the water wing.
      (3) Turn off the exhaust and intake fans in the office and auxiliary buildings.
   b. If the outage is expected to last for greater than an hour:
      (1) Complete the above actions.
      (2) Shut down the reactor and turn off the SBHE fans.
      (3) Maintain coolant circulation through the reactor.
      (4) Open the cooling tower bypass and turn off the large secondary circulating pumps and turn on PU-14.
   c. If the outside temperature drops to less than 25°F and the steam outage is suspected to last for more than ten minutes, perform all of the above.
   d. If the reactor is shut down, ensure adequate afterheat removal and complete the Shutdown Checklist.
   e. Notify the Reactor Supervisor.
   f. Ensure that the exit temperature of the reactor coolant remains above 80°F.

8.3.3.5 HFIR abnormal operating instruction No. 5 - loss of instrument air. NOTE: With one air compressor in operation, two in standby, and one emergency air compressor available, it is not likely that a complete loss of instrument air would occur. However, most of the HIFR control instrumentation is pneumatic and the loss of instrument air would have a variety of effects. This procedure addresses a complete loss of air supply.

1. Symptoms:
   a. Possible alarms
      (1) Instrument air low
      (2) Instrument air pressure low
   b. Parameter changes
      (1) Fluctuations in primary system pressure
      (2) Loss of temperature control system
      (3) Decrease in reactor power
      (4) Loss of all level indicators on the graphic panel (deaerators, head tank, surge tank, etc.)
2. Possible Causes:
   a. Rupture in piping on the exit line of the emergency air compressor
   b. Failure of all air compressors
   c. Failure of the pressure-relief valves on the air dryers or air receivers
3. Automatic action:
   a. Reduction of servo demands due to loss of flow signal.
   b. The decreasing servo flow signal should cause the flow/demand clamp to set back the reactor power. Should the flow signal decrease sufficiently fast, this setback

should occur before the flux signal has caused the power to be increased and only a reduction in the power level will occur.

c. Depending on the exact nature of the loss of instrument air, some effect to the primary temperature control system could occur, leading to either a full opening or full closing of the secondary control valve (FCV-377).

d. The standby pressurizer pump may energize, due to a false signal from the 127 pressure control system.

e. The letdown and block valves will close.

f. Tower makeup flow control valve (FCV-236) will fully open.

g. The pool coolant and cleanup pumps may de-energize.

h. The primary coolant and cleanup pumps may de-energize.

i. The pressurizer pumps may de-energize (due to the loss of the pressureizer pumps from the false, low head tank level).

j. The emergency pressurizer pump (PU-11) may energize. If this pump does not maintain the pressure due to the transients, the reactor will scram.

k. The standby SBHE and off-gas fans will energize due to flow signal loss.

4. Operator action:

a. Shut the reactor down.

5. Follow-up actions:

a. Ensure adequate afterheat removal.

b. Notify the Reactor Supervisor and/or other HFIR supervision.

c. Attempt to locate the break in the air system or determine the reason for the failure of all the air compressors.

d. Initiate repairs, as applicable.

8.3.3.6 HFIR abnormal operating instruction No. 6 - significant changes in differential pressure across the reactor vessel and inlet strainer - an increase in differential pressure across the reactor vessel

1. Symptoms:
   a. Possible alarms
      (1) Reactor vessel ΔP high
   b. Parameter changes
      (1) Pressure drop across the vessel increases
      (2) Possible change in primary flow rate
      (3) Possible change in strainer ΔP
2. Possible Causes:
   a. Obstruction to water flow through the core
3. Automatic action:
   a. Possible low flow initiated setback.
   b. Possible printout of hydraulic data.
4. Operator action:
   a. Check PdR-106 for vessel ΔP.
   b. Check core ΔT. If an increase has occurred, flow blockage should be suspected.
   d. Check primary coolant flow rate.
   d. Check the strainer ΔP. If indications are such that an obstruction to flow through the core exists, scram the reactor and investigate.

5. Follow-up Actions:
   a. If the reactor was scrammed, complete the Shutdown Checklist.
   b. Ensure adequate afterheat removal.
   c. Notify the Reactor Supervisor and/or other HFIR supervision.

A decrease in differential pressure across the reactor vessel

1. Symptoms:
   a. Possible alarms
      (1) Reactor vessel ΔP low
   b. Parameter changes
      (1) Pressure drop across the vessel decreases
      (2) Possible change in primary flow rate
2. Possible Causes:
   a. Any loss of or sudden decrease in primary water flow.
   b. Decrease in total pressure drop across the core due to abnormally high flow rates through regions which require relatively low flow. Perturbations in flow paths sufficient to cause this alarm could increase the total flow rate approximately 1000 gpm. A corresponding increase in strainer ΔP may cause an alarm at 350 in. H_2O.
   c. Loss of operating primary pumps.
3. Automatic action:
   a. Possible printout of hydraulic data
4. Operator action:
   a. If the pressure vessel ΔP decreases to 125 psi (alarm setpoint) during normal operation with a corresponding flow increase of approximately 1000 gpm, shut down the reactor.

b. If flow decreased due to the loss of a primary pump, attempt to restart the pump. If unsuccessful, valve in the spare primary pump-heat exchanger and return to full-power operation.

5. Follow-up actions:

a. If the flow has bypassed the core, observe the total flow, the vessel ΔP, the strainer ΔP, and the hydraulic data printout from the computer to determine the source of trouble.

b. If the reactor is shut down because of a malfunction of PdT-106, initiate repairs immediately so that the reactor may be restarted.

c. If the reactor was scrammed, complete the Shutdown Checklist.

d. Ensure adequate afterheat removal.

e. Notify the Reactor Supervisor and/or other HFIR supervision.

An increase in differential pressure across the reactor vessel

1. Symptoms:

a. Possible alarms

(1) Inlet strainer ΔP high

b. Parameter changes

(1) Possible increase in total flow rate

2. Possible Causes:

a. Plugged strainer caused by the introduction of foreign material from elsewhere in the primary system or cleanup system.

b. An increase in total flow.

3. Automatic action:
   a. Possible printout of hydraulic data
4. Operator action:
   a. Reactor power should be reduced to 50 MW while an evaluation is being made. If this alarm occurs simultaneously with a flow increase of greater than 1000 gpm, shut down the reactor.
   b. If the strainer ΔP instrumentation malfunctions, observe the safety flow recorders continuously while repairs are being made. If the total flow increases 1000 gpm, shut down the reactor.
5. Follow-up Actions:
   a. If a slight decrease in total system flow and a slight increase in the vessel ΔP occurs, the reactor may have to be shut down to remove the foreign material from the strainer.
   b. If the reactor was scrammed, complete the Shutdown Checklist.
   c. Ensure adequate after-heat removal.
   d. Notify the Reactor Supervisor and/or other HFIR supervision.

8.3.3.7 HFIR abnormal operating instruction No. 7 - loss of EF-2 flow. NOTE: Although the loss of the pool cleanup flow does not present a problem of any significance by itself, the loss will necessitate shutting down the reactor if EF-2 coolant if affected.

1. Symptoms:
   a. Possible alarms
      (1) EF-2 facility flow low
   b. Parameter changes
      (1) Decrease in flow to the EF-2 experiment facility

2. Possible Causes:
   a. Loss of pool cleanup flow
   b. Failure of piping systems resulting in leaks
3. Automatic action:
   None
4. Operator action:
   a. Adjust pool coolant flow control valves to restore EF-2 flow.
   b. If the EF-2 facility is affected, shut down the reactor if the problem is not resolved within a reasonable period of time.
5. Follow-up actions:
   a. Notify the Reactor Supervisor.
   b. If the reactor must be shut down, ensure adequate after-heat removal and complete the Shutdown Checklist.

8.3.3.8 HFIR abnormal operating instruction No. 8 - control-rod drive system failure

1. Symptoms:
   a. Possible alarms
      (1) Rod asymmetry
      (2) 2/3 insert error
      (3) No. 5 rod pressure balance system ΔP high
   b. Parameter change
      (1) Selsyn indicators do not show repositioning of control rods when the operator attempts to move the rods.
      (2) Abnormal voltage indication for the No. 5 rod (on the console)

2. Possible causes:
   a. Rod-drive-motor troubles
   b. Debris in rod-drive mechanism
   c. Loss of balance fluid for the No. 5 cylinder
   d. Failure of No. 5 cylinder drive gearbox
3. Automatic action:
   Rod asymmetry setback
4. Operator actions:
   a. Shut down the reactor with operable control rods and verify shutdown status.
   b. Check the fluid accumulators in the subpile room and determine if there is a failure in the lead screw.
   c. Attempt to insert the rod from the subpile room using the hand-operated crank (or air motor for the inner control cylinder).
   d. If several control-rod drives have malfunctioned, the poison injection system may have to be used to effect a shutdown.
5. Follow-up actions:
   a. Notify the Reactor Supervisor.
   b. Complete the Shutdown Checklist.
   c. Ensure adequate afterheat removal.

8.3.3.9 HFIR abnormal operating instruction No. 9 - loss of secondary cooling system

1. Symptoms:
   a. Possible alarm
      (1) Secondary cooling water temperature high
      (2) 2.4-kV main breaker trip
      (3) Tower basin level low

(4) Reactor inlet temperature high

(5) Inlet temperature trip

(6) Fire alarm bell code No. 843

b. Parameter change

(1) Basin temperature increases

(2) Increase in primary inlet temperature

(3) Loss of secondary flow

2. Possible Causes:

a. Failure of cooling tower fans or fan controller

b. Loss of secondary pump

c. Major break in the secondary piping

d. Fire at the cooling tower

e. Misvalving

3. Automatic action:

a. Tower fans are automatically de-energized as a result of a fire at the cooling tower.

b. Secondary flow control valve opens.

c. Reactor scram, from inlet temperature of 130°F, if corrective action is not taken.

4. Operator action:

a. If an increase in secondary temperature, without water loss, has caused the problem, do the following:

(1) Check cooling tower fan lights to determine if fans are operating.

(2) Check TR-310-1 and -2 for the temperature of the water entering the cooling tower basin.

(3) Check FI-300 for secondary water flow rate to the primary heat exchangers. If the primary coolant inlet temperature reaches the alarm point, lower the reactor power sufficiently to clear the alarm.

(4) If all cooling tower fans have been stopped by a fire alarm at the cooling tower, reset the relays R-60 and R-61 in the fire alarm system. These are located in the cooling tower equipment building. These relays are labeled and are on the east wall of the electrical room. A fire alarm bypass switch and indicating lights have been installed to allow the resetting of the relays in the event there is no fire. This allows fan restart while the fire alarm system is actuated. If there is actually a fire at the cooling tower, do not reset the relays but shut the reactor down.

(5) If the trouble is due to failure of TC-310, place the fan controls in manual and push the slow speed buttons on the control panel. If necessary, place some or all fan control switches in the fast-forward position.

b. If a water loss from the secondary system has caused the problem, do the following:

(1) Verify a low level in the tower basin.

(2) Check the operation of valve LCV-335. If this valve has failed, provide another means to supply makeup water to the basin. (NOTE: Potable water may be piped to the basin from a nearby fire hydrant in the event of an emergency.)

(3) Check for piping leaks. If a major leak has occurred, shut down the reactor. An emergency secondary cooling water supply line has been provided so that potable water may be used to supply

the primary heat exchangers in the event of total failure of the secondary system. A 2 1/2-in. line ties into the main secondary water header just downstream of flow control valves FCV-377 and FCV-377A. This line extends to the top of the valve pit and has a connection so that a fire hose may be connected from a nearby fire hydrant to the line. (The fire hose is located near the valve pit. If this system is placed in service, notify the fire department.)

5. Follow-up actions:
   a. If the reactor is scrammed, ensure adequate afterheat removal.
   b. Complete the Shutdown Checklist.
   c. Notify the Reactor Supervisor.
   d. Inform the fire department if fire hydrants are used for makeup water.

8.3.3.10 HFIR emergency operating instruction No. 10 - an uncontrolled or unexpected change in reactivity while at full power R

1. Symptoms:
   a. Possible alarms
      (1) 2/3 insert error
      (2) Reverse
      (3) Five-second period
      (4) 1.1 0/flow fast reverse
      (5) Shim request
      (6) Any of the safety system annunciators (rate, heat power, inlet temperature, level trip, cladding failure, low-low-flow, low pressure)

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R. V. McCord, Reactor Operations Section
S. S. Hurt, Reactor Supervisor

b. Parameter change

(1) Fluctuation in reactor power

2. Possible causes:

a. Rod drive failure

b. Failure in core component

3. Automatic action:

a. Setback

b. Reverse

c. Scram

4. Immediate operator actions:

a. Insert rods, if necessary, to make the reactor stable and ensure that it is not on an unexplained positive period. If the unstable condition is not corrected immediately and the power level is increasing, scram the reactor.

b. Evaluate the overall situation in regard to equipment and personnel and attempt to determine the cause of the problem.

5. Follow-up actions:

a. If the reactor is shut down, complete the Shutdown Checklist.

b. Ensure adequate afterheat removal.

c. Notify the Reactor Supervisor and/or other HFIR supervision.

8.3.3.11 HFIR abnormal operating instruction No. 11 - uncoupled inner control rod

1. Symptoms:

a. Possible alarms

(1) Five-second period

(2) Rate trip

(3) Level trip

b. Parameter changes

(1) The power level would increase very rapidly if the momentarily stuck cylinder became free during a rod withdrawal.

(2) The neutron flux level would increase rapidly.

(3) There would be a loss of servo control.

2. Possible Causes:

The No. 5 cylinder's locking nut was not properly secured during its replacement.

3. Automatic action:

a. Setback

b. Reverse

c. Scram

4. Operator action:

If there is an unexplained addition of reactivity during the routine withdrawal of the inner control cylinder, scram the reactor and insert the No. 5 cylinder.

5. Follow-up actions:

a. Ensure adequate after-heat removal.

b. Notify the Reactor Supervisor.

c. Complete the Shutdown Checklist.

d. Prepare for inspection of the No. 5 control cylinder's locking device.

8.3.3.12 HFIR abnormal operating instruction No. 12 - loss of control rod position indication

1. Symptoms:

a. Possible alarms

(1) Rod asymmetry

b. Parameter changes

(1) Selsyn indicators for individual control rod fail to show any change as operator attempts to reposition control rods

(2) Significant discrepancy with meter stick indications in the subpile room.

2. Possible causes:

Mechanical or electrical problems with the Selsyn indicators

3. Operator Actions:

a. Verify loss of control rod position indications by the console Selsyns by comparing them with the meter-stick readings in the subpile room.

b. If the failure occurs during a startup, terminate the startup and have the faulty Selsyn repaired.

c. If the failure occurs during an operating cycle, use the computer to obtain position of the rods and post an operator in the subpile room during the movement of the affected rod.

4. Follow-up actions:

a. Notify the Reactor Supervisor.

b. Ensure adequate afterheat removal.

c. If a shutdown is necessitated, complete the Shutdown Checklist.

8.3.3.13 HFIR abnormal operating instruction No. 13 - fuel damage during power operation

1. Symptoms:

a. Possible alarms

(1) Primary coolant radiation high

(2) Primary deaerator off-gas radiation high

(3) FFED

(4) Stack activity

(5) Cladding failure detector

(6) Radiation monitors (from the FRCAS)

b. Parameter change

(1) Increase in the radiation level in the subpile room, by the cleanup system piping, etc.

(2) Major increase in radioactivity level in the primary water system

(3) Possible rapidly oscillating servo system indicators

(4) Possible oscillations in all neutron-sensitive instrument readouts caused by reactivity variations of forming and collapsing of voids

2. Possible Causes:

a. Flow blockage of fuel lement coolant channels

b. Poor bonding of fuel cladding

c. Pin hole leak in cladding

3. Automatic action:

a. Reactor is scrammed by FFED and radiation block valves close.

4. Operator action:

a. If the trend in radiation-monitoring instruments and safety and control instruments indicate fuel damage, manually scram the reactor if it has not scrammed automatically.

b. If a scram is initiated automatically by the FFED system:

(1) Stop all pressurizer pumps and allow the primary system pressure to decrease through leakage to atmospheric pressure

(2) Ensure afterheat removal

c. Check should be made of the constant air monitors in the building to assure that no radioactive gases are escaping. The stack beta-gamma and alpha particulate monitors, with readouts in the main control room, will indicate whether there is any release of particulate activity into the atmosphere.

Precaution

(1) Should activity exceeding the tolerance escape into the building atmosphere, immediate evacuation is necessary.

5. Follow-up actions:

a. Notify the Reactor Supervisor.

b. Inform the Emergency Control Center, if needed.

8.3.3.14 HFIR abnormal operating instruction No. 14 - an increase in the radiation level in the primary coolant system

1. Symptoms:

a. Possible alarms

(1) Primary coolant radiation high

(2) FFED

(3) Primary deaerator off-gas radiation high

(4) Stack activity

(5) Cladding failure detector

b. Parameter change

(1) Possible oscillations in servo system indicators

(2) Increased radiation level in the subpile room and near cleanup system piping

(3) Increased radioactivity in routine water samples

2. Possible Causes:
   a. Failure of the fuel element cladding
   b. Failure of the target cladding
   c. Failure of an experiment
   d. Failure of a hydraulic-tube-sample cladding
   e. Control plate failure
3. Automatic action:
   a. Possible scram (by FFED) and closing of radiation block valves
4. Operator action:
   a. If there is any reason to conclude that an unsafe condition exists, manually scram the reactor.
   b. If a scram was initiated automatically by the FFED system, stop all pressurizer pumps and allow system to depressurize.
   c. Investigate for high levels of radiation in the vicinity of the pipe corridor, pipe tunnel, heat exchanger cells, deaerator cell, and demineralizer cells. Exercise caution to prevent overexposure of personnel to high radiation levels.
5. Follow-up actions:
   a. Notify the Reactor Supervisor.
   b. Ensure adequate afterheat removal.
   c. Complete the Shutdown Checklist.

8.3.3.15 HFIR abnormal operating instruction No. 15 - high radiation level in the secondary water system

1. Symptoms:
   a. Possible alarms
      (1) Tower waste radiation high β-γ (125 c/min/ml)
      (2) Secondary cooling radiation high (1 mr/h)
      (3) Head tank makeup

b. Parameter changes

(1) Water makeup to primary system

2. Possible Causes:

a. Ruptured tube in a primary coolant heat exchanger

3. Automatic action:

Diversion valves send blowdown to the No. 1 pond.

4. Operator action:

a. Check RR-1000 and observe the level and trend of contamination.

b. Check the makeup rate to the primary coolant system on FR-215 in the control room. If an appreciable increase in makeup is noted, there is probably a heat-exchanger tube ruptured.

c. Sample secondary water system to determine the amount of radioactivity present.

5. Follow-up actions:

a. Attempt to locate the leaking heat exchanger by placing the standby unit in service.

b. If the radiation level or water loss is excessive and/or remains for an extended period of time (e.g., after switching heat exchangers), shut down the reactor.

c. Notify the Reactor Supervisor.

8.3.3.16 HFIR abnormal operating instruction No. 16 - high radiation level in the off-gas systems (SBHE, CHOG, and OHOG)

1. Symptoms:

a. Possible alarms

(1) Stack activity

(2) Stack iodine inert gas radiation high

(3) Stack ionization chamber high level monitor

(4) Radiation instruments

(5) Primary deaerator off-gas

b. Parameter changes

(1) Increase in activity in the reactor primary off-gas system

(2) Increase in activity in the reactor building

(3) Increase in activity in an experiment facility (e.g., off-gas system)

2. Possible causes:

a. Failure of the fuel cladding

b. Failure of an experiment facility

3. Automatic action:

a. Possible reactor scram (from FFED)

b. Possible reactor setback (from experiment)

c. Possible automatic evacuation signal from the Facility Radiation Contamination Alarm System (FRCAS)

4. Operator action:

a. Verify the increase in airborne activity by checking the radiation recorders.

b. Evaluate the rate of increase in activity.

c. Locate the source of activity.

d. If an experiment caused the increase in airborne activity, notify the experimenter.

5. Follow-up actions:

a. If the increase in activity is progressing slowly but appears that it will rise to a dangerously high level, reduce the reactor power level to approximately 50 MW to see if the condition remains under control. If it appears

that, due to the source of activity and/or nature of the release to the off-gas systems, personnel and/or equipment are in any jeopardy, shut down the reactor.

b. Notify the Reactor Supervisor.

c. Ensure adequate afterheat removal.

d. If a building evacuation was necessitated, notify the Emergency Control Center.

8.3.3.17 HFIR abnormal operating instruction No. 17 - failure of primary pressure-relief valves

1. Symptoms:

   a. Possible alarms

      (1) Head tank makeup

      (2) Reactor pressure low

      (3) Low pressure trip

      (4) Reactor pressure high

   b. Parameter change

      (1) Increase in level in the storage tank

      (2) Increase in makeup water to the head tank

2. Possible Causes:

   a. Operator error in establishing primary system pressure

   b. Pressure transient from failure of pressurizer pump along with pump's pressure cut-off switch

3. Automatic action:

   a. Makeup of water

   b. Low pressure scram

4. Operator action:

   a. Observe the rate of increase in level in the underground storage tank and determine if the spring-actuated relief valve (or valves) have failed to reseat.

b. If there is a very slow change, along with a relatively low makeup rate, notify the Reactor Supervisor and/or other HFIR supervision.

c. If the leak rate is such as to indicate that the spring-actuated relief valve has failed to reseat, shut down the reactor, ensure adequate after-heat removal, and complete the Shutdown Checklist.

5. Follow-up actions:

a. Notify the Reactor Supervisor and/or other HFIR supervision and then investigate the problem.

8.3.3.18 HFIR abnormal operating instruction No. 18 - failure of a primary pump check valve. Failure of a check valve located on the discharge side of a reactor primary-coolant pump is, in itself, not a problem. Such a failure would be detected during the testing of the check valves. However, should a pony motor fail in the same pump cell during the time a check valve has failed, it is conceivable to create a low-flow condition through the core following a shutdown when the pony motors only are supplying the forced cooling (e.g., during an electrical power outage).

1. Symptoms:

a. Possible alarms

(1) Pony motor current high

(2) Pony motor current low

(3) Pony battery trouble

(4) Low-low-flow alarm

b. Parameter changes

(1) A lower than normal flow rate

2. Possible Causes:

Failure of the pony motor in the same heat-exchanger-pump cell in which a check valve had failed.

3. Automatic action:

a. Low-low-flow scram

4. Immediate operator action:

a. Identify the cell in which the problem has occurred.

b. Isolate the cell by closing the motorized valves.

c. Ensure adequate after-heat removal. If necessary, place the standby heat exchanger in service.

5. Follow-up actions:

Notify the Reactor Supervisor and/or other HFIR supervision.

8.3.3.19 HFIR abnormal operating instruction No. 19 - operation during tornado watches and/or warnings

1. Symptoms:

a. Possible alarms

(1) Ractor bay ΔP low

(2) Negative pressure indicators down and off-scale

(3) West and east SBHE low flow

b. Parameter changes

Extreme fluctuations in the negative pressure indicators (usually down and off scale)

2. Possible causes:

Adverse weather conditions, high-velocity winds, etc.

3. Automatic action:

Standby off-gas fans (SBHE, CHOG, and OHOG) may energize.

4. Operator action:

a. Announce on the public-address system that a tornado watch and/or warning has been given and request that all personnel remain inside the reactor building.

b. Ensure that the containment flow remains within the technical specifications limits. If this cannot be achieved, scram the reactor, ensure adequate afterheat removal, and then notify the Reactor Supervisor.

c. If the tornado or high-velocity winds damage the cooling tower, shut down the reactor.

5. Follow-up actions:

a. If the tornado does not cause a reactor shutdown by damaging the HFIR's electrical supply systems or cooling tower, continue operation; but inspect the area for possible damage after the storm has abated.

b. If the reactor was shut down, either manually or automatically, ensure adequate after-heat removal, complete the Shutdown Checklist, and survey the area for possible damage.

8.3.3.20 HFIR abnormal operating instruction No. 20 - operating during earthquake conditions

1. Symptoms:

a. Possible alarms

(1) Primary pump vibration switches

b. Parameter change

(1) Decrease in reactor primary coolant as pumps de-energize

(2) Decrease in reactor power

(3) Tower fan indicating lights out

2. Possible Causes:

Excessive vibration due to ground acceleration caused by the earthquake

3. Automatic action:

   a. Vibration switches on each of the reactor primary pumps will cause the pumps to de-energize which in turn will effect an immediate reactor power reduction.

   b. Vibration switches on the cooling tower fans will cause the fans to de-energize.

4. Immediate operator action:

   a. If an earthquake is felt and recognized as being of substantial magnitude, shut reactor down.

5. Follow-up actions:

   a. Ensure adequate afterheat removal.

   b. Inspect the area for possible damage.

8.3.3.21 HFIR abnormal operating instruction No. 21 - loss of electrical power

1. Symptoms:

   a. Possible alarms

      (1) All annunciator lights would go out and stay out as long as the dual failure remained.

   b. Parameter changes

      (1) Reactor power will decrease from setback and be shut down from scram

      (2) Secondary coolant flow stops

      (3) Pony motors maintain primary flow at approximately 10% normal

      (4) Primary water temperature increases

      (5) All building lights except those that are battery powered will go out

2. Possible causes:

   a. TVA power failure coupled with failure of No. 1 diesel generator

3. Automatic action:
   a. Reactor power is reduced to 10 MW by the servo system.
   b. Reactor will scram from low pressure.
   c. Instrument air compressor C-1B will operate if No. 2 diesel generator starts.
   d. Building containment will be maintained by SBHE fan FN-1 and HOG fans FN-3 and FN-5.
   e. Pony motors will maintain primary flow at approximately 10% normal but system will heat up due to loss of secondary flow.
4. Operator actions:
   a. Connect the emergency secondary system fire hose to the adjacent fire hydrant and provide heat transfer to the secondary system to prevent the primary system from overheating.
   b. Monitor the primary temperature to assure adequate heat removal.
5. Follow-up actions:
   a. Continue after-heat removal as outlined.
   b. Notify supervision.
   c. When TVA power becomes available, restart secondary pumps.
   d. Do not restart the reactor until the cause of the failure of No. 1 diesel generator is determined and corrected.

8.3.3.22 HFIR abnormal operating instruction No. 22 - loss of 2.4-kV electrical power

1. Symptoms:
   a. Possible alarms
      (1) Process systems not OK
      (2) Reactor vessel ΔP low
      (3) Reactor pressure low
      (4) 2.4-kV breaker trip

(3) Reactor pressure low

(4) 2.4-kV breaker trip

b. Parameter change

(1) Reactor power will decrease

(2) Secondary coolant flow stops

(3) Pony motors maintain primary flow at approximately 10% normal

(4) Primary water temperature increases

2. Possible Causes:

a. 2.4-kV circuit overload

b. Opening of breaker cubicle top door

3. Automatic action:

a. Reactor power is reduced to 10 MW by the servo system.

b. Reactor may scram from low pressure.

c. Pony motors will maintain primary flow at approximately 10% normal but system will heat up due to loss of secondary flow.

4. Operator action:

a. Start PU-14 auxiliary secondary pump high speed winding.

5. Follow-up actions:

a. Monitor the primary temperature to assure adequate heat removal.

b. Assist the shift electrician in trouble-shooting the cause of 2.4-kV system failure.

c. Raise reactor power or restart reactor only after the problem has been corrected.

8.4. Radiation-Contamination Emergencies

8.4.1 Fission-product release, direct indication

There are several possible indications, both direct and indirect, of a fuel element or target cladding failure in the HFIR. A fission-product release may come about from a fuel element or target

cladding failure due to either a meltdown or a defect in the cladding itself. In any event, the situation must be analyzed carefully and quickly because indications may be different depending on whether the reactor is at stable full power operation, is being started up, or is at a stable 10% (N_L) operation. If there is any suspicion of a significant fission-product release, reactor power should be reduced 50% while the situation is being analyzed. Some of the indications of a release are:

1. High radiation detected by the gross-gamma radiation detectors.
2. An alarm by the fission-break monitors.
3. High radiation detected by monitrons located near the cleanup-system piping.
4. A rapidly oscillating change in reactivity, as detected by the servo system, followed by the high-radiation alarms described above.
5. Rapid oscillations of the neutron-sensitive instrumentation followed by high-radiation alarms.
6. A high-radiation alarm from the subpile room monitron.

Gross-gamma detector. A high-level gross-gamma radiation detector (faulty fuel element scram parameter) will sense abnormal radiation levels in the primary water system. This detector will indicate high radiation levels for sudden bursts of activity as the fission product gases and particles pass by the probe. For leaky fuel elements or targets, the detector may show a steady increase in activity to abnormal levels.

Fission-break monitor. This instrument will detect radioactive fission products as they are dispersed in the primary water system. A

continuous readout instrument is located in the main control room with an annunciator on panel "C" which will alarm when abnormal radiation levels are detected.

Monitrons. In the event of a meltdown, fission products may enter the low pressure cleanup system causing high radiation levels in the equipment and piping. Monitrons, located near the cleanup system piping, will likely give high-radiation alarms shortly after the fission break occurs.

Subpile room monitron. A monitron, located in the subpile room, may give an alarm upon the release of fission products into the primary coolant system. If a fuel plate should melt, molten fuel may fall to the lower portion of the reactor pressure vessel thus increasing the general background in the subpile room.

8.4.2 Fission product release, indirect indication

Boiling. Since most of the more subtle meltdown situations may be slow acting and may be caused by a loss of cooling capacity, boiling can be expected. This boiling is likely to be local in extent so that any steam formed would condense rapidly. The result is a continuous series of small gains and losses in reactivity and also a small constant total gain or loss in reactivity, depending on the void coefficient's sign. (The void coefficient in the target island is positive; the void coefficient in the fuel area is negative.) If enough boiling takes place to restrict the cooling water flow through a water channel, the fuel-plate temperature may rise above the melting point of the cladding and fuel. Indications of boiling are:

1. A change in reactivity, as evidenced by a change in the critical rod position caused by the average void coefficient.

2. Oscillations in the neutron-sensitive instrumentation caused by the reactivity variations of forming and collapsing voids. These are generally seen only on the linear instruments at high power levels. Logarithmic instruments may show the oscillations at very low power levels. Gamma monitoring instrumentation will likely be affected only slightly or not at all, since the average power is the same and the change in absorption between the core and the chamber is slight.
3. "Hunting" by the servo system as the servo tries to drive the regulating rod up and down to counteract the rapid variations in flux. It is possible that only one or two servo chambers will see the change in neutron flux. In this case only the affected chambers would show the oscillations on the servo-current indicators, and the rod position might not change since the mechanical parts of the servo drive are not designed for rapid fluctuations.
4. Variations in period indication. The count-rate period would likely begin to show the rapid flux changes as period spikes of larger magnitude than the normal noise level of the channel.

8.4.3 Immediate steps to take if a fission-product release occurs

If a fuel meltdown or target rupture takes place, the reactor must be shut down immediately to prevent further damage to the core and to prevent further release of fission products into the primary coolant system. An immediate check should be made of the constant air monitors in the building to assure that no radioactive gases are escaping. If the air activity is above masking tolerance, the building should be evacuated. Monitrons and laboratory monitors should be

watched for indications of direct radiation. No area of the building should be entered by personnel without checking for radiation.

The stack beta-gamma and alpha particulate monitors, with readouts in the main control room, will indicate whether there is any release of particulate activity into the atmosphere due to failure of the filters. The gross-gamma activity detector, also located in the stack, will indicate the release of radioactive noble gases into the atmosphere. Close attention should be given to the detection of gaseous activity and direct radiation to minimize the exposure of personnel to radiation.

ORNL personnel of the Emergency Control Center (phone 911) should be notified so that their assistance can be made available. The Laboratory Shift Supervisor will be notified by the Emergency Control Center.

In the event that the building has been evacuated (see Evacuation Procedure 8.3.5), clearance by the Health Physics Section should be obtained before re-entry. Assistance should be given to Health Physics personnel in analyzing and evaluating the source and extent of the air activity to facilitate re-entry into the building.

Water Sampling. To determine the degree of contamination to the primary coolant system, water samples must be taken and a radiochemical analysis performed according to the approved analytical procedure. The results of this analysis should be compared with the gamma spectrums of the two previous operating cycles. These investigations enable the Technical Assistance Group (1) to determine whether the source of the activity is the target, fuel, or isotope

sample, and (2) to estimate the amount of contamination in the system before the reactor vessel is opened. These results will also be of assistance in determining the methods of decontamination to use.

One-liter samples should be taken of the primary coolant water at points upstream of the deaerator, upstream of the cation column of the demineralizers, and downstream of the anion column of the demineralizers. These samples should be taken and analyzed as soon as possible after the fuel element failure occurs and every three hours, subsequently. CAUTION: The water samples could be highly radioactive; therefore, care must be taken to prevent overexposure.

An additional sample of the primary coolant water should be taken from a point upstream of the deaerator and kept so that it can be counted at regular intervals and used as a control to determine the effectiveness of the cleanup system.

The following analyses should be performed on the water samples:

1. Gross-gamma activity.
2. Deaerator gross-gamma activity.
3. Radiochemical analysis for $Cs^{136-137}$, Te^{132}, $I^{131,133}$, $Ru^{103,106}$, Sr^{91}, Np^{239}, and Na^{24}. (The results from these analyses should be compared with the results of previous analyses.
4. Gamma-ray spectrum.
5. Alpha spectrum.

Successive samplings at 3-h intervals for any or all of the above analyses should be made. Decay measurements also should be made for any samples taken above. Twelve hours after a fuel element

failure samples may be taken at 9-h intervals.

Precautions

1. The importance of immediate shutdown of the reactor and closing of the block valves upon discovery of a fission-product release, cannot be overemphasized. A few minutes delay could mean the difference between one or two days cleanup and one or two weeks of cleanup work and the possible overexposure of personnel to gaseous activity and/or direct radiation.
2. Gaseous activity in the reactor building should be at a minimum due to the dynamic containment system. However, should activity exceeding the maximum permissible concentration escape into the building atmosphere, immediate evacuation is necessary.
3. Direct radiation from water lines in the cleanup system may prohibit entry into the deaerator cell, the demineralizer and filter cells, and into the pipe corridor. In this case the areas should be roped off and the appropriate "radiation zone" signs placed near the entrances.
4. If any part of the building becomes contaminated, measures must be taken to assure that the contamination is not spread into clean areas. The contaminated areas must be roped off and personnel entering must wear protective clothing. Upon leaving the contaminated areas, personnel must be monitored to prevent spreading the contamination. Careful attention to these details will prevent a major cleanup of the building and surrounding areas.

Personnel coordination. In case of a severe release, the combined efforts of several groups will be necessary to expedite decontamination and to prevent overexposure of personnel. Usually the HFIR supervisor or a delegated alternate will coordinate the cleanup operation.

1. Reactor Operations Section personnel will be utilized to the fullest extent; that is, the cleanup operation takes precedence over other projects that may be under way at the time. Assignment of additional personnel to shifts to cover around-the-clock cleanup operations will be made by the reactor supervisor. He will make these assignments to provide the most experienced and efficient coverage during the cleanup period.
2. Assistance from the Operations Division Technical Assistance Section will be utilized whenever possible.
3. Other ORNL groups may be called upon for assistance when necessary.

8.4.4 Movement of a defective element to the defective fuel element storage rack

The method of removal of the defective element from the reactor depends upon several conditions. Some of these conditions are:

1. The activity of the primary coolant water. In the more severe type of meltdown, the water will probably be so grossly contaminated that it will have to be purged, insofar as possible, to either the underground water storage tank or to the ILW tank before the reactor vessel can be opened.

2. The nature of the fission-product release. A leaky element (where no melting has occurred) can be removed easily to the defective fuel element storage rack as soon as it can be determined that gross escape of fission gases from the element has ceased.
3. The extent of meltdown. In the event of a fuel meltdown or a partial fuel meltdown, it must be determined if the two elements can be separated for removal. If they are stuck together, it will be necessary to use poison strips between the fuel plates to assure against criticality while transferring the element to storage.

8.4.5 Disposal of the defective element

The method of disposal of a defective element also depends upon the severity of the damage to the element. The important considerations are the danger of criticality and the possibility of spreading contamination.

8.4.6 Reactor startup after a fission-product release

After a defective fuel element has been removed and the systems have been cleaned, it is important to be very careful when returning the reactor to power operation. If a meltdown has occurred, it is possible that small particles of fuel might remain in the primary coolant system. If these particles become dislodged and begin to circulate in the primary coolant system, they will become radioactive when passing through the core and might cause higher than normal off-gas and primary coolant water activity; therefore, the approach to full-power operation must be very deliberate.

8.4.7 Decontamination

Cleanup methods. The method of cleanup of the primary coolant system after a fission product release depends upon several factors. Among the factors which must be considered are (1) the length of time (MWd) the fuel element or target has been irradiated, (2) the severity of the release, and (3) the length of time the reactor has been in operation.

The quantity of fission products contained in a fuel element is dependent upon the amount of burnup the element has undergone. A fresh element which has just been made critical contains relatively small quantities of fission products while one which is almost depleted contains kilogram quantities. A large quantity of fissionable uranium is contained in the element at any time during the cycle.

A fission product release into the coolant stream is usually the result of one of two types of failure. One is a small hole through the cladding which allows minute quantities of fission products to escape from the fuel element or target. This type release results in a slow buildup of radioactive contaminants in the primary system and usually can be detected in time to prevent major contamination problems.

The other type of failure is a gross loss of the cladding such as might occur during a meltdown or target rupture. In this type of failure, large amounts of fission products are released to the coolant stream and the problems regarding radiation and contamination can be difficult to cope with unless prior consideration has been given to decontamination of the coolant system.

If a minor release occurs, decontamination of the system can usually be accomplished simply by circulating the water through the

cleanup system. This procedure removes most of both the suspended and dissolved solids. Frequent regeneration of the ion exchange columns may be necessary, especially the anion columns which collect the iodine.

If a gross release into the system occurs, there is a possibility that "plating out" of the contaminants onto the piping and equipment will complicate the cleanup job. This "plating out" is the adsorption of the various radioactive elements by the oxide film which builds up, over a period of time, on the stainless steel and aluminum components. Removal of the contaminants is difficult unless the film they adhere to is also removed.

The following procedure has been developed, and is proposed, for the decontamination of the primary coolant system after a gross fission product release is experienced: (It is emphasized that this procedure is intended for use only after other methods of decontamination have failed. Chemicals used in the procedure are corrosive to aluminum and beryllium; therefore, reactor components made of these two materials must be removed and decontaminated separately.)

1. Suspended contaminants, and those in solution, are removed by circulating the primary water through the cleanup system. This operation may require several hours to complete. Demineralizer regeneration will probably be necessary after a relatively short period of operation. Both demineralizers should be placed in service to speed up the operation. While circulating water through the cleanup system, samples should be taken periodically and radioactivity

analyses made on the samples (see Section 8.4.3). From these analyses, it can be determined when it is safe to open the reactor vessel without the danger of fission product gases escaping into the building atmosphere. When it has been determined safe, the quick opening hatch can be removed and the fuel element removed and placed in the defective element storage rack (see Section 8.4.4).

2. Stainless steel and aluminum corrosion test coupons, which were installed inside the reactor vessel before startup are removed periodically and used to make studies of the corrosion rate of the primary system piping and structural components. From these studies, the most effective methods of decontamination can be determined. These studies are necessary because the corrosion film changes chemically with respect to time and different methods of removal may be required depending on the period of time the reactor has operated. As soon after meltdown as safety considerations will permit, additional test coupons should be removed and tested for feasibility of decontamination by using various chemicals to determine the most satisfactory method. Experience at other reactor facilities has resulted in a general decontamination procedure which is suggested for use at the HFIR. This decontamination procedure consists of the use of:

   a. A buffered solution of oxalic acid and hydrogen peroxide.

b. Alkaline permanganate (18% NaOH, 3% $KMnO_4$) followed by a proprietary oxalic acid solution (10%) to remove films and fission products adsorbed on the films.

c. Alkaline permanganate followed by an 8% solution of dibasic ammonium citrate with ethylenediaminetetraactic acid (EDTA), to remove films deposited by the oxalic acid solution.

Cleanup procedures. After the primary coolant water has been demineralized for several hours:

1. Treat with oxalic-peroxide-peracetic solution of pH 4 to 5 at 175°F for a 1-h period. (The solution is heated by simply running the primary coolant pumps.) CAUTION: Demineralized water must be used to purge the pump seals to prevent damage from the chemicals.
2. Rinse with demineralized water. This step consists of purging the system to the ILW at the rate of 100 gpm for a period of 2 h. (At the rate of 100 gpm, 39% of the system is purged at the end of 1 h; 63% at the end of 2 h; and 88% at the end of 3 h.)
3. Treat with oxalic-peroxide-gluconic solution of pH 4 to 5 at 175°F for 1 h.
4. Rinse with demineralized water until the $H_2C_2O_4$ concentration is less than 30 ppm.
5. Treat with alkaline permanganate at 195°F for a period of 2 h.
6. Rinse with demineralized water until the MnO_4 concentration is approximately 10 ppm or less.

7. Rinse with 1% oxalic acid solution to a pH of 10 or below.
8. Treat with a solution of proprietary oxalic-acid compound at 185°F for 2 h.
9. Rinse with demineralized water until the specific resistance reaches approximately 10,000 ohm-cm.
10. Repeat steps 5 through 9.
11. Repeat step 5.
12. Repeat step 6.
13. Treat with a solution of 8% dibasic ammonium citrate with 1% EDTA at 185°F for 2 h.
14. Rinse with demineralized water until the specific resistance reaches 10,000 ohm-cm.

Solutions. The solutions used in the above proceudres are mixed as follows:

Oxalic-Peroxide-Peracetic

Sodium oxalate	32 g/l
Oxalic acid	2.3 g/l
H_2O_2	15 g/l (50 g/l of 30% solution)
Oxine	1 g/l
Peracetic acid	5 g/l

Oxalic-Peroxide-Gluconic

Oxalic acid	2.3 g/l
Sodium Oxalate	32 g/l
H_2O_2	15 g/l
Oxine	1 g/l
Gluconic acid	2.5 g/l
Sodium Gluconate	10 g/l

Alkaline Permanganate

18% NaOH and 3% $KMnO_4$ prepared by adding 180 g of NaOH and 30 g of $KMnO_4$ to each 790 g of water.

Dilute Oxalic Acid Solution (1%)

Prepared by adding 10 g of oxalic acid to 990 g of water.

Proprietary Oxalic Acid Solution (9%)

Prepared by adding 90 g of proprietary oxalic acid compound to each 910 g of water.

Ammonium Citrate - EDTA (8%)

Prepared by adding 80 g of dibasic ammonium citrate and 10 g of EDTA to each 910 g of water.

8.5. Radiation Warning and Communication System

Continuous general monitoring for radiation and airborne contamination is by means of standard ORNL monitrons and continuous air monitors, at various selected locations. The individual instruments provide local and control room alarms; certain monitrons and CAMs are designated as part of the "evacuation system," and will actuate the HFIR building evacuation system when a coincident high radiation alarm is indicated by two or more monitrons or CAMs. The Laboratory Emergency Control Center at Guard Headquarters is automatically notified through an annunciation system of the evacuation condition.

8.5.1 Monitron

The monitron consists of a sensitive beta-gamma ionization chamber with power supply and signal amplifier. Indicating meters on the front panel of each instrument read radiation level, and a lamp

and bell annunicate locally any radiation above intermediate level. Output contacts signal high radiation level ("red" alarm) at about 23 mr/h, intermediate radiation level ("yellow" alarm) at about 7.5 mr/h, and instrument-inoperative ("white" alarm) conditions for remote annunciation. Reset of all alarm contacts is automatic following removal of the condition causing the alarm; the reset is immediate for the instrument inoperative and the intermediate level radiation alarms, and is delayed about 1 min for the high radiation condition.

8.5.2 Continuous air monitor

The CAM draws a continuous air sample through a paper tape filter, and measures the sum of the radioactivity of airborne gases and of accumulated particles on the filter. A G-M tube, shielded from external radiation and sensitive to beta and gamma, and a pulse amplifier are employed for the radiation measurement. The local CAM cabinets are equipped with indicating meters and miniature recorders for radiation readout, manual and timed automatic control for stepping tape advance, buzzer audible alarms for intermediate radiation, and bell audible alarms for high radiation. Output contacts for remote annunciation signal intermediate radiation ("yellow" alarm) when the count rate exceeds 1,000 counts per minute. Additional contacts signal high radiation ("red" alarm) conditions. Reset of the intermediate radiation and instrument inoperative alarm contacts is automatic following removal of the condition that caused the alarm; high radiation alarm contacts must be reset manually by means of controls on the CAM cabinets. Each CAM has a "popper" audio amplifier and speaker for audible monitoring of count rate, a test pushbutton for checking the local alarm lamps, air flowmeter, and other condition lamps.

8.5.3 Control room readout

Each of the listed CAMs and monitrons has its alarm contacts connected to actuate one indicator module of the radiation alarm panel in the control room. The modules each have three lamps; red, yellow, and white, corresponding to the previously mentioned alarm conditions. All of the lamps glow dimly under normal conditions; when an alarm condition develops, the appropriate lamp or lamps glow brightly, and an annunciator alarm sounds (radiation instruments). The annunciator may be silenced by the acknowledge button on the console; the alarm lamps can be dimmed by depressing the reset pushbutton on the indicator modules, but will remain dimmed only if the alarm condition has been eliminated.

When a CAM or monitron is disconnected locally from the central system, all three lamps on the associated module will glow brightly.

8.5.4 Building evacuation system

The radiation alarm panel in the control room includes a switching system, whereby simultaneous high radiation ("red") alarm condition in any pair of modules associated with certain of the CAMs, or any pair associated with certain monitrons, will signal building evacuation request. Evacuation request consists of the following:

1. One or both lamps on the evacuation alarm modules of the radiation panel in the control room glow brightly, indicating high radiation (monitrons) and/or contamination (CAMs) as originating the request.
2. Corresponding lamp or lamps are illuminated on the Laboratory Emergency Control Center radiation alarm panel at Guard Headquarters, accompanied by audible alarm.

3. The building evacuation horns sound.
4. The flashing beacons on the outside corners of the building are energized.

The horns are powered from individual nitrogen bottle reservoirs with three-to-four minute supplies, and are turned on by a solenoid valve that is energized-to-open; the valves must be manually reset after operation. The alarm panel, horn solenoid valve, and flashers are powered from a source with emergency diesel backup; following a power interruption, there is an automatic time delay before the local radiation instruments are reconnected into the control room alarm and evacuation systems, in order to permit the instruments to warm up and restore to their correct readings. A key-operated lockout is provided at the radiation alarm panel, which blocks operation of the evacuation horn and flashers during tests of the evacuation system; the evacuation request lights on the control room panel are not disabled by the lockout, but the corresponding Emergency Control Center lamps are energized by the lockout.

The evacuation horn gas supply includes the high-pressure reservoir, main shutoff valve, and a pressure reducer with pressure indicators on high and low sides. Pressure switches respond to low reservoir pressure, main shutoff valve, and a pressure reducer with pressure indicators on high and low sides. Pressure switches respond to low reservoir pressure, and to high or low pressure output from the reducer. The switches actuate a single horn supply trouble lamp on the radiation alarm panel in the control room, without audible alarm.

8.6. Poison Injection System

8.6.1 References

Drawings:

E-50157 Piping Arrangement

E-50161 Flow Sheet

8.6.2 Introduction

The poison injection system, utilizing cadmium nitrate in solution, has been provided as an emergency backup for the normal reactor safety system.

There are several methods of shutting down the reactor by use of the shim plates. These methods are:

1. scram of the shim-safety plates;
2. reverse of the shim-safety plates and the shim-regulating cylinder;
3. insertion of the shim-safety plates with the air motors;
4. insertion of the shim-regulating cylinder using the portable air motor located in the subpile room; and
5. insertion of the shim-safety plates manually, using the hand crank.

In all of the above methods, it is necessary that the shim plates be movable. If conditions should exist whereby it is impossible to maintain control of the reactor by manipulation of the shim plates, it may become necessary to use the poison injection system to shut the reactor down. It is not planned to ever inject the poison into the reactor system unless it is really needed.

8.6.3 Precautions

1. The poison injection system should only be used during an

extreme emergency; such as, shutdown cannot be accomplished using any of the first three methods mentioned above. If the system is used, a considerable amount of time is required to remove the cadmium nitrate poison from the reactor system.

2. Cadmium nitrate is toxic; therefore, every precaution should be taken to prevent its ingestion into the body. If any of the solution gets on the body, no harmful effects will result; however, it should be removed by washing with water.

8.6.4 Injection into the primary system (see Fig. 8.1)

NOTE: This procedure assumes the reactor is operating with one pressurizer pump running with a discharge flow rate of approximately 180 gpm.

1. The first indication that the reactor power level is increasing above that demanded by the servo system is the actuation of the "2/3 servo insert error" annunciator on panel C. The power level should be checked to make sure that it does exceed the demand.
2. Open the box cover of the poison injection system control valve box located in the control room at the bottom of panelboard EXP. 1 and PULL the three valve knobs labeled 1, 2, and 3 in that order. Check the level in the sight glass on the side of the tank to assure the poison is being injected. If the level is not dropping, go immediately to the ground floor and check the valve positions. Manually operate the valve which failed to actuate.

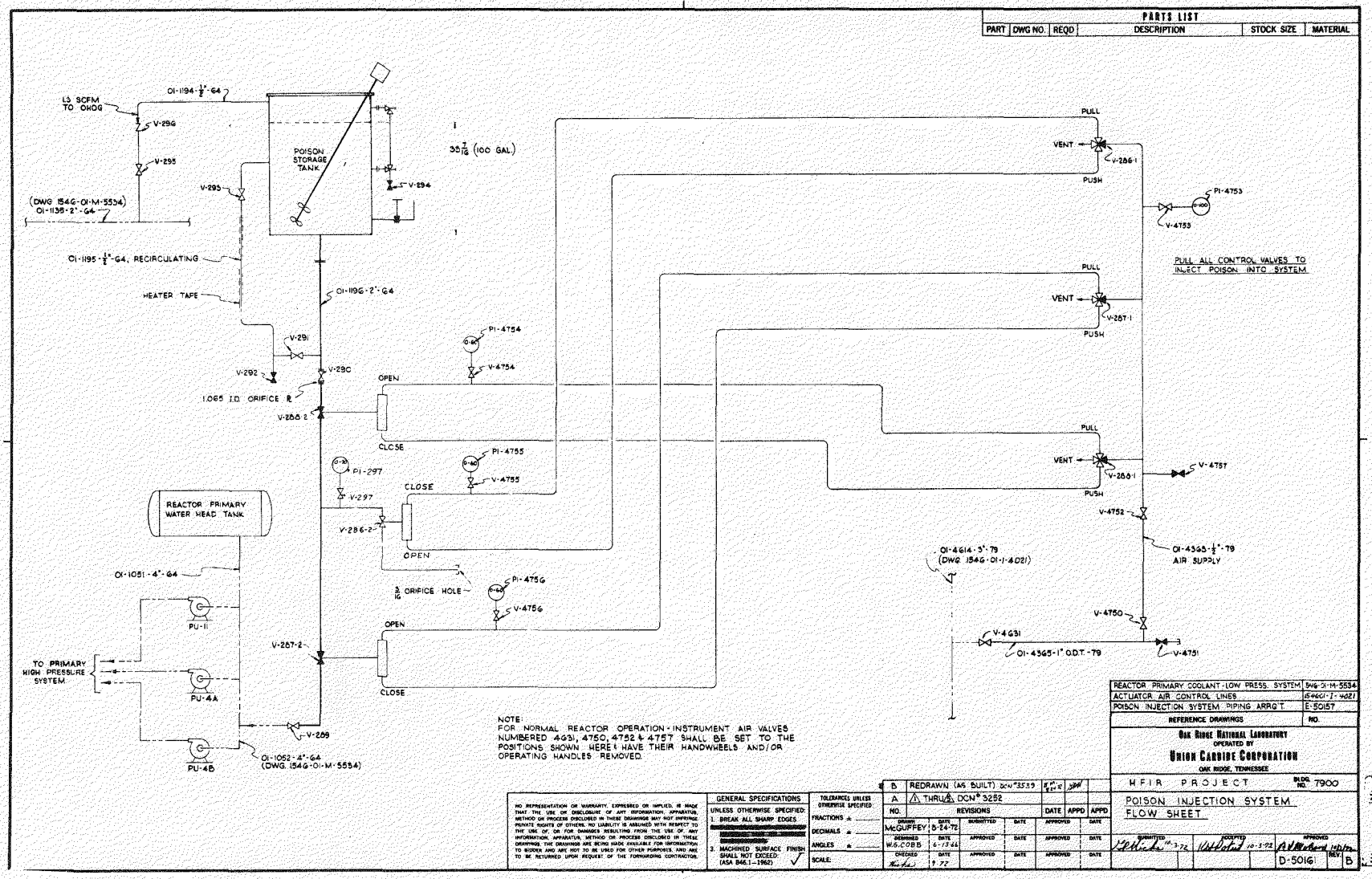


Fig. 8.1. Poison injection system flow sheet.

3. The sequence of events which occurs when step 2 is accomplished is as follows:
   a. Valve V-286-2 on the drain line is closed.
   b. Valves V-288-2 and V-287-2 are opened to allow the poison to flow to the pressurizer pumps and thus be injected into the primary system.
4. Allow approximately 4 min for the solution to be injected.
5. Stop the letdown flow by turning the letdown block valve switch to "block" position. This block valve switch is located in the control room near the bottom of panelboard E.
6. Remove the valve "stop" from behind the valve knobs and PUSH valve knobs 2 and 3 all the way in to isolate the poison injection system.
7. Stop the primary pumps. NOTE: A minimum flow of that produced by two pony motor pumps must be maintained for removal of afterheat.
8. Allow the main pressurizer pump to continue running.
9. Observe the nuclear instruments and report these actions to the Reactor Supervisor.

8.6.5 Normal conditions and checks

1. The system will be maintained in the standby conditions as follows:
   a. Manual valve V-295 open to allow 1.35 cfm to OHOG from the storage vent.
   b. Manual valves V-291 and V-293 open to allow recirculating flow by thermal convection.
   c. Manual valves V-290 and V-289 locked in the open position to allow injection when the air-operated valves V-288-2, V-287-2, and V-286-2 are actuated.

d. Valve V-286-2 open to atmosphere to assure that any leakage past valve V-288-2 does not enter the system while in the standby condition. (The drain line from V-286-2 will normally be capped; the cap will contain a small vent hole.) The position of the air control valves in the control room should be in the "mid" position and the "stop" placed behind the valve knobs to prevent their being pushed inward.

e. The tank level should be maintained between 31 and 33 in. full.

2. A weekly check is made of the specific gravity. The sample is taken at valve V-292. The normal specific gravity is approximately 1.496 at 68°F. The minimum specific gravity allowable is 1.476 at 68°F.

8.6.6 Poison injection system valve operation test

The purpose of this test is to assure that the air-operated poison-injection valves are in operating condition. The test consists of measuring the air pressure required to actuate the valves after a period of time in which they were not used. A comparison of the present actuating pressure to those obtained when the system was first installed is indicative of the status of friction forces on the ball valves. These actuating pressures were determined on May 17, 1966, and are as follows:

Valve Number	Function	Cracking Pressure	Actuating Pressure
V-286-2	Vent	5.0 psi	7.0 psi
V-287-2	to pumps	3.0 psi	3.0 psi
V-288-2	from tank	4.0 psi	4.0 psi

If the pressure required to actuate any valve exceeds 20 psig during performance of the following tests, the valve should be removed for maintenance or replacement.

Test Procedure

1. The reactor must be shut down and the Shutdown Checklist completed.
2. Two operators are required to conduct this test - one in the control room and one at the presurizer pumps. Communication should be established using the sound-powered telephone system.
3. Close manual valves V-290 and V-289 at the pressurizer pump.
4. Remove the orificed cap on the end of the vent line. Attach a hose coupling and a 10-ft hose to the fitting. Position a 5-gal capacity plastic container so the hose can empty into it. R
5. Close valve V-4752 on the air supply line in back of panelboard E-4. Open valve V-4757 which vents the air supply line and observe PI-4753 drop to zero pressure. V-4752 is to remain closed.
6. The control room operator should now pull valve 3 (V-288-1) in the valve box on the front of panelboard E-4.
7. Close communication should now be established between the two operators.
8. The operator at the pressurizer pumps should now pay close attention to PI-4754 and place his hand on valve stem of V-288-2 and instruct the control room operator to slowly open V-4752 until a small amount of air can be heard coming from the vent line. Notify the operator at the pressure gauge and valves that air is to be fed to the valve, R

L D Eagle	R V McCord	G G Hunt
Technical Section	Reactor Operations Section Head	Reactor Supervisor

causing it to actuate. By observing PI-4753 (to the left of the vent valve), the rate at which pressure builds up to the valve can be observed. Very slowly close the vent valve V-4757. The first flicker of the gauge indicator (PI-4753) after at least 2 or 3 lbs of pressure buildup is the breaking pressure of the valve. When the operator at the pressure gauges and valves signifies that the valve is fully actuated in the opposite position, record the value observed for both the breaking pressure and full actuation. Record the pressure at which the valve starts to move and when fully actuated to the opposite position.

9. When V-288-2 opens, the trapped solution will drain into the plastic container. After the solution has drained into the container, open valve V-290 until a full flow of solution begins to fill the container. Close V-290 immediately. Completely empty the hose into the container. Remove the hose and hose fitting. Insert a plastic tube or tygon hose into the vent line and try to flush as much of the inside of the pipes as possible to the floor drain. Use demineralized water. Return the container of $Cd(NO_3)_2$ solution to the storage tank adjacent to the control room. R
10. When the flushing is complete, replace the orificed cap on the vent line. The control room operator should be instructed to push valve 3 (V-288-1) to close valve V-288-2 (air pressure is required from V-4752); then return valve 3 to the intermediate position. The operator at the valves should verify that V-288-2 is closed.
11. The control room operator should now close V-4752 and open

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V-4757 to vent the air supply line and observe PI-4753 drop to zero pressure. Valve V-4757 remains open; V-4752 is to remain closed.

12. Pull valve 2 (V-287-1) in the valve box.
13. Establish close communication between operators.
14. The operator at the pressurizer pumps should now pay close attention to PI-4756 and V-287-2 and instruct the control room operator when he is ready.
15. Repeat Step 8. Record the pressures for valve V-287-2.
16. The control room operator should be instructed to push valve 2 (V-287-1) to close V-287-2 (air pressure from V-4752 is required); then return valve 2 to the intermediate position. The operator at the valves should verify that V-287-2 is closed.
17. The control room operator should now close V-4752 and open V-4757 to vent the supply line and observe PI-4753 drop to zero pressure. Valve V-4757 remains open; V-4752 is to remain closed.
18. Pull valve 1 (V-286-1) in the valve box.
19. Establish close communication between operators.
20. The operator at the pressurizer pumps should now pay close attention to PI-4755 and valve V-286-2 and instruct the control room operator when he is ready.
21. Repeat Step 8. Record the pressures for valve V-286-2.
22. The control room operator should be instructed to push valve 1 to open valve V-286-2 (air pressure from V4752 is required); then return valve 1 to the intermediate position. The operator at the valves should verify that V-286-2 is open.

23. The control room operator should now fully close valve V-4757 and open valve V-4752. Remove the handles of both valves.

24. Complete the following checklist.

    a. V-4750 valve open and handle removed _____
    b. V-4752 valve open and handle removed _____
    c. V-4757 valve closed and handle removed _____
    d. V-4631 valve open and handle removed _____
    e. PI-4753 reading approximately 60 psig _____ R
    f. Knobs 1, 2, and 3 at intermediate position _____
    g. V-286-2 open; V-287-2 closed; V-288-2 closed _____

25. Backflush water from the head tank suction to drain

    a. Make sure valves V-289, V-290, V-287-2, and V-288-2 are closed. If not close them. R
    b. Close valves V-1051, V-1052, and V-1053 at the suction of the three pressurizer pumps.
    c. Remove the pipe cap on the drain line from V-286-2 which contains an orifice and make sure no solution is leaking out. Install the "Chicago coupling" and pipe coupling on the line where the cap was removed. Attach a water hose to the coupling and run it to drain.
    d. Open head tank outlet valve V-1050.
    e. Open V-289 and pull knob 2 in the control room to open V-287-2. Water should flow from the head tank through V-286-2 and the water hose to drain. Allow it to run 10 to 20 s, then close V-289.
    f. When all the water has drained from the line, remove

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the hose, Chicago coupling, and pipe coupling. Replace the pipe cap with the 3/16-in. orifice.

g. Push knob 2 in the control room to the intermediate position, then all the way in position. Observe that valve V-287-2 closes. Pull knob 2 to the intermediate position.

26. Complete the following checklist:

a. Knobs 1, 2, and 3 in the control room at the intermediate position _____

b. Valves V-287-2 and V-288-2 closed; V-286-2 open _____

c. Open valve V-289 and lock in the open position _____

d. Open valve V-290 and lock in the open position _____

e. Open V-1051, V-1052, and V-1053 at the suction of the three pressurizer pumps _____

8.7. Emergency Secondary Cooling to Primary Heat Exchangers

An emergency secondary cooling water supply line has been provided so that potable water may be used to supply the primary heat exchangers in the event of total failure of the secondary system.

A 2 1/2-in. line ties into the main secondary water header just downstream of flow control valves, FCV-377 and FCV-377A (see Fig. 8.2). This line extends to the top of the valve pit and has a connection so that a fire hose may be connected from a nearby fire hydrant to the line. The fire hose is located near the valve pit.

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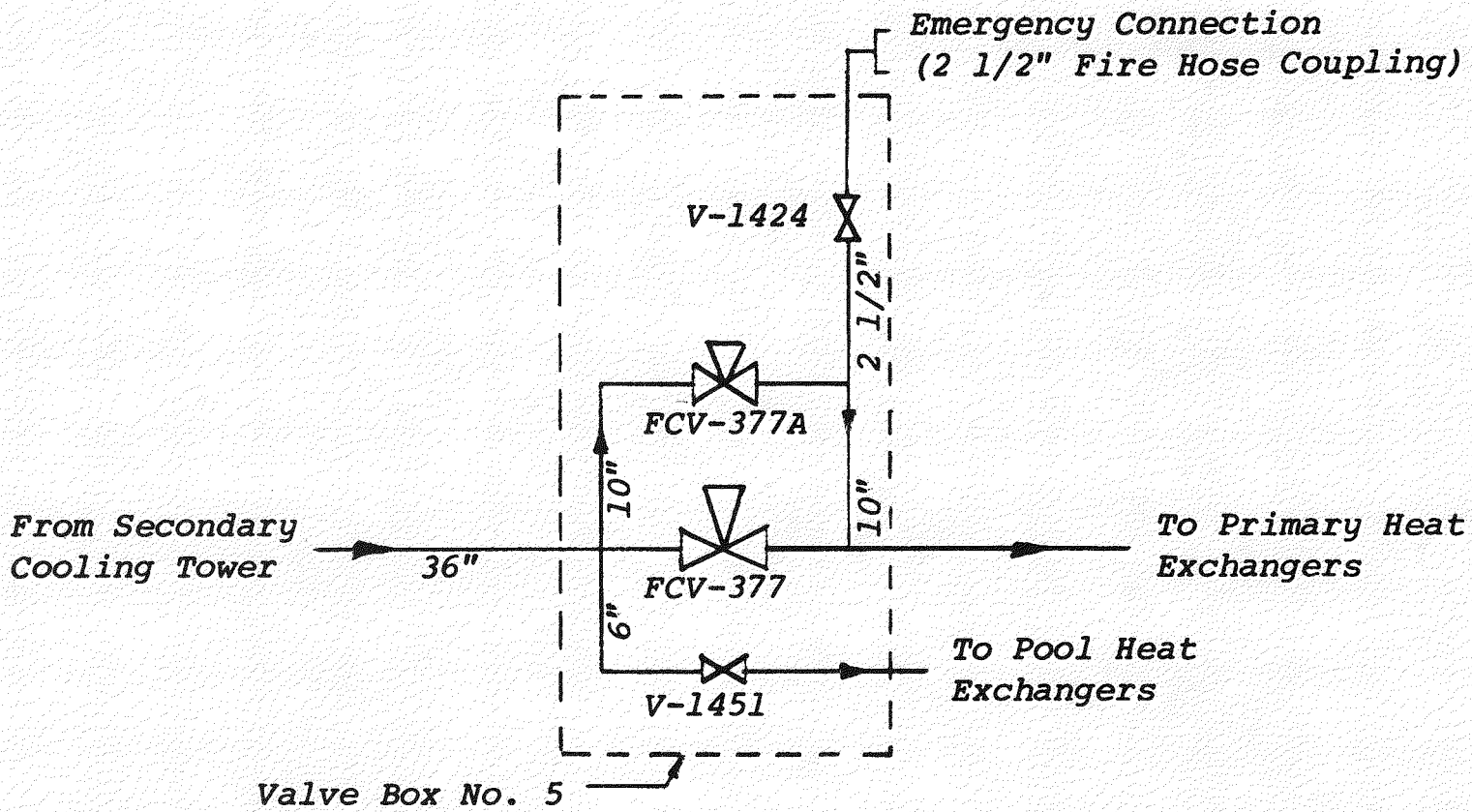


Fig. 8.2. Emergency secondary cooling.

It is not expected that this system will ever be used; however, in the unlikely event of failure of the secondary system due to the loss of all three pumps or to failure of both flow control valves, the hose may be quickly connected and sufficient secondary coolant provided. The ORNL fire department must be notified if the system is placed in service.

9. WASTE SYSTEMS

9.1. Process Waste System

9.1.1 References

Drawings:

1546-05-U-7111, -U-7115	Yard Piping
1546-05-U-7126, 1546-I-4008, 1546-05-I-4036	Valve Boxes and Monitoring Boxes
1546-05-U-7130	Process Waste Sump, Details
1546-05-U-7145	Process Waste Flow Diagrams
1546-05-U-7306	Process Waste Basins

Singmaster & Breyer Specifications: 61 Process Waste

9.1.2 Introduction

The process waste disposal system collects, provides decay time for, and then disposes of, low-level radioactive liquid wastes. These wastes are collected from experiment drains, floor drains, equipment drains, SBHE filter pit drains, and the cooling tower blowdown which may, because of leaks, contain radioactive contamination. Decay time is provided by holdup basins before allowing the waste to enter Melton Branch or before sending it to the ORNL waste collection system (see Fig. 9.1).

9.1.3 Operation of the System

To place the system into service. Close FCV-700 and open FCV-701 remotely from the control room with selector switch SS-20 on the liquid waste panel.

Instrumentation and Control Division personnel will place the monitoring and control system into service. Check the automatic operation of this system by placing a radioactive source near the

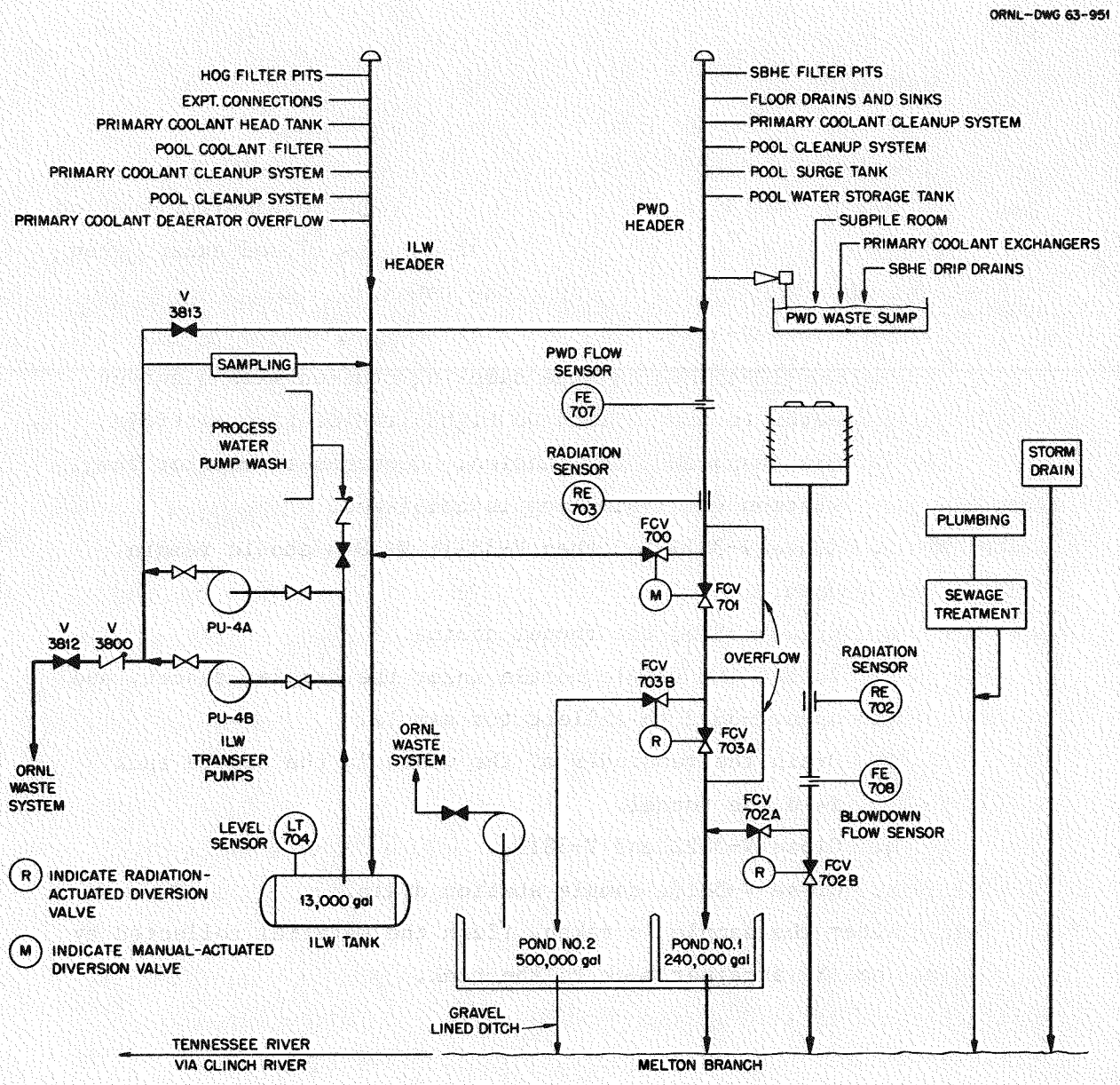


Fig. 9.1. Liquid-waste monitoring system.

monitors and observing the operation of the diversion valves and the alarms received in the control room.

1. Monitor box No. 2
    a. Approach RE-703 with the source. An alarm, "Process Waste Radiation Hi," should annunciate in the control room. Observe that FCV-703B opens and FCV-703A closes. These valves are located in valve box No. 2.
    b. Bring the source closer to RE-703. Another alarm, "Process Waste Radiation Very Hi," should annunciate in the control room.
2. Monitor box No. 1
    a. Approach RE-702 with the source. An alarm, "Tower Waste Radiation Hi," should annunciate in the control room. Observe that FCV-702B closes and FCV-702A opens. These valves are located in valve box No. 1.
3. Process Waste Sump
    a. Open V-3105 and V-3106, main steam supply to the ejectors.
    b. Close V-3109, level control valve bypass.
    c. For ejector EJ-4 operation only, close V-3108 and open V-3107.
    d. For ejector EJ-5 operation only, close V-3107 and open V-3108.
    e. For operation of both ejectors, open both V-3107 and V-3108.

After the system is placed in service, operation of the process waste sump ejectors is automatically controlled by LCV-710A. The span of control by LCV-70A is 30 in.

Normal operation. Liquid process waste from the reactor building area flows by gravity through valve box No. 3, on the southwest side of the reactor building, where it is monitored by RE-703. If medium level activity (600 c/min) is detected, it will be annunciated in the control room where the operator can remotely divert the flow to the ILW tank. Should low level activity (500 c/min) be detected, the waste flows to valve box No. 2 where it is automatically diverted into retention pond No. 2 for decay and disposal to the Laboratory Equalization Basin.

If no activity is detected by RE-703, the waste flows into retention pond No. 1 where it is held for varying lengths of time before being discharged into Melton Branch.

Waste from the cooling tower area (blowdown, etc.) normally discharges directly into Melton Branch by way of valve box No. 1. However, should activity levels above background be detected by RE-702, the flow is diverted to retention pond No. 1 for holdup.

Operation during an outage of normal power. The monitor system and diversion valve motors are connected to the No. 1 normal-emergency power distribution system through MCC "J" and will operate approximately 20 s after startup of the No. 1 diesel-generator.

Table 9.1. Process waste radiation monitoring system

Radiation sensor	Location of diversion valves	Setpoint	Alarm	Action
		Reactor Building Process Waste Drainage		
RE-703	Valve box No. 2 (FCV-703A, 703B)	Background		Flows to pond No. 1
		>Background but <500 c/min	Process waste radiation high	Flow is automatically diverted from pond No. 1 to pond No. 2
	Valve box No. 3	>600 c/min	Process waste radiation very high	Flow may be diverted to ILW tank with SS-20
		Cooling Tower Waste		
RE-702	Valve box No. 1 (FCV-702A, 702B)	Background		Flows directly to Melton Branch
		>Background	Tower waste radiation high	Flow is automatically diverted to pond No. 1

9.2. Intermediate-Level Waste System

9.2.1 References

Drawings:

1546-05-U-7111, -U-7115	Yard Piping
1546-05-U-7128	Filter Pit Details
1546-05-U-7145	Flow Diagrams
1546-05-U-7304	ILW Tank, Pumps, and Sampling System
1546-05-M-5518, -M-5519, -M-5520	Drains

Singmaster & Breyer Specifications:

61 Intermediate-Level Waste

42 ILW Pumps

9.2.2 Introduction

Intermediate-level wastes are liquids which contain gross beta-gamma activity levels greater than 5.8×10^3 d/m/ml. Collection of ILW is from primary coolant loop drains, decontamination fluids, hot off-gas filter pit drains, experiment drains and spent resin disposal drains (see Fig. 9.2).

The wastes flow by gravity to the ILW collection tank for temporary storage. Disposal consists of neutralizing, if necessary, with NaOH to the desired pH (>7.0) and pumping to the Melton Valley Waste Collection Station.

9.2.3 Precautions

The volume of waste allowed to discharge into the ILW system should be kept at a minimum because: (1) the capacity of the system is limited, and (2) it is expensive to dispose of this type of waste.

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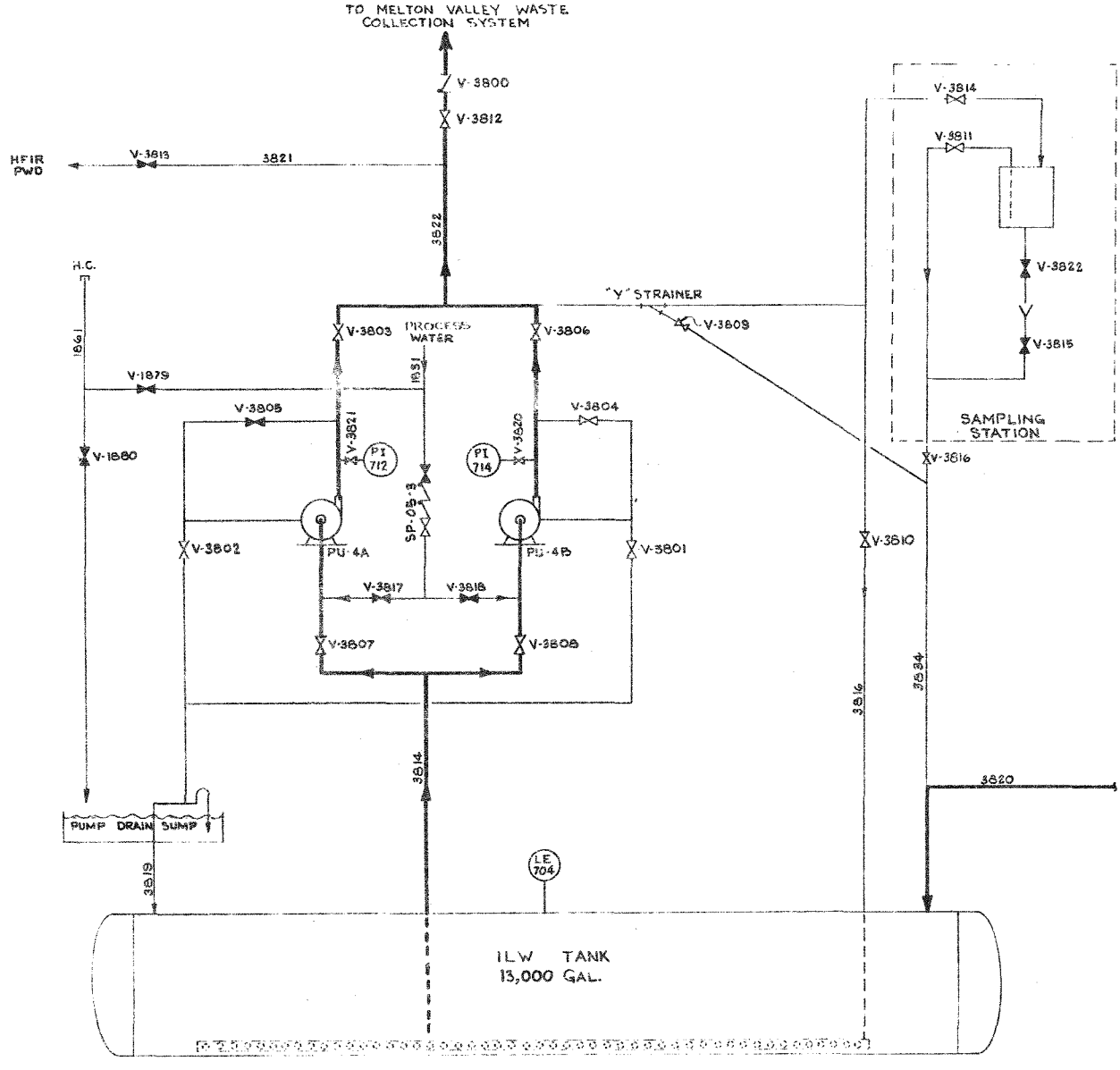


Fig. 9.2. Schematic flow diagram ILW tank and pump station.

j. Open V-3809 on the strainer flush line. Allow water to flush the strainer for at least 3 min.

k. Close V-3809 to stop the flushing.

Return the system to standby.

l. Close V-3803 (V-3806).

m. Stop the pump.

n. Close V-3807 (V-3808).

3. Transfer waste to the Melton Valley Central Waste Station

a. If the activity of the above sample is $>5.8 \times 10^3$ d/m ml, contact the ORNL Waste Disposal System supervisor for permission to pump to the Melton Valley Central Waste Station.

b. Neutralize the waste with NaOH.

c. Open V-3807, pump suction (V-3808).

d. Open V-3803, pump discharge (V-3806).

e. Close V-3805, pump discharge drain (V-3804).

f. Close V-3813, to PWD system.

g. Open V-3812, to Melton Valley Central Waste Station.

h. Start the east pump, PU-4A.

i. Open V-3803, pump discharge.

Observe suction and discharge pressures to be sure waste is being pumped. When the transfer is completed:

j. Close V-3803, pump discharge.

k. Stop the pump.

l. Close V-3807 and V-3812.

4. To neutralize the waste with NaOH

Sample the waste as per standard procedures. Add caustic

as necessary, while waste is being recirculated, to make the pH higher than 7. Caustic is added from the day tank as follows:

a. Close V-6010, caustic drain to PWD.
b. Close V-6002, caustic pump suction.
c. Open V-6001, discharge from bottom of day tank.
d. Open V-6011, caustic drain to ILW tank.
e. Allow caustic to flow until sampling at the ILW tank shows a pH of 7 or above.
f. Close V-6011 and V-6001.
g. Place V-6002 and V-6010 in position for normal operation.

5. Flush the pumps and lines with process water before entering the pump pit. Flush pumps one at a time because the process water supply is not sufficient to flush both pumps at once. Valves V-3801 and V-3802, continuous pump seal drains, should always be locked in the open position.

a. Close V-3807 and V-3808, suction side of pumps PU-4A and PU-4B.
b. Open V-3817 (V-3818), process water supply to pumps.
c. Open V-3803 (V-3806), discharge to pumps.
d. Open V-3810, recirculation line to tank. Allow water to flow through the pump for 2 min, then close V-3810.
e. Open V-3811 and V-3814, sampling station. Allow water to flow for 2 min, then close both valves.
f. Open V-3809, strainer flush line, and allow water to flow for 2 min.

When the flushing is completed, place the system back in

standby condition:

g. Close V-3803 (V-3806).

h. Stop pump.

i. Close V-3817 (V-3818).

6. Flush the pump pit sump. (This will be necessary only if the sump becomes contaminated.)

   a. Open V-1880, process water line.

   b. Crack open V-1879 to allow water to flow into the sump, but not enough to force water from the hose connection on top of the pit. Process water flows into the sump, filling it to a depth of 6 ft where the overflow takes it into the storage tank.

   After sufficient time has elapsed for complete purging of the sump, close V-1879 and then V-1880.

Daily checks

1. Record the storage tank level from LR-704 in the control room. The level should not be allowed to exceed 75% of tank capacity (approximately 13,000 gal). This leaves sufficient space for emergency drainage into the tank. When the volume of the waste in the tank reaches 75% of its capacity, the tank should be emptied by disposing of the waste as indicated in procedure 9.2.3.

9.3. Hot Off-Gas Systems

9.3.1 References

Drawings:

1546-01-H&V-3001	Air Flow Diagrams
1546-01-H&V-3028	Building Control Diagram
RC-11-10-9	Instrument Application Diagrams
RC-11-10-11	Gaseous Waste Monitoring

Singmaster & Breyer Specifications: 59 Charcoal Bed Filters
62 Open and Closed Hot Off-Gas Systems

9.3.2 Introduction

The HFIR radioactive gaseous waste disposal system consists of two separate and independent off-gas systems - the Open Hot Off-Gas System (OHOG) and the Closed Hot Off-Gas System (CHOG). The two systems collect gases and particulate matter from equipment and experiments from which fission gases could be accidentally released and from which small amounts of radioactive gases are routinely released. These gases are decontaminated by filters and then discharged to the atmosphere through the 250-ft high HFIR stack. The systems provide high vacuum (-55 in. H_2O) and low-flow exhaust (500 cfm) (see Figs. 9.3, 9.4, and 9.5).

9.3.3 Precautions

1. When transferring either of the off-gas systems to the center filter compartment, the compartment operation and the center compartment must be paralleled before the operating compartment is valved out of service. This assures continuous operation of the system.

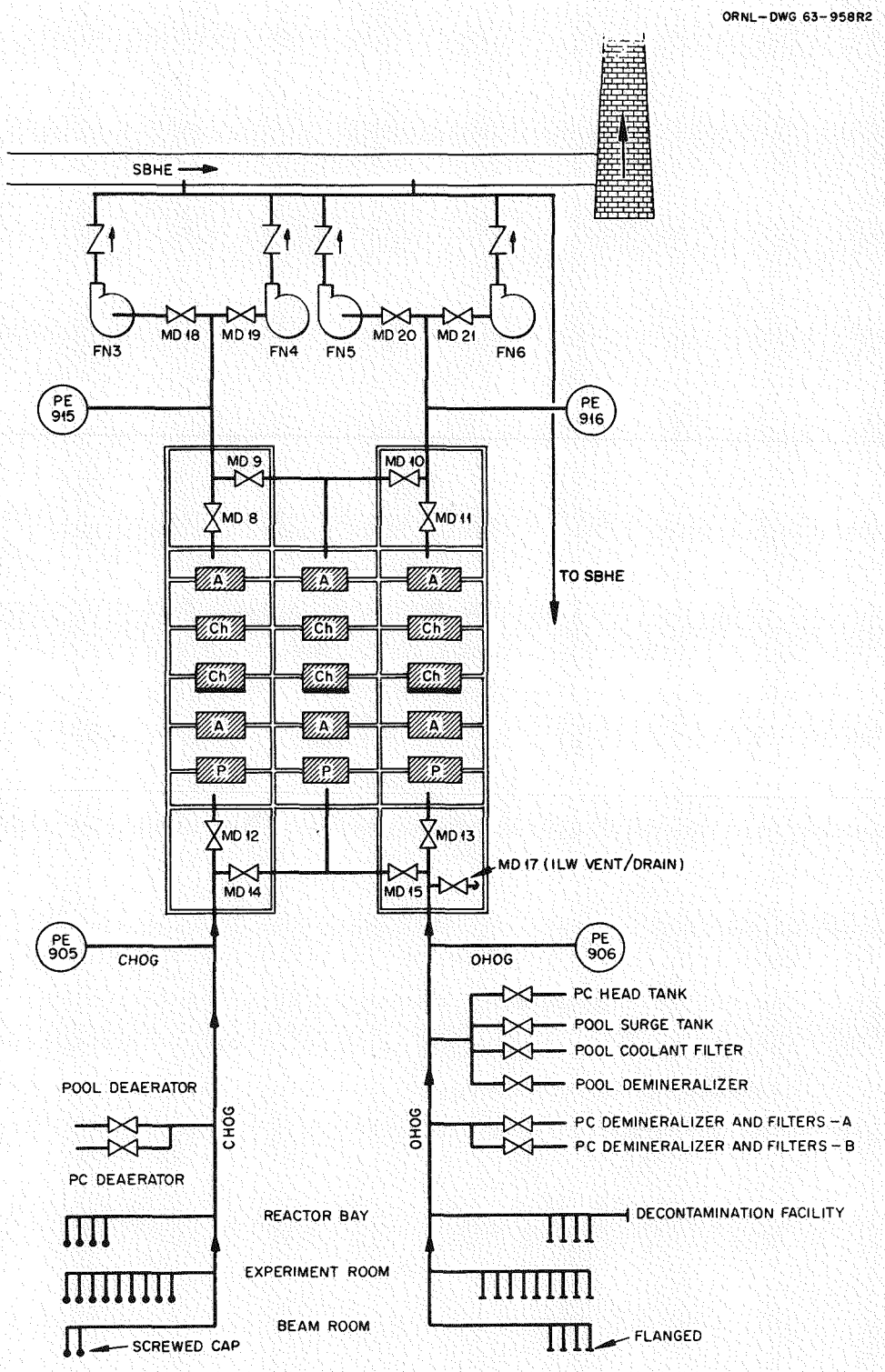


Fig. 9.3. Hot off-gas system.

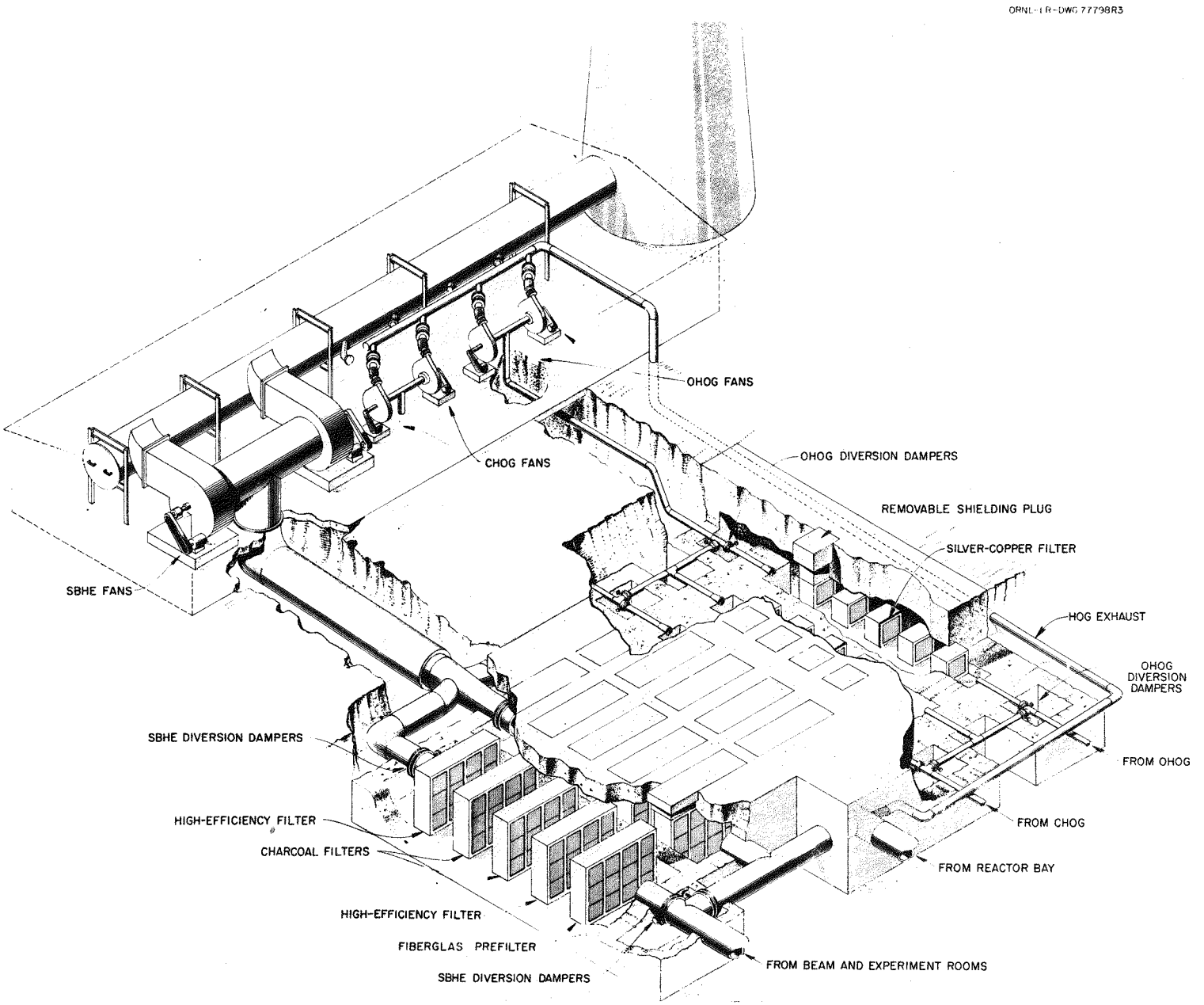


Fig. 9.4. Isometric of exhaust fans and filter pits.

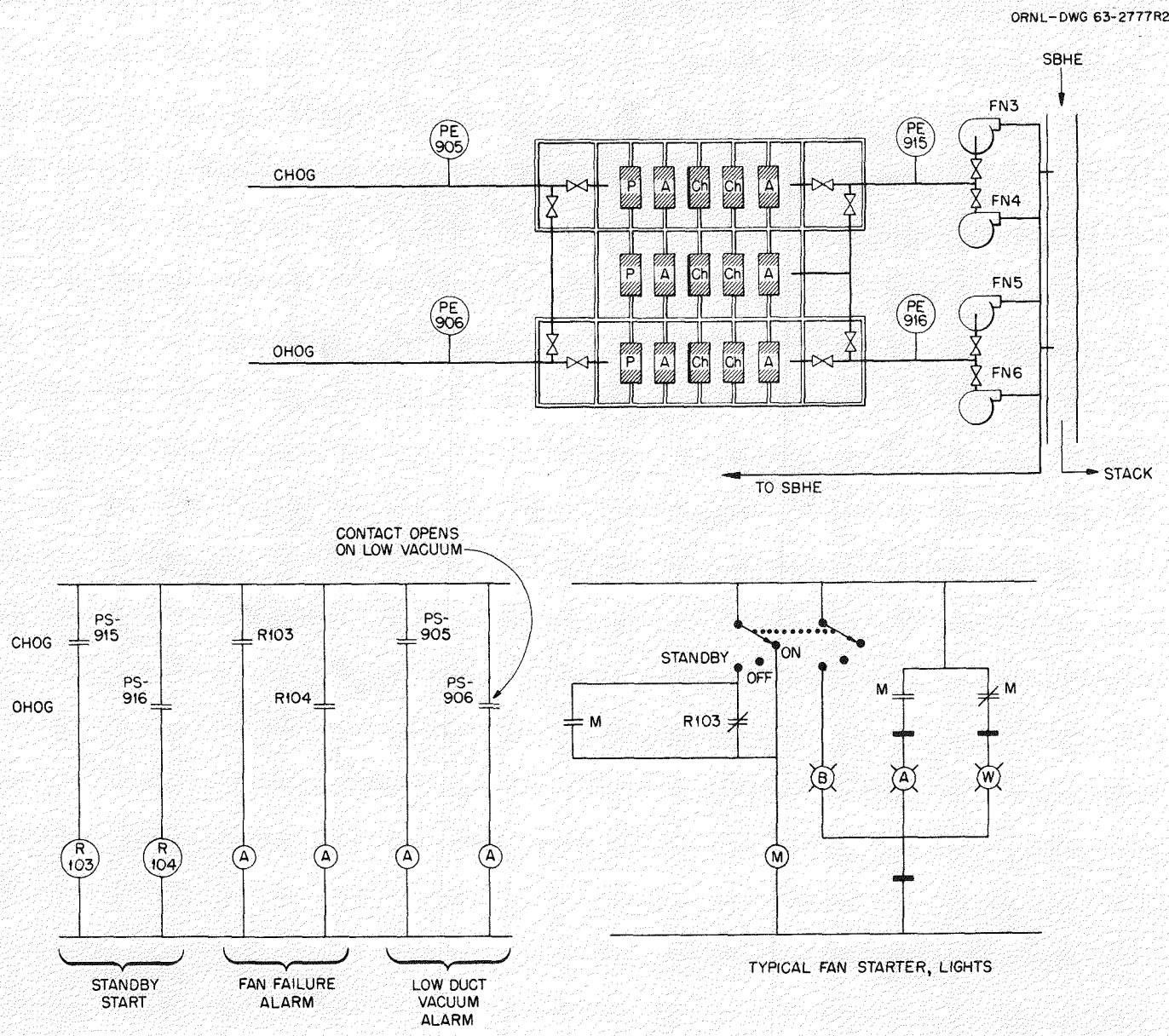


Fig. 9.5. HOG fan controls.

2. The off-gas systems should never be removed from service while the reactor is in operation.
3. All HOG manual dampers are clockwise to open, and counter-clockwise to close.

Table 9.2. Pressure indicators, setpoints, and actions

System	PI	Location	Sensor location	Normal pressure inches H_2O	Setpoint inches H_2O	Action
OHOG	906	Control room	Reactor side of OHOG filters	-48	-43	Alarm
	916	Fan shed	Fan side of OHOG filters	-54	-41	Standby fan starts
CHOG	905	Control room	Reactor side of CHOG filters	-48	-43	Alarm
	915	Fan shed	Fan side of CHOG filters	-54	-41	Standby fan starts

perating Procedures

To Place the OHOG System into Service

1. Open the ILW vent damper, MD-17, at the valve pit on the inlet side of the OHOG filter compartment.
2. Open dampers MD-13 on the inlet side and MD-11 on the exit side of the east off-gas filter compartment.
3. Close dampers MD-15 on the inlet side and MD-10 on the exit side of the center off-gas filter compartment.
4. Open dampers MD-20 on the suction side of the west OHOG fan (FN-5) and MD-21 on the suction side of the east OHOG fan (FN-6).
5. Close the breakers for fans FN-5 and FN-6 in MCC "G" and MCC "H."
6. Test the "standby-start" feature of the fan controls while placing the system into service. In the following, A is the fan which is to be operated and B is the fan which is to be on standby.
   a. Establish two-way communication between fan shed and the control room.
   b. Place the fan B control switch in the "standby" position. The fan should start.
   c. Turn the control switch for fan A to the "standby" position.
   d. Place the control switch for fan B in the "off" position. An annunciator, "OHOG Flow Low," in the main control room should alarm. Almost immediately, the alarm should clear as the standby fan, fan A, starts. The white "off" light for fan B should be on.

e. Place the control switch for fan B in the "standby" position. The blue "standby" light for fan B on the gaseous waste panel should come on and the white light should remain on to indicate that B is not running.

f. Place the control switch for fan A in the "on" position.

The OHOG system is now in normal operating condition. Observe all pressure indicators in the fan shed and in the reactor building for normal operation conditions.

To place the CHOG system into service

1. Open damper MD-18 on the suction side of the west CHOG fan (FN-3).
2. Open damper MD-19 on the suction side of the east CHOG fan (FN-4).
3. Open dampers MD-12 on the inlet side and MD-8 on the exit side of the west off-gas filter compartment.
4. Close dampers MD-14 on the inlet side and MD-9 on the exit side of the center off-gas filter compartment.
5. Close the breakers for FN-3 and FN-4 in MCC "G" and MCC "H."

Test the "standby-start" feature of the fan controls while placing the system into service.

Observe all pressure indicators in the fan shed and in the reactor building for normal operating pressures.

Routine checks. Checks on the off-gas systems are performed by operators on a routine shift, daily, and weekly basis. They are incorporated in the reactor master checklist.

1. Shift checks
   a. Listen for any unusual noises in the fan shed which would indicate bearing failure, belt slippage, or fan shaft misalignment. Report any unusual conditions.
   b. Check fan-and-motor bearing temperatures by feel. Report any unusual conditions.
   c. Report any abnormal leakage of oil or grease.
   d. Observe both fan-control switch positions. One should be in the "on" position, the other in the "standby" position.
2. Daily checks
   a. Record duct pressure indicator readings from the fan shed and the control room. Compare the readings obtained at each location. Report any variations.
   b. Record the pressure drops across the individual off-gas filters. The differential pressure indicators (Table 9.3.) are located in the fan shed. If readings indicate dirty filters, follow the filter compartment switching procedure.

Table 9.3. Hot off-gas pressure differentials across filters

PdI OHOG	CHOG/ OHOG	PdI CHOG	Filters	Normal P (in. H_2O)	Abnormal P* (in. H_2O)
15	14	13	Prefilter	0.09	0.30
18	17	16	1st absolute	1.10	3.30
21	20	19	Charcoal	0.68	>0.68
24	23	22	2nd absolute	1.10	1.60

*Abnormal pressure drops usually indicate dirty filters. See maintenance manual for instructions on filter change.

To switch fans between standby and run. Optimum performance from the off-gas fans is best obtained by switching the standby and operating fans periodically. During this switching operation, a check of the "standby-start" feature of the fans should be made as follows:

1. To generalize, assume fan A is running and fan B is in standby mode.
2. Establish two-way communication between the fan shed and control room.
3. Switch fan A to "off." Normally fan B will start and assume the load. If fan B does not start, switch fan A back to "run" and inform the shift supervisor of the malfunction of fan B.
4. When fan B assumes the load, switch fan A to "standby." Indicator lights in the control room will show white and blue for fan A.

5. Switch fan B from "standby" to "on." The blue "standby" light will go out and the amber "run" light will remain on.

Malfunction of both fans in a system. In the improbable case of a malfunction of both fans of either system, the vacuum in both systems can be maintained by valving as follows:

1. Open the filter intake damper from the malfunctioning system to the center filter compartment.
2. Open the exhaust damper from the center compartment to the operating system.
3. Close both intake and exhaust filter dampers, on the compartment to be isolated, until the fans have been repaired.

To switch the center filter compartment into service. When diverting the flow of either of the two off-gas systems to the center filter compartment, it is important that the two compartments be operated in parallel before removing the original compartment from service. This assures uninterrupted service while the switching is being done.

1. OHOG
   a. Open dampers MD-10 on the exit side and MD-15 on the inlet side of the center filter compartment. This parallels the flow through the two filter compartments.
   b. Close dampers MD-11 on the exit side and MD-13 on the inlet side of the east filter compartment.
2. CHOG
   a. Open dampers MD-9 on the exit side and MD-14 on the inlet side of the center filter compartment. This

parallels the flow through the two filter compartments.

b. Close dampers MD-8 on the exit side and MD-12 on the inlet side of the east filter compartment.

Removal of the HOG systems from service. CAUTION: It is important that the reactor be shut down and that all experiments discharging into the system be valved out before removing the system from service.

1. OHOG
   a. Isolate the ILW vent by closing damper MD-17 on the inlet side of the filters.
   b. Turn the standby fan control switch to the "off" position.
   c. Turn the operating fan control switch to the "off" position.
   d. Close dampers MD-20 on the suction side of the west OHOG fan (FN-5) and MD-21 on the suction side of the east OHOG fan (FN-6).
   e. If the OHOG filters are to be isolated, close dampers MD-11 on the exit side and MD-13 on the inlet side of the east filter compartment.
2. CHOG
   a. Turn the standby fan control switch to the "off" position.
   b. Turn the operating fan control switch to the "off" position.
   c. Close dampers MD-18 on the suction side of the west CHOG fan (FN-3) and MD-19 on the suction side of the east CHOG fan (FN-4).

d. If the filters are to be isolated, close dampers MD-8 on the exit side and MD-12 on the inlet side of the west filter compartment.

9.3.5 Action on loss of vacuum in the HOG ducts

Conditions which may cause a loss of vacuum are:

filter plugging,

fan failure,

closed damper, and

diesel-generator failure during an outage of normal power.

Four electro-pneumatic pressure switches (two in the OHOG and two in the CHOG) provide alarm and standby fan-start signals as follows: a drop in vacuum, to -43-in. H_2O, on the reactor side of the filters of either system will sound an alarm in the control room. Should the loss of vacuum be caused by failure of a fan, a pressure switch located on the fan side of the filters will sense a loss of vacuum and, at -41-in. H_2O will start the standby fan, simultaneously giving an alarm in the control room.

9.3.6 Action on an outage of normal power

Exhaust fans FN-5 in the OHOG system and FN-3 in the CHOG system are connected to the No. 2 normal-emergency power distribution system through MCC "H." Upon a failure of normal power, the No. 2 diesel-generator will start. Power will then be supplied to the fans as soon as the normal-emergency switchgear transfers to the diesel generator.

Similarly, FN-6 in the OHOG system and FN-4 in the CHOG system are connected to the No. 1 normal-emergency power distribution system through MCC "G." Upon a failure of normal power, the No. 1 diesel-generator starts and the fan load is applied as soon as the normal-emergency switchgear transfers to the diesel-generator.

10. ON-SITE UTILITES

10.1. Process Water System

10.1.1 References

Drawings:

1546-05-U-7114 Yard Piping

1546-05-U-7141 Flow Diagram, Fire and Potable Water

1546-05-U-7147 Flow Diagram, Chemical Treatment

1546-01-M-5535 Flow Diagram, Process Water System

1546-I-4007 Instrument Application, Process Water System

Singmaster & Breyer Specification: 68 Process Water

10.1.2 Introduction

Process water at the HFIR is supplied by the potable water system. Air breaks and backflow preventers serve as a means of separating the two systems. The process water system is separated into two independent parts (see Fig. 10.1). The first supplies the reactor building area and is isolated from the potable water system by two parallel backflow preventers in room 103 of the water wing.

The second part of the system supplies the cooling tower area. An air-gap exists between the discharge of the secondary coolant make-up water line and the cooling tower basin. A backflow preventer is located in the potable water line which supplies the acid mixer for the chemical mixing and dispensing system in the cooling tower equipment building.

10.1.3 Place the system in service

NOTE: This procedure assumes that the system has been filled and vented.

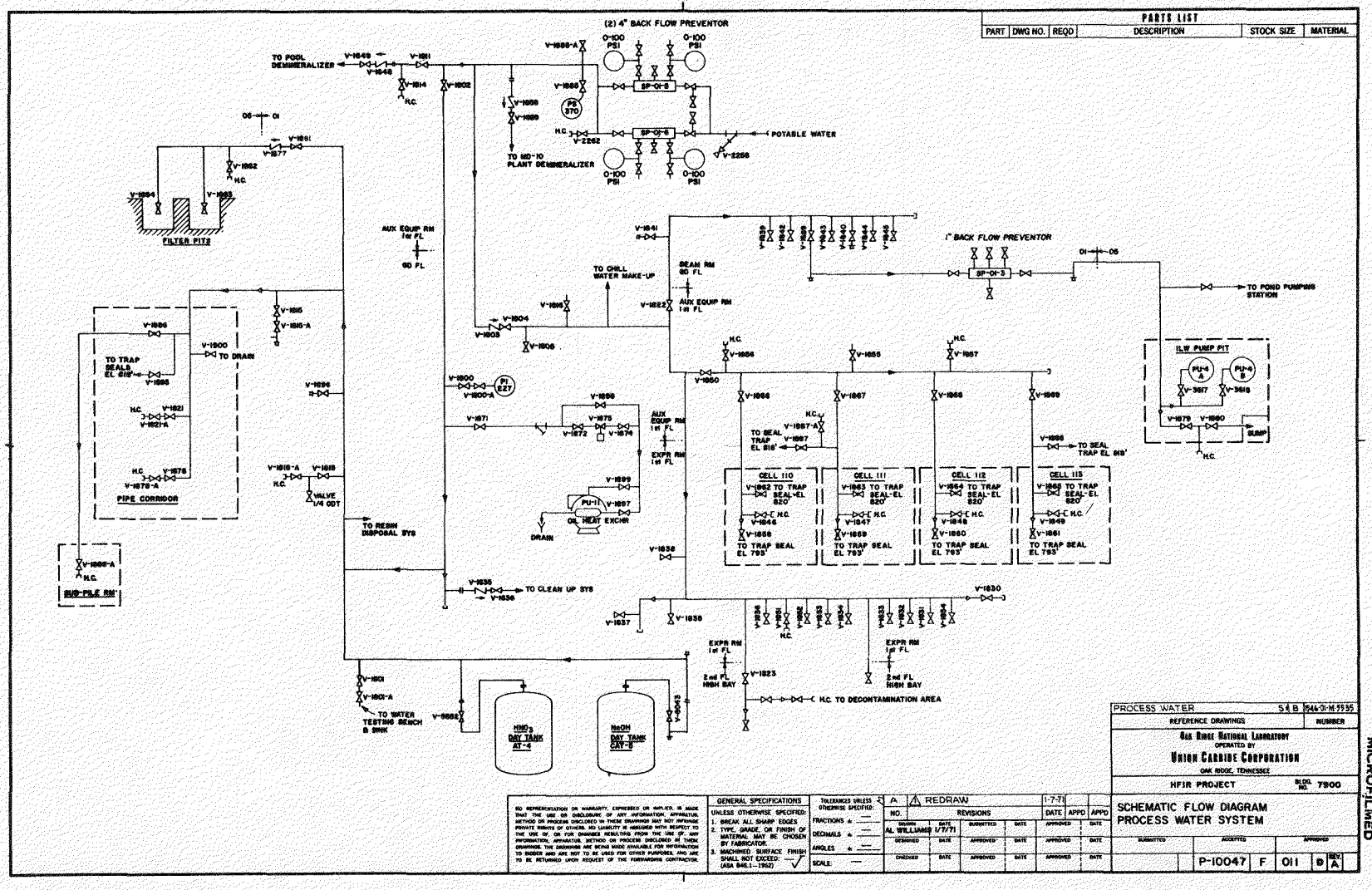


Fig. 10.1. Process water system.

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1. Open the backflow preventer isolation valves to SP-01-5 and note that the pressure gauges on either side indicate the correct potable water pressure.
2. Open a process water valve downstream of the backflow preventer and note that the downstream pressure gauge continues to indicate system pressure.
3. Close the isolation valves to SP-01-5 and open the isolation valves to SP-01-6.
4. Repeat step 2.
5. Open the isolation valves to SP-01-5 leaving both backflow preventers in service.

10.1.4 Normal operation

During normal operation, water from the potable water system is supplied to the process water system through two parallel backflow preventers. Either of the backflow preventers is capable of supplying process water needs of the HFIR; thus, these may be removed from service one at a time for semiannual testing.

Routine shift checks

1. Observe that the upstream and downstream pressure gauges on both backflow preventers indicate approximately the same. Check for water leakage from the leak detector lines on the backflow preventers.

10.1.5 Remove the system from service

1. Close the isolation valves on both backflow preventers and bleed system pressure down to atmospheric pressure.

10.2. Plant Demineralized Water System

10.2.1 References

Drawings:

1546-01-M-5534 Flow Diagram, Demineralizer

1546-01-M-5501 Flow Diagram, Demineralized Water

1546-01-M-5502 Flow Diagram, Plant Demineralizer

Singmaster & Breyer Specifications: 51 Plant Demineralizer Equipment

55 Plant Demineralized-Water Storage Tank

65 Plant Demineralized-Water System

10.2.2 Introduction

Demineralized water used as makeup for the primary coolant and pool coolant systems and for various other applications is produced by the plant demineralized-water system (see Fig. 10.2). This system consists of a package monobed demineralizer, a 20,000-gal storage tank, and two centrifugal pumps and their associated equipment.

10.2.3 Placing the monobed unit in service

This procedure assumes the unit has been regenerated and recently rinsed so that the effluent water quality is satisfactory.

1. Open V-1689, process-water supply to the demineralizer.
2. Push the "service" pushbutton on the demineralizer control panel door.
3. Open V-1608 and V-1611 in the header to the storage tank.
4. Record the reading on flow totalizer FQ-373.
5. Slowly open unit block valve V-1632 until the flow rate reaches 90 gpm.

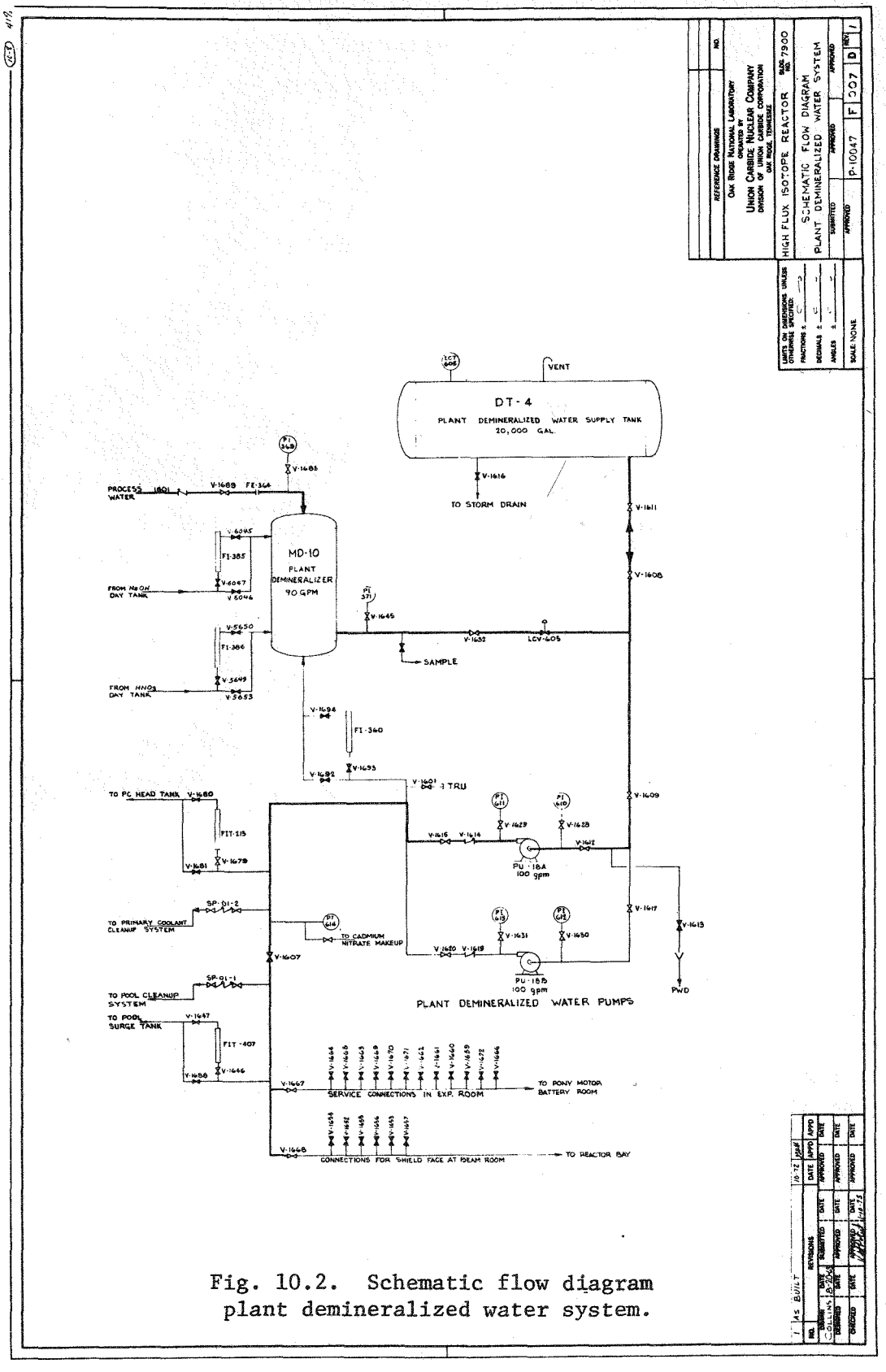


Fig. 10.2. Schematic flow diagram plant demineralized water system.

10.2.4 Normal operation

The unit will produce demineralized water at a rate of approximately 90 gpm until the storage-tank level reaches 95%. The level-control valve, LCV-605, will then close until the tank level drops. When the resistivity of the effluent water becomes less than 500,000 ohm-cm, the unit shuts itself down automatically and annunciates the shutdown in the control room. Regeneration must be initiated manually.

10.2.5 Pressurizing the building demineralized water header

This procedure assumes that water is available in the demineralized-water storage tank. It is not necessary that the plant demineralizer be in operation.

1. Check that V-1608 and V-1611, in the header from the storage tank to the pumps, are open.
2. Open V-1609, V-1612, and V-1617 in the pump suction lines.
3. Start either of the demineralized-water pumps using the "start" switch in the control room.
4. Open the discharge valves on both pumps, V-1615 on pump PU-18A and V-1620 on pump PU-18B.
5. Observe pressure indicators PI-612 and PI-613 on pump PU-18B or PI-610 and PI-611 on pump PU-18A to make sure water is being pumped.

The system is now being fed by the demineralized-water storage tank and, if in service, by the demineralizer.

10.2.6 Regeneration of the monobed demineralizer

Plant demineralizer regeneration is semi-automatic; i.e., after manual initiation, regeneration proceeds automatically. Four hundred gallons each of 5% nitric acid and 5% caustic solutions must

be available in the day tanks before starting the regeneration process. If acid or caustic mixing to replenish the supply in the day tanks is necessary, follow the procedure established in Section 10.3. of this manual.

1. To start the nitric acid pump:
   a. Open V-5601, pump suction.
   b. Start the pump.
   c. Open V-5604, pump discharge.
   d. Open V-5649 and V-5650 on flow indicator FI-386 so that acid flow to the demineralizer may be monitored and adjusted. Normal flow is 12 gpm during the 30-min period that acid is being injected into the demineralizers.
2. To start the caustic pump:
   a. Open V-6001 and V-6002, located between the day tank and the pump.
   b. Start the caustic pump.
   c. Open V-6004, to the plant demineralizer.
   d. Open V-6045 and V-6047, on flow indicator FI-385, so that caustic flow to the demineralizer may be monitored. Normal flow is 12 gpm during the 30-min period that caustic is being injected into the demineralizer.
3. To start the regeneration, push the "regeneration" button on the demineralizer control panel door. The following steps occur automatically and can be identified by the step number on the sequencing cam inside the control panel door.

a. Step 3: Backwash and separation of resin with process water. This step requires 18 gpm for a period of about 10 min. Flow adjustment is made using the stop on valve "E." Valves "D" (wash outlet) and "E" (wash inlet) are open during this period.

b. Step 4: Two minutes of lag time is provided to allow the separated resin to settle smoothly.

c. Step 5: Acid and caustic injection. Injection of acid and caustic into the demineralizer must be adjusted initially to 12 gpm each using V-6045, on FI-385, in the caustic system and V-5649, on FI-386, in the nitric-acid system. Once the two valves are adjusted, they should be tagged with "do not operate" tags and left in this condition. Check the flow rates in both systems during each regeneration. Minor adjustments may be necessary each time because of differences in pumping pressures and pressure drops in the system. During this step, valve "A" (caustic inlet), valve "G" (acid inlet), and valve "J" (interface outlet) are open.

d. Step 6: Regenerant displacement and slow rinse. The purpose of this step is to rinse the resin beds of excess caustic and acid so that the final rinse (step 10) will be of short duration thereby preventing waste of resin capacity due to excessive final rinsing. The time required for this step is 83 min. The flow to the cation part of the unit was adjusted

during the backwash. Flow rate to the anion part should be set by the limit stop on valve "B" for 15 to 20 gpm.

e. Step 7: Drain and air mix. "Vent" valve "K" and "interface" valve "J" are opened to drain the unit. When draining is completed inlet air valve "H" opens, the blower starts, and the resin is fluffed for a period of 15 min.

f. Step 8: Two minutes of lag time is provided to allow the mixed bed to settle.

g. Step 9: Refill. "Vent" valve "K" and "demineralized water in" valve "B" open to allow the unit to refill. The termination of this step is evidenced by water overflowing through the vent pipe. Ten minutes is allowed for this step; however, slight adjustment of the timing device may be necessary from time to time.

h. Step 10: Final Rinse. Approximately 35 gpm, process water flow, is allowed for a period of 10 min. Valve "C" (process water inlet) and valve "I" (rinse outlet) are open during this process.

i. Steps 11 and 12: During these steps power to the conductivity indicator is restored, the "regenerating" lamp on the control panel is extinguished, the "service" lamp is lighted, and the process water inlet valve "C" is opened. The unit is now in service, and the stepping cam rotates back to step No. 1.

4. Stop the acid pump
   a. Close V-5604, pump discharge.
   b. Stop the pump.
   c. Close V-5601, pump suction.
   d. Close V-5650 on flow indicator FI-386. Do not close V-5649 on the flow indicator.
5. Stop the caustic pump
   a. Stop the pump.
   b. Close V-6001 and V-6002 which are located between the day tank and the pump.
   c. Close V-6004, from the pump to the plant demineralizer.
   d. Close V-6047 on the flow indicator FI-385. Do not close V-6045 on the flow indicator.

10.2.7 Placing the monobed unit in service after standing idle.

If the mixed bed with unused capacity has been standing idle for a period of time and is then returned to service, the first water produced may be impure. In this event the Solu Bridge will automatically shut the unit down by closing the outlet valve. If this occurs, manual rinsing is necessary.

1. Open the rinse outlet valve "I" by opening the three-way air cock located on the valve. Continue to rinse the unit to the process waste system until the resistivity of the effluent increases above 500,000 ohm-cm.
2. Close the three-way cock and place the demineralizer back in the automatic mode of operation.

10.2.8 Removing the system from service

NOTE: Since the demineralized-water system provides makeup for the pool coolant and primary coolant systems, it should never be removed from service while the reactor is in operation. This procedure assumes that the reactor is not in operation and that an outage of demineralized water can be tolerated.

1. Remove the monobed demineralizer from service by turning the "hand-off-auto" switch to the "off" position. This closes the outlet valve and extinguishes the "in-service" lamp.
2. Close the plant demineralized-water pump discharge valves, V-1615 for pump PU-18A and V-1620 for pump PU-18B.
3. Stop the pump.
4. Close V-1612 and V-1617, inlet valves to pumps PU-18A and 18B, respectively.
5. To isolate the demineralized-water supply tank DT-4, close V-1611.

10.3. Acid and Caustic

10.3.1 References

Drawings:

1546-05-U-7147 Flow Diagram, Chemical Treatment

1546-01-M-5501 Engineering Flow Diagram

Singmaster & Breyer Specifications:

45 Nitric Acid Storage Tank and Day Tank

46 Sulfuric Acid Storage Tank

47 Caustic Storage Tank and Day Tank

78 Nitric Acid Storage and Distribution

91 Caustic Storage and Distribution

10.3.2 Introduction

Acid and caustic are provided at the HFIR for water treatment, demineralizer regeneration, and for cleaning primary coolant and pool coolant cleanup system filters. The chemicals are delivered to the plant in concentrated form by truck and are diluted before use. Outside storage tanks are provided for the concentrated chemicals while mixing and storage of the diluted chemicals is inside the building (see Figs. 10.3, 10.4, and 10.5).

10.3.3 Precautions

Sulfuric and nitric acids are dangerous when improperly handled. Concentrated solutions are rapidly destructive to skin tissues they contact, producing severe burns. Contact with eyes will cause severe damage and blindness. Inhaling vapors from hot acid may also be harmful.

Caustic soda may cause serious burns on contact with skin tissue of eyes, or if taken internally. Great care must be taken to avoid contact when preparing and handling caustic solutions.

Protective clothing such as gloves, aprons, and face masks must be worn to prevent the solutions from coming into contact with the skin. If caustic or acid does accidentally come into contact with the skin, wash with cold water immediately. Safety showers and eye baths are provided in areas where handling of the solutions takes place. These showers should be used when spills on the body occur. Two persons should be present when handling acid or caustic.

ORNL DWG. 63-3701

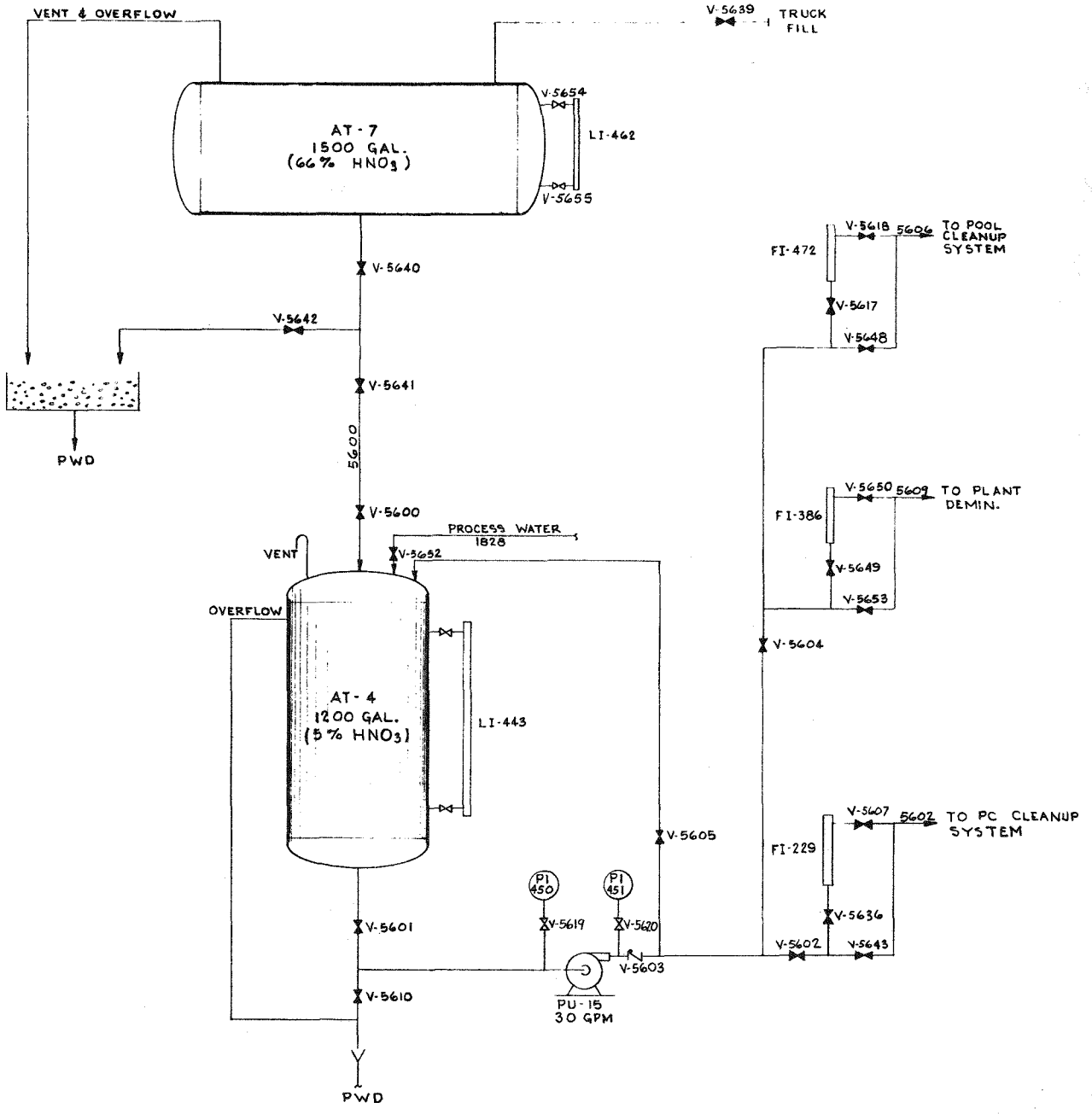


Fig. 10.3. Schematic flow diagram nitric system.

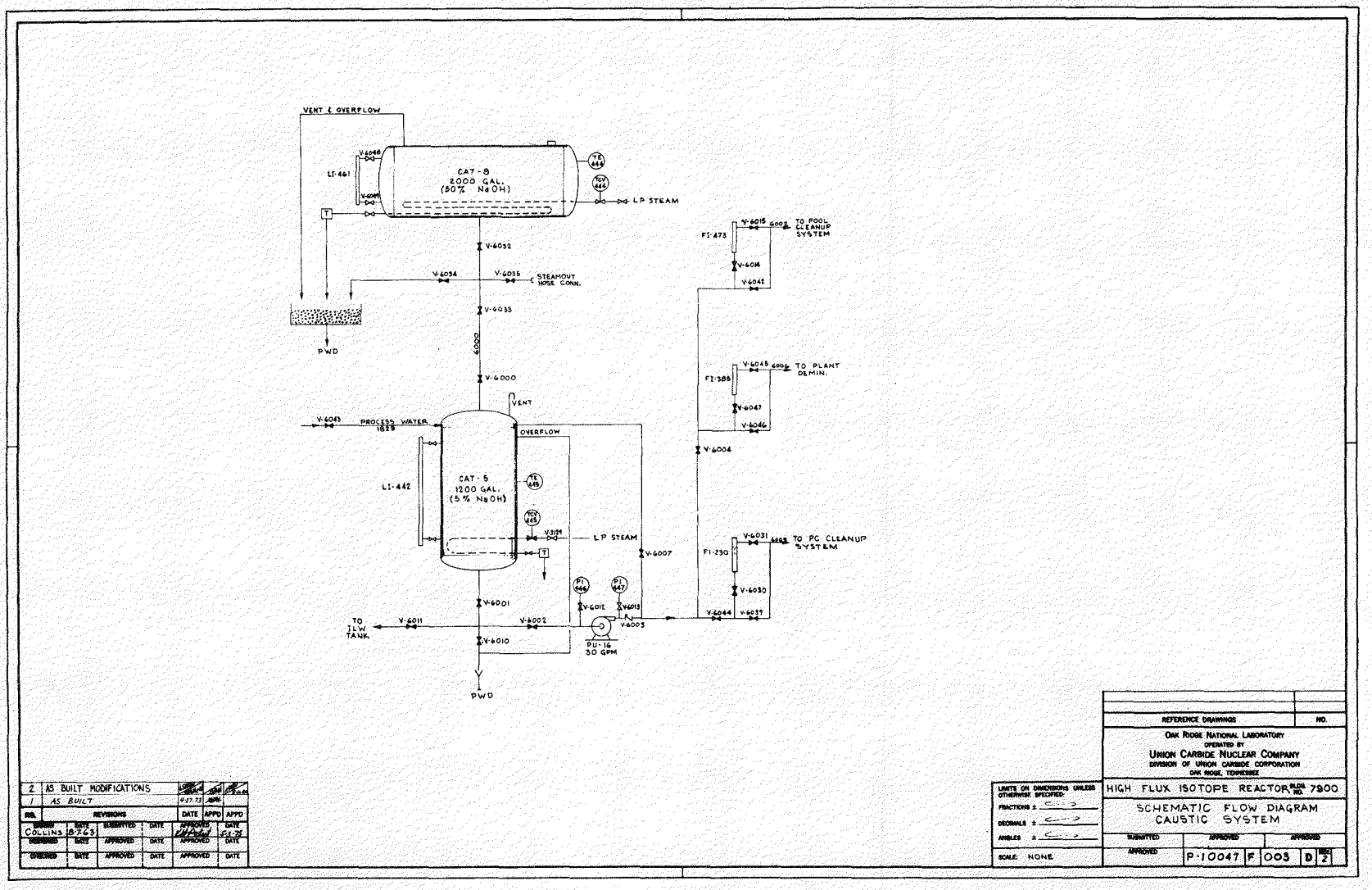


Fig. 10.4. Schematic flow diagram caustic system.

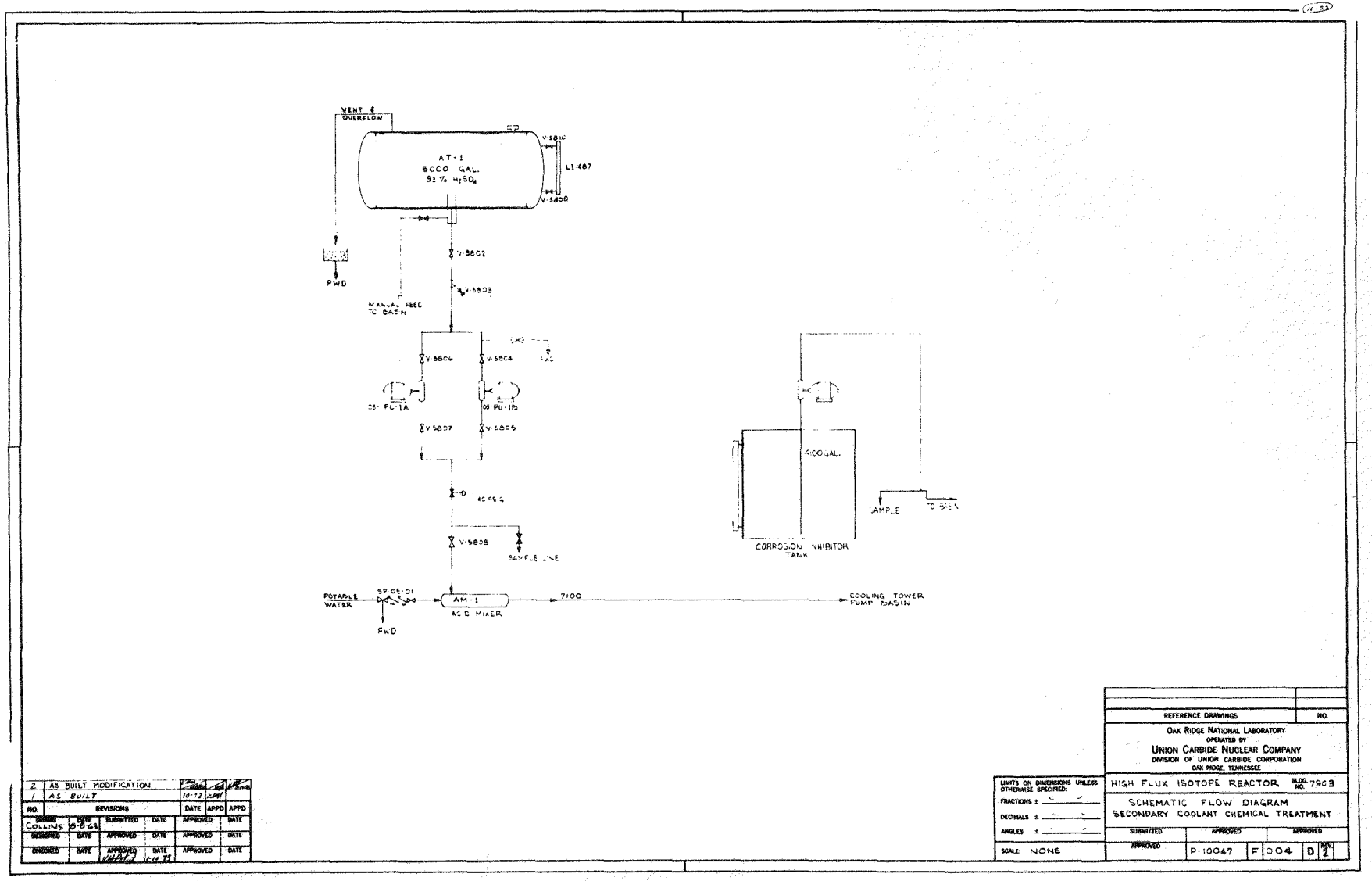


Fig. 10.5. Schematic flow diagram secondary coolant chemical treatment.

10.3.4 Fill the nitric acid storage tank

1. Remove the fill flange atop the storage tank.
2. Connect the 3/4-in. flexible fill line to the truck tank and insert the opposite end into the open flange atop the storage tank.
3. Connect the 1/4-in. air line from the air compressor to 1/4-in. valve atop the truck tank.
4. Close the 1/4-in. air valve and the 3/4-in. acid valve atop the truck tank.
5. Start the air compressor and allow the pressure to build up until its pressure relief valve relieves at approximately 30 psig. Stop the air compressor and bleed the pressure off using the bleed valve.
6. Open the 3/4-in. valve atop the truck tank; then open the 1/4-in. air valve.
7. Clear all personnel away from the truck and acid tank; then start the air compressor. Observe connections for leaks.
8. Use sightglass indicator, LI-642, to observe the level increase in the storage tank.
   When the truck tank is empty, the pressure gauge on the air compressor will show approximately 0 psig.
9. Stop the air compressor and observe that all air pressure bleeds off.
10. Observe that the truck tank level indicator shows empty; then physically measure with dip stick the acid level in the truck tank. There should be none left.
11. Remove the flexible fill line from atop the storage tank

and place it where it will drain onto the gravel underneath the tank.

12. Fill the truck tank with approximately 100 gal of water from a nearby hose.
13. Flush the water from the truck tank in the same manner that acid is pumped out. The flush water will drain into the PWD system through a drain located under the gravel.

10.3.5 Fill the nitric acid day tank

The nitric acid day tank is filled with a 5% solution by mixing concentrated (66%) acid with process water.

1. Determine the amount of process water needed to mix a 5% solution. (Use a ratio of 12.2 gal of water to one gallon of 66% acid.)
2. Open V-5652, process water supply, and fill the tank to the desired level.
3. Check to make sure the valves V-5610, V-5604, V-5602, and V-5605 are all closed.
4. Open V-5601, acid pump suction.
5. Start the pump and open V-5605, pump discharge. Check pressure indicators, PI-450, pump suction pressure and PI-451, pump discharge pressure to be sure the liquid is being circulated.
6. Open V-5640 and V-5641, concentrated acid supply valves located at the storage tank.
7. Open V-5600, concentrated acid supply valve located at the day tank.
8. Allow the proper amount of concentrated acid to flow into the tank; then close V-5600.

9. Allow the acid pump to circulate the solution for 1 h to be sure it is thoroughly mixed. Stop the pump and close V-5605, V-5601, V-5640, and V-5641.
10. Take a sample of the 5% solution and check for a Sp. G. of 1.02 to 1.03.
    a. Open V-5601.
    b. Slowly open V-5610 and take a sample.
    c. Close V-5610 and V-5601.

10.3.6 Fill the caustic storage tank

1. Connect the portable caustic pump discharge line to the steamout hose connection at V-6035.
2. Connect the portable pump suction line to the truck tank drain line.
3. Close V-6034 and V-6033. Open V-6035 and V-6032.
4. Open the truck tank drain valve which is now connected to the portable pump.
5. Start the pump and observe for leaks.
6. Continue pumping caustic to the storage tank until the truck tank is empty. This can be observed by removing the manhole cover on top of the truck tank.
7. Close the valve which drains the truck tank. Close V-6032 and V-6035.
8. Carefully disconnect the portable pump suction line from the truck tank and the discharge line from the storage tank. Flush pump and lines thoroughly with water.

10.3.7 Fill the caustic day tank

1. Determine the amount of process water needed to fill the tank with a 5% solution. (Use a ratio of 9 gal of water to 1 gal of 50% caustic.)
2. Open V-6043, process water. Fill the tank to the desired level.
3. Open V-6001 and V-6002, suction side of the caustic pump.
4. Close V-6011, ILW drain.
5. Close V-6007, pump discharge to day tank.
6. Close V-6004, pump discharge to the pool demineralizer.
7. Close V-6044, pump discharge to the PC demineralizer.
8. Start the pump and open V-6007. Check pressure indicators PI-446 on the suction side of the pump and PI-447 on the discharge side of the pump to be sure the caustic is being pumped.
9. Open V-6033 and V-6032, supply valves located at the storage tank.
10. Open V-6000, supply valve located at the day tank.
11. As the solution is circulated by the pump, allow concentrated caustic to flow into the day tank until the desired level is reached.
12. Close V-6000.
13. Close V-6033 and V-6032 and open the drain valve, V-6030, located beneath the storage tank. Wash down any spilled caustic with water.
14. Continue to circulate the 5% solution in the day tank for 1 h to be sure it is thoroughly mixed.

15. Close V-6007, pump discharge, and stop the pump.
16. Close V-6001 and V-6002, suction side of the pump.
17. Take a sample of the 5% solution in the day tank and check for a Sp. G. of 1.05 to 1.06.
    a. Open V-6001.
    b. Slowly open V-6010 and take the sample.
    c. Close V-6010 and V-6001.

10.3.8 Fill the sulfuric acid storage tank

The following procedure applies to emptying an ORNL owned truck. If a bulk lot truck is used to deliver acid from the vendor, the truck driver uses his own equipment to unload it.

1. Remove the fill flange atop the storage truck.
2. Connect the 3/4-in. flexible fill line to the truck tank and insert the opposite end into the open flange atop the storage tank.
3. Connect the 1/4-in. air line from the air compressor to 1/4-in. valve atop the truck tank.
4. Close the 1/4-in. air valve and the 3/4-in. acid valve atop the truck tank.
5. Start the air compressor and allow the pressure to build up until its pressure relief valve relieves at approximately 30 psig. Stop the air compressor and bleed the pressure off using the bleed valve.
6. Open the 3/4-in. acid valve and then open the 1/4-in. air valve.
7. Clear all personnel away from the truck and acid tank; then start the air compressor. Observe connections for leaks.

8. Use the level indicator located inside the chemical treatment room to observe the level increase in the storage tank. When the truck tank is empty, the pressure gauge on the air compressor will show approximately 0 psig.
9. Stop the air compressor and observe that all air pressure bleeds off.
10. Observe that the truck tank level indicator shows empty; then physically measure with dip stick the acid level in the truck tank. There should be none left.
11. Remove the flexible fill line from atop the storage tank and place it where it will drain onto the gravel underneath the tank.
12. Add approximately 100 gal of water from a nearby hose. BE SURE the tank is empty of concentrated sulfuric acid before adding water. The addition of water to concentrated sulfuric acid can be very dangerous because of the exothermic reaction which generates a large amount of heat.
13. Flush the water from the truck tank in the same manner that acid is pumped out. The flush water will drain into the PWD system through a drain located under the gravel.

10.4. Steam

10.4.1 References

Drawings:

1546-05-U-7101, -7102	Utility Plans
1546-05-U-7140	Steam Flow Diagram
1546-01-H&V-3017	Steam Service Piping
1546-02-H&V-3042	Office and Maintenance Building Steam Flow Diagram
1546-01-H&V-3003	Reactor Building Steam Flow Diagrams

Singmaster & Breyer Specifications:

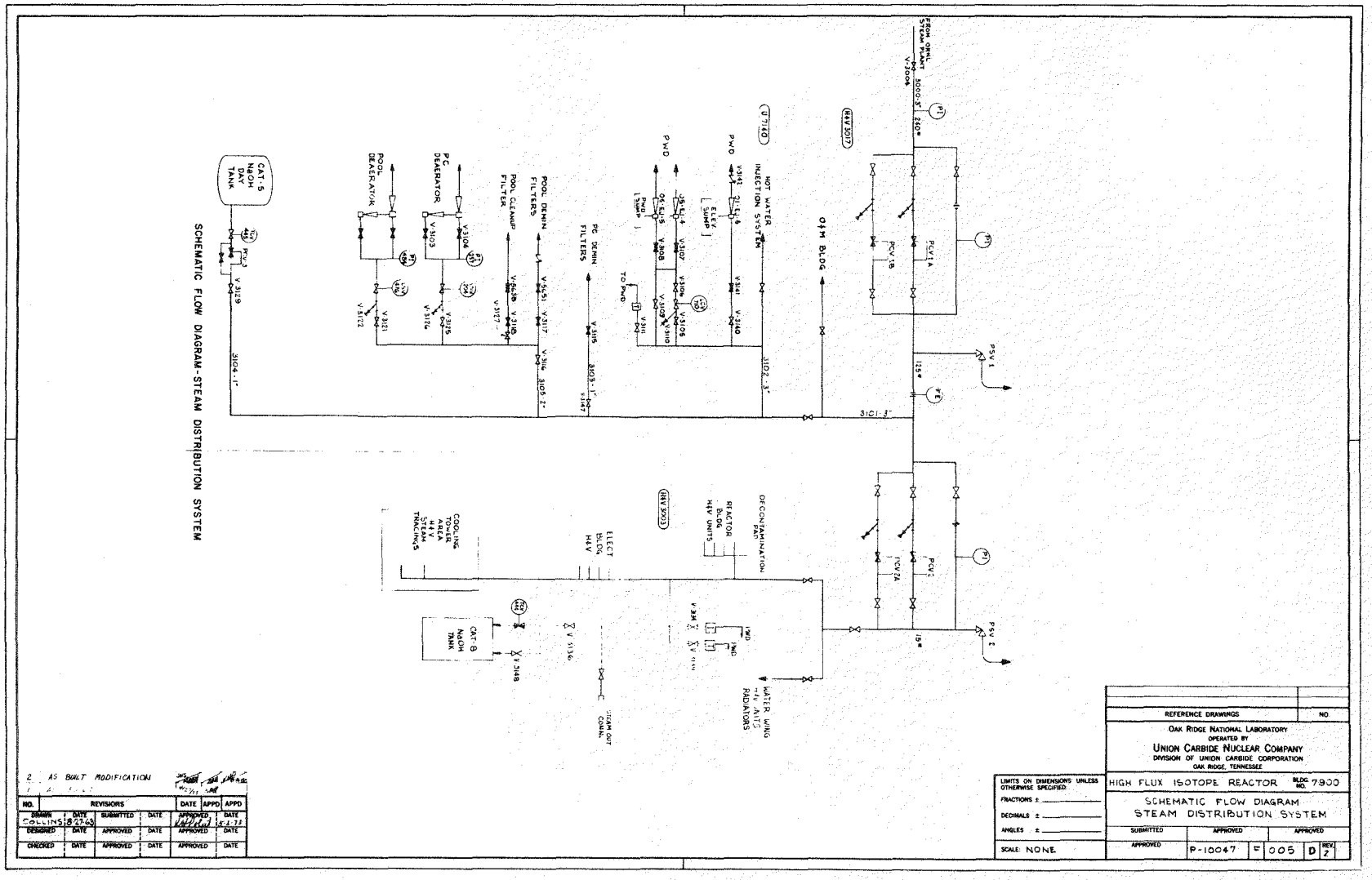
73 Steam Distribution and Steam Tracing System

10.4.2 Systems using 125-psig steam (see Fig. 10.6)

Steam, supplied by the ORNL steam plant enters the building at 250 psig and, through two pressure control valves, is reduced to 125 and 15 psig respectively. Systems using 125-psig steam are:

1. elevator sump pit ejector,
2. process waste sump ejectors,
3. hot water injection system,
4. caustic storage tank and tracing,
5. primary coolant high vacuum and low vacuum ejectors,
6. pool coolant high vacuum and low vacuum ejectors,
7. primary coolant cleanup system filters,
8. pool coolant cleanup system filters, and
9. office and maintenance building steam heating system.

Procedures. Only those systems which are not covered elsewhere will be dealt with in these procedures.


SCHEMATIC FLOW DIAGRAM - STEAM DISTRIBUTION SYSTEM
FROM ORNL STEAM PLANT
CAT-5 NaOH DAY TANK
POOL DEAERATOR
PG DEAERATOR
POOL DEMIN FILTERS
POOL CLEANUP FILTER
PG DEMIN FILTERS
PWD
HOT WATER INJECTION SYSTEM
ELEV. SUMP
PWD SUMP
TO PWD
Q1M BLDG
PCV-1A
PCV-1B
PCV-2A
PCV-2
PSV 1
PSV 2
125#
150#
3104-1"
3105-2"
3103-1"
3107-3"
3101-3"
COOLING TOWER AREA H & V SYSTEMS TRACINGS
ELECT. BLDG. H & V
REACTOR BLDG. H & V UNITS
DECONTAMINATION PAD
CAT-B NaOH TANK
STEAM OUT COMM.
WATER WING H & V UNITS RADIATORS
REFERENCE DRAWINGS
NO.
OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
DIVISION OF UNION CARBIDE CORPORATION
OAK RIDGE, TENNESSEE
LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED:
FRACTIONS ±
DECIMALS ±
ANGLES ±
SCALE: NONE.
HIGH FLUX ISOTOPE REACTOR
BLDG. NO. 7900
SCHEMATIC FLOW DIAGRAM
STEAM DISTRIBUTION SYSTEM
SUBMITTED
APPROVED
APPROVED
APPROVED
P-10047
E 005
D
REV. 2
2. AS BUILT MODIFICATION
NO.
REVISIONS
DATE
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1. Elevator sump pit ejector

   Water which collects in the sump is ejected to the process waste system by a manually controlled steam-operated ejector.

   To place the system into service:

   a. Open V-3140, steam supply valve.
   b. Adjust the steam supply to the ejector with V-3140. Once the adjustment is made, use V-3141 for on-off control.

2. Process waste sump ejector

   After the system is placed in service, operation of the process waste sump ejectors is automatically controlled by LCV-710A.

   To place the system into service:

   a. Open V-3105 and V-3106, main steam supply to the ejectors.
   b. Close V-3109, level control valve bypass.
   c. EJ-4 only, open V-3107 and close V-3108.
   d. EJ-5 only, open V-3108 and close V-3107.
   e. Both ejectors, open V-3107 and V-3108.

3. Caustic day tank

   To place the system in service:

   a. Open V-3129, V-3130, and V-3131, steam supply valves.
   b. Open V-3133, discharge to the flash tank. Steam flow is controlled automatically by TCV-445. Check the operation by observing that it opens and closes properly.

10.4.3 Systems using 15-psig steam

1. Electrical building heating system
2. Cooling tower equipment building heating system
3. Cooling tower area tracing
   a. Steam tracing in the cooling tower area protects
      1. PT-309 and PS-399, secondary cooling water pump discharge pressure instrumentation.
      2. FE-336, secondary cooling water make-up flow element.
      3. FT-325, secondary cooling water flow transmitter.
      4. PI-311, -314, and -319, secondary cooling water pump discharges.
   b. To place the system in service:
      1. Open V-3201, steam supply to the tower area. This valve is located in the cooling tower equipment building.
      2. Open V-3207, tracing supply to FE-336.
      3. Open V-3202, tracing supply to PU-309.
      4. Open V-3204, steam supply to the tower.
      5. Open V-3205, tracing supply to FT-325.
      6. Open V-3209, tracing supply to PI-311.
      7. Open V-3210, tracing supply to PI-314.
      8. Open V-3211, tracing supply to PI-319.
3. Caustic storage tank and tracings

   The caustic storage tank is steam heated to prevent solidification of the caustic. The temperature is regulated automatically by TCV-444 which controls steam flow to the tank.

To place the system into service:

a. Open V-3136, steam supply, and V-3137, to the process waste drain.

b. Check the operation of TCV-444 by observing that it opens and closes properly.

c. Supply steam to the pipe tracing around the tank by opening V-3134 and V-3148.

10.5. Instrument Air System

10.5.1 References

Drawings:

1546-01-U-7146 Instrument-Air Flow Diagram

1546-01-M-5505, -5513 Piping Drawings

Singmaster & Breyer Specifications:

54 Equipment for the Compressed Air System

79 Instrument-Air Distribution System

10.5.2 Introduction

Instrument air for the HFIR is produced by a system consisting of two 75-HP compressors and a 30-HP compressor, each an independent unit (see Fig. 10.7).

The building instrument air load can be supplied by any one compressor. It is dried and filtered before use (see Fig. 10.8).

An emergency compressor supplies the servo system instrumentation if the compressed air system fails.

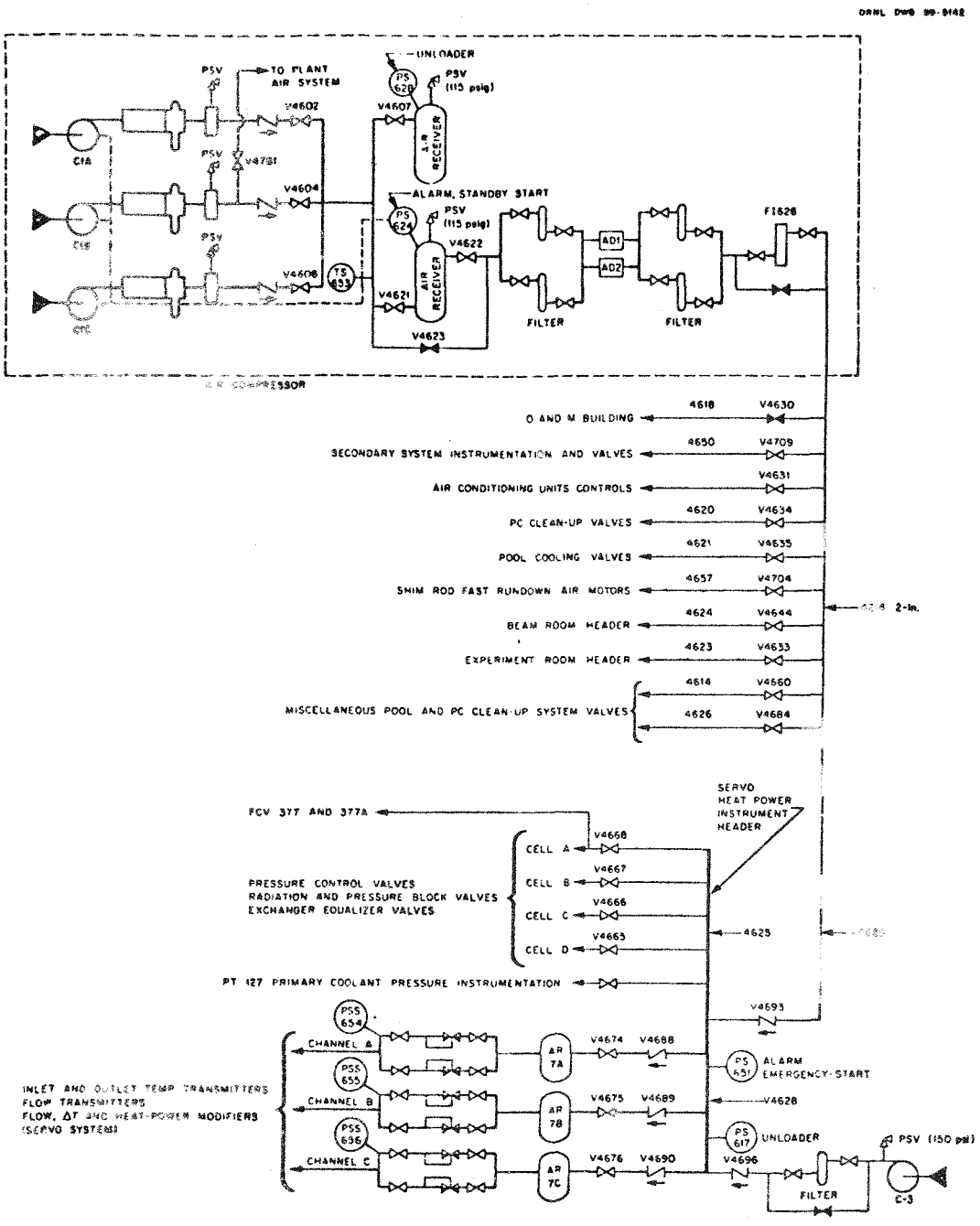


Fig. 10.7. Instrument air system.

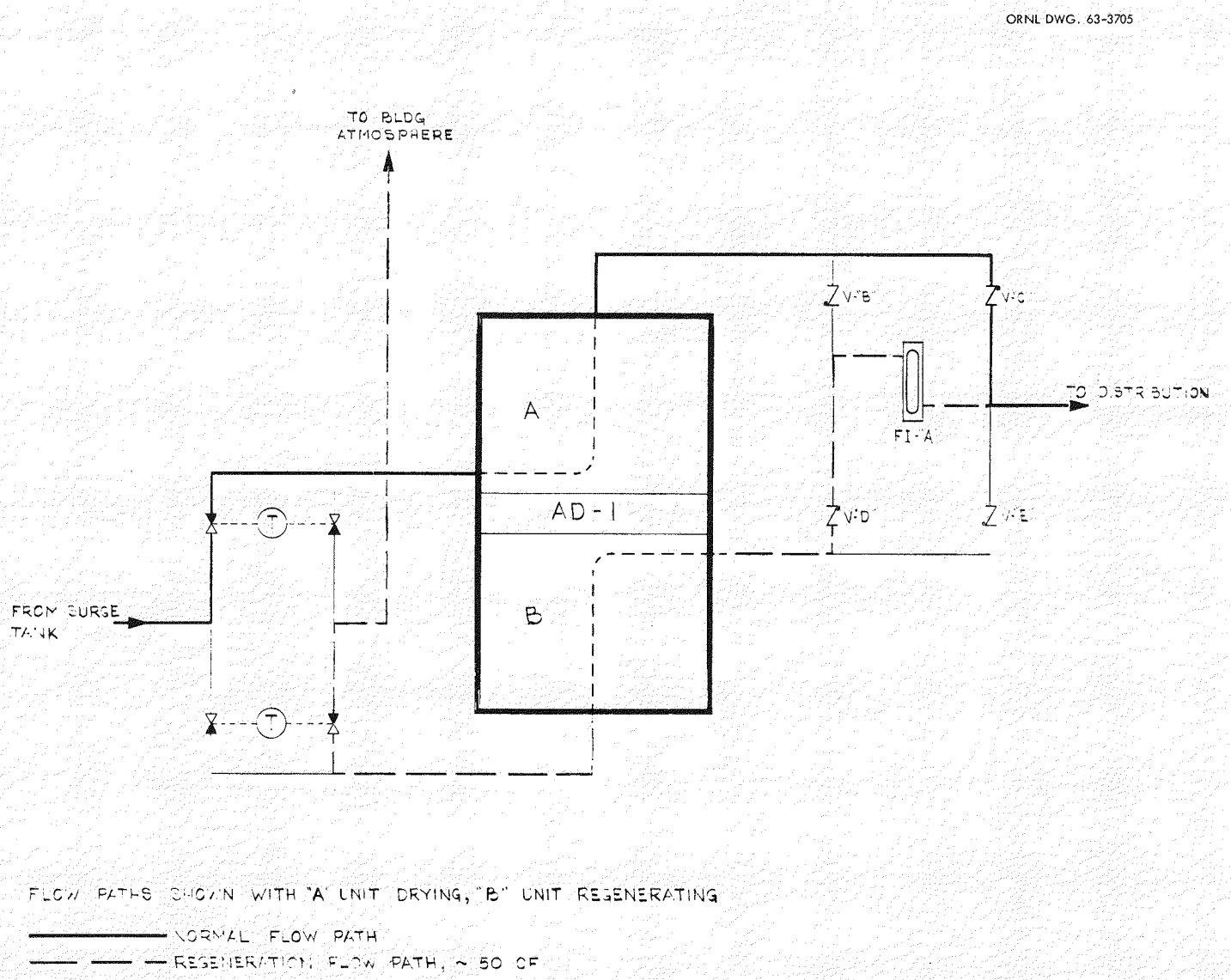


Fig. 10.8. Air dryer regeneration.

10.5.3 Precautions

Unless absolutely necessary, two air compressors should not be removed from service simultaneously while the reactor is operating. If an operating compressor is malfunctioning, a standby compressor should be started and proved reliable before removing the defective unit from service.

10.5.4 Place the system in service

NOTE: Before starting the compressor, assure that an adequate supply of oil for lubrication is available by observing the level in the sight glass.

1. Open the secondary water supply to the aftercooler and compressor.
2. Before starting the system, valve the components of the system as follows:
   a. Compressor. Open the loading supply air line to the compressor and the exhaust from the aftercooler to the header.
      C-1A Open V-4705 and V-4602
      C-1B Open V-4706 and V-4604
      C-1C Open V-4764, V-4765, and V-4606
   b. Open the aftercooler system
      C-1A Open V-4609, V-4610; close V-4628
      C-1B Open V-4611, V-4612; close V-4629
      C-1C Open V-4750, V-4751; close V-4760 (line vent)
   c. Air receivers AR-6A and AR-6B. Open V-4621, V-4622, V-4607 (header valves), V-4638, and V-4624 (drain valves). Close V-4623 (bypass), and V-4625 (trap bypass).

d. Air prefilter FL-6A (or FL-6B in parentheses). Open V-4613, V-4614, and V-4617 (V-4615, V-4616, and V-4618).

e. Air dryer AD-1 (or AD-2 in parentheses). Open V-4619 and V-4620 (V-4743 and V-4742).

f. Afterfilter FL-6C (or FL-6D in parentheses). Open V-4639, V-4640, and V-4641 (V-4642, V-4643, and V-4647).

This completes the valve arrangement of the air production system to the output flow meter, FI-626.

3. Turn the local switch at the nearby compressor control panel to the "auto" position. Turn the selector switch in the control room to the "start" position.

The compressor starts and loads in approximately 10 s and remains loaded until the air receiver pressure reaches 70 psig at which time it is unloaded and remains unloaded until the air receiver pressure drops to 60 psig.

4. To make sure the system is operating properly:

a. Check the discharge cooling water temperature. It should not exceed 120°F. If the temperature increases beyond this limit, adjust the water flow rate to bring it within this limit.

b. Check the aftercooler discharge-air temperature. It should be <90°F. If the temperature increases above this value, increase the cooling-water flow to the aftercooler.

c. Check the loading and unloading pressures. If they are not the proper values, make the necessary adjustments.

5. Valve the flow indicator FI-626 into the system by opening V-4728 and V-4729. Close bypass valve V-4730.
6. Check the efficiency of the air dryer with moisture detector AmI-627 located on column D-2 just southeast of the compressors. Moisture content of the compressed air should not exceed 600 ppm; normal condition is <100 ppm.
7. Valve the emergency air compressor into the system as follows:
   a. Open V-4697 and V-4691; close V-4699.
   b. Place the "run-off-auto" selector switch in the "auto" position. The compressor will start if the air pressure in the main header to the three surge-air receivers drops to 43 psig.
8. Valve the three surge-air receivers into the system by opening V-4676, V-4675, and V-4674.
9. Place the local switch to the two standby compressors in the "auto" position. Place the "standby-off-start" switches to the two standby compressors in the "standby" position. These are located in the main control room.

10.5.5 Normal operation

Periodic checks should be made to insure that the instrument air system is functioning properly. These checks are made routinely by the roving operator each shift.

1. Record the air pressure from PI-625A and P-625B located

on the instrument air panel in the control room. They should indicate between 60 and 70 psig.

2. Record the moisture content in the system from AmI-627.
3. Check the operating compressor and its driving equipment for malfunctions and for unusual noises. Make sure that the compressor and the aftercooler are not overheating.
4. Record the aftercooler air temperature and oil pressure.

10.6. Electrical System

10.6.1 References

Drawings:

1546-05-E-2001	Electrical Key Plans
1546-04-E-2002	Normal Power - 13.8 and 2.4 kV Distribution
1546-01-E-2003, -2006	480-V Normal Power
1546-04-E-2007, -2008	Normal-Emergency and Fail-Free Systems
1546-01-E-2009	Instrument Power

Singmaster & Breyer Specifications:

107 Electrical Work, 13.8 kV Switching Station, Diesel Generators, and Normal-Emergency Switchgear, Motor Control Centers, Cable Batteries, and Battery Chargers

108 Electrical Installation Work, Nuclear Instrumentation and Control Equipment

10.6.2 Introduction

All electrical power at the HFIR is supplied by one or more of four systems. These four systems include:

Normal power. This is supplied by one of two 13.8-kV feeders which come from the main ORNL substation. The preferred feeder (HFIR) supplies power under normal conditions. The alternate feeder (No. 3) supplies power, with a reduced capacity, in the event the preferred feeder experiences troubles. An automatic transfer system switches from the preferred to the alternate system when difficulties are experienced.

Normal-emergency systems (see Figs. 10.9, 10.10, 10.11 and 10.12). Under normal conditions power to these systems is taken from the preferred 13.8-kV feeder. In the event of failure of both 13.8-kV feeders, two diesel-generators supply power to certain critical components of the HFIR complex. Diesel startup and switching is automatic.

Failure-free system. Certain critical components are supplied with dc power from batteries in the event of failure of the 13.8-kV feeders. Batteries are kept charged by the normal-emergency system.

Instrument power. Specially shielded, low-noise transformers are employed for reactor and experiment instrumentation. These transformers are supplied from the 13.8-kV feeder system.

During normal operation, electrical power is taken from the preferred 13.8-kV feeder and distributed to the various loads through seven transformers. One of the transformers supplies 2400-V power to ten motors, four transformers supply 460-V power to motor-control centers and bus ducts, and the other two supply 120/240-V instrument power (see Fig. 10.13).

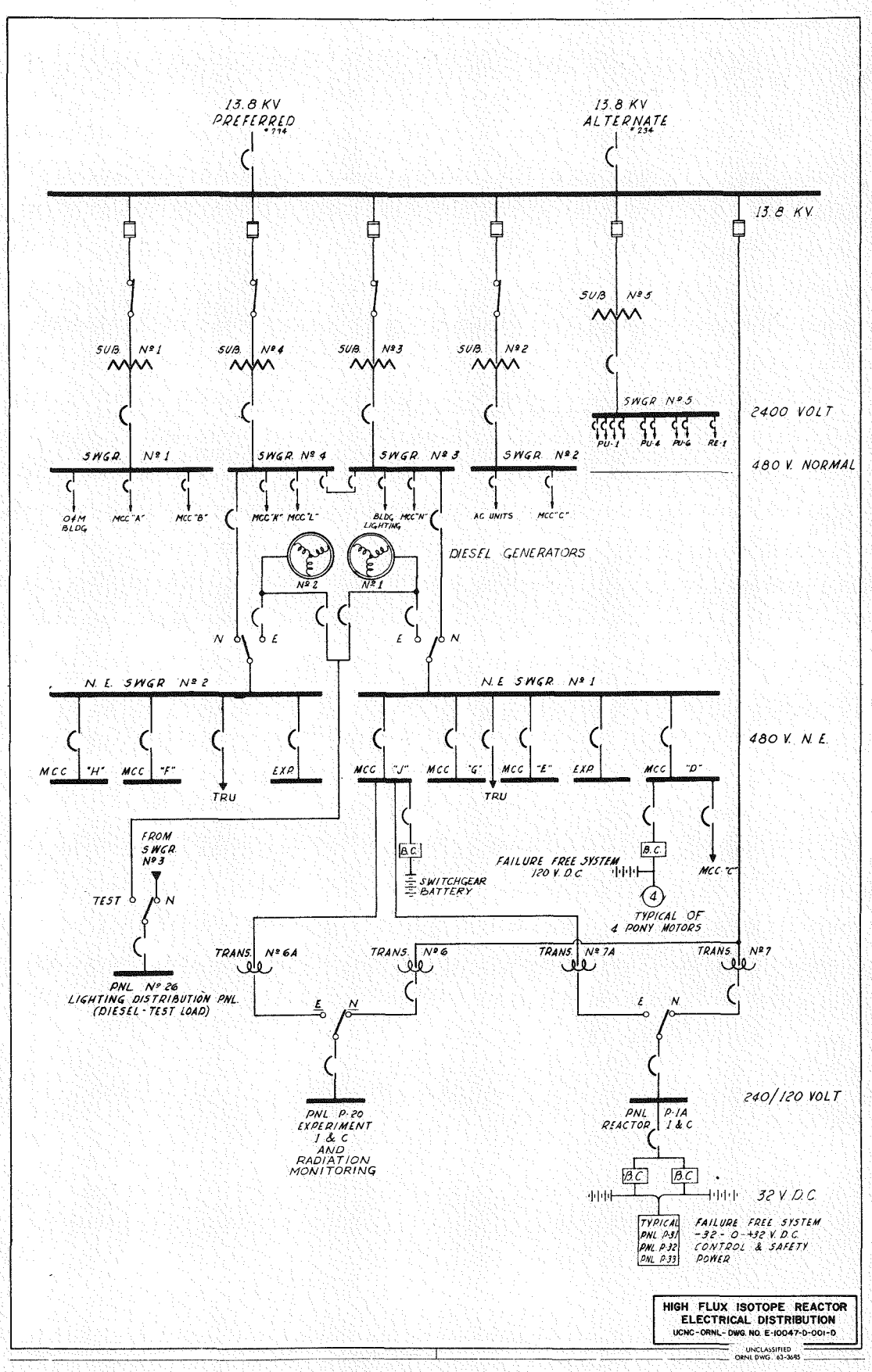


Fig. 10.9. Normal-emergency systems.

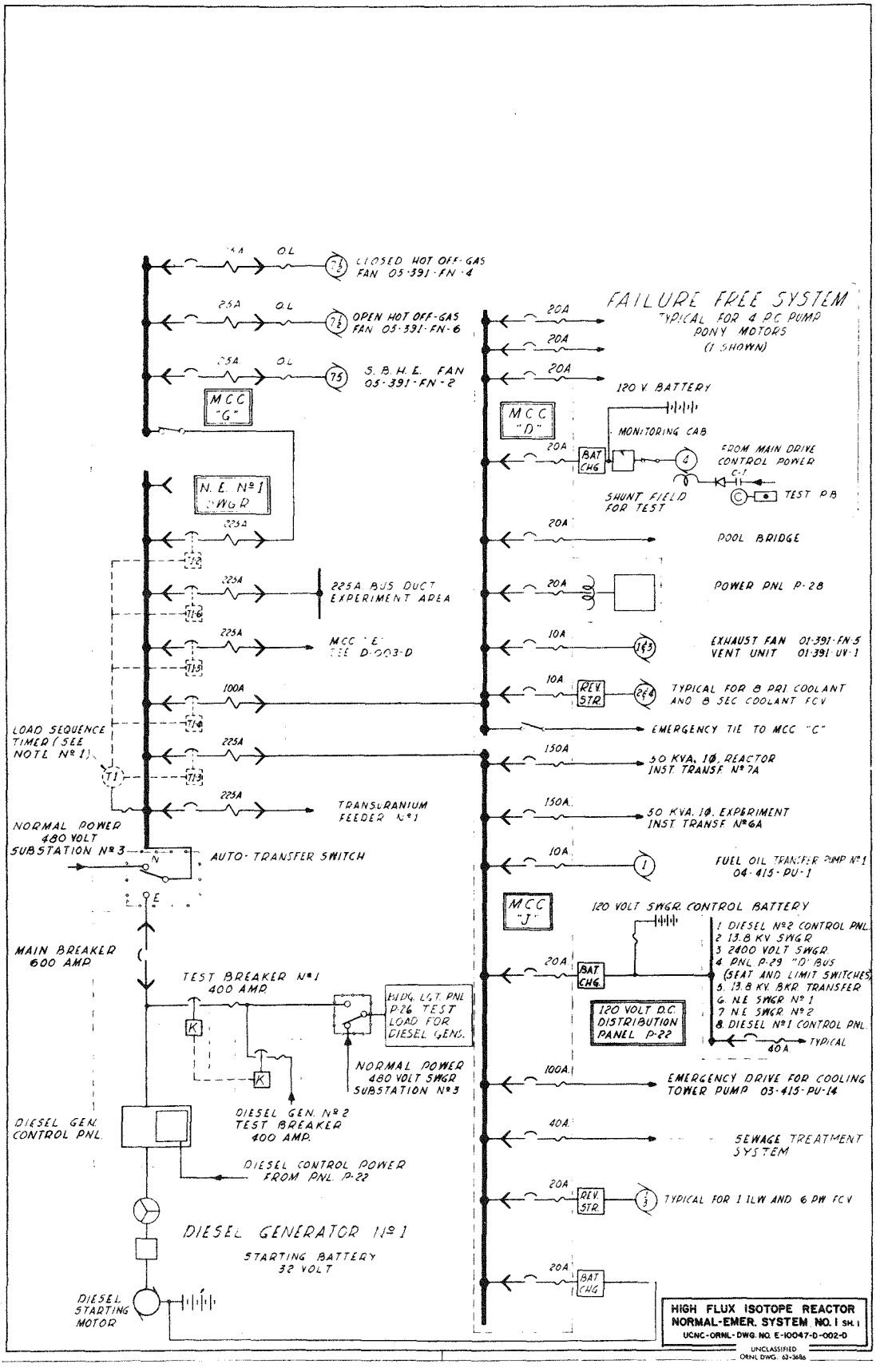


Fig. 10.10. Normal-emergency system No. 1.

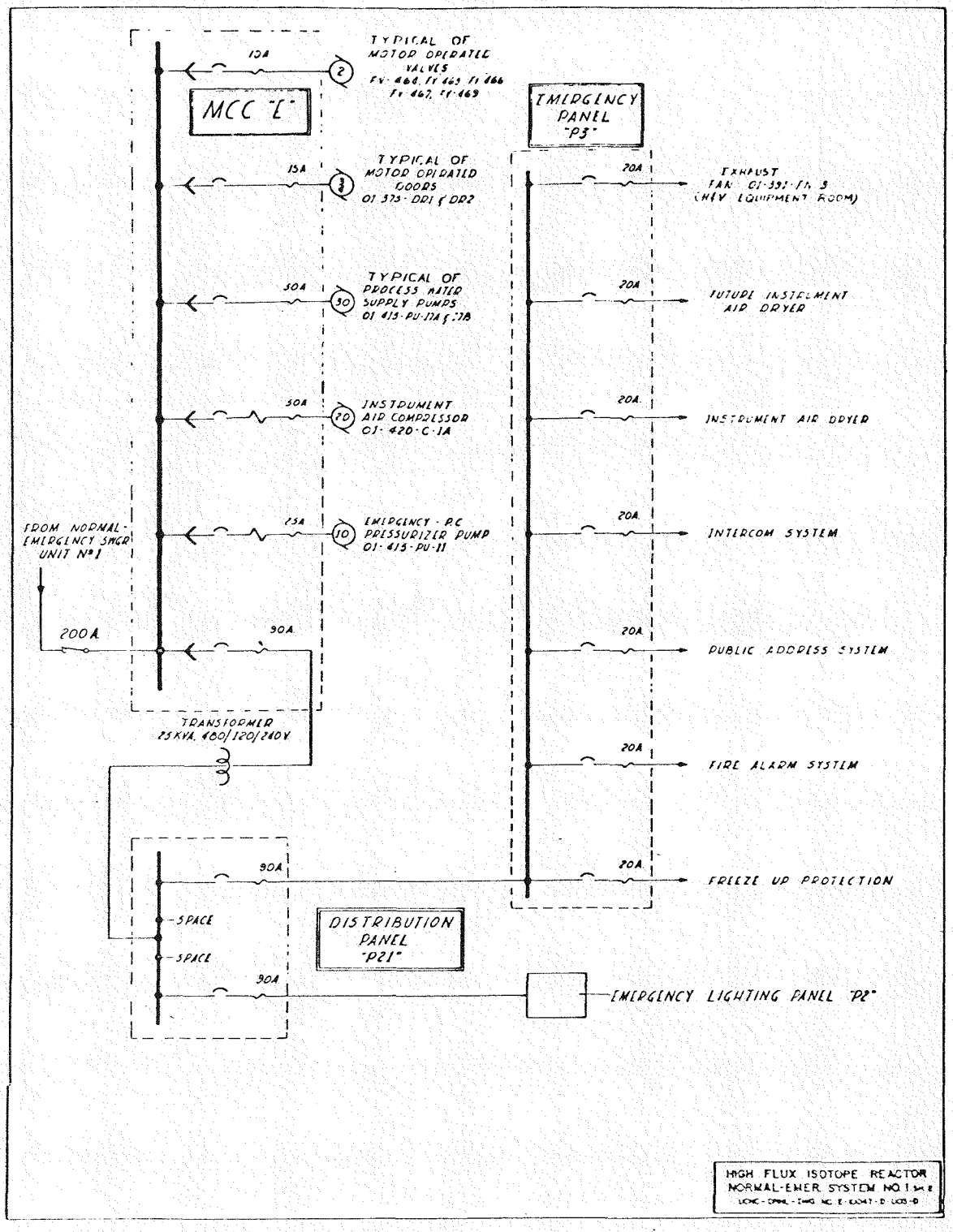


Fig. 10.11. Motor control center "E".

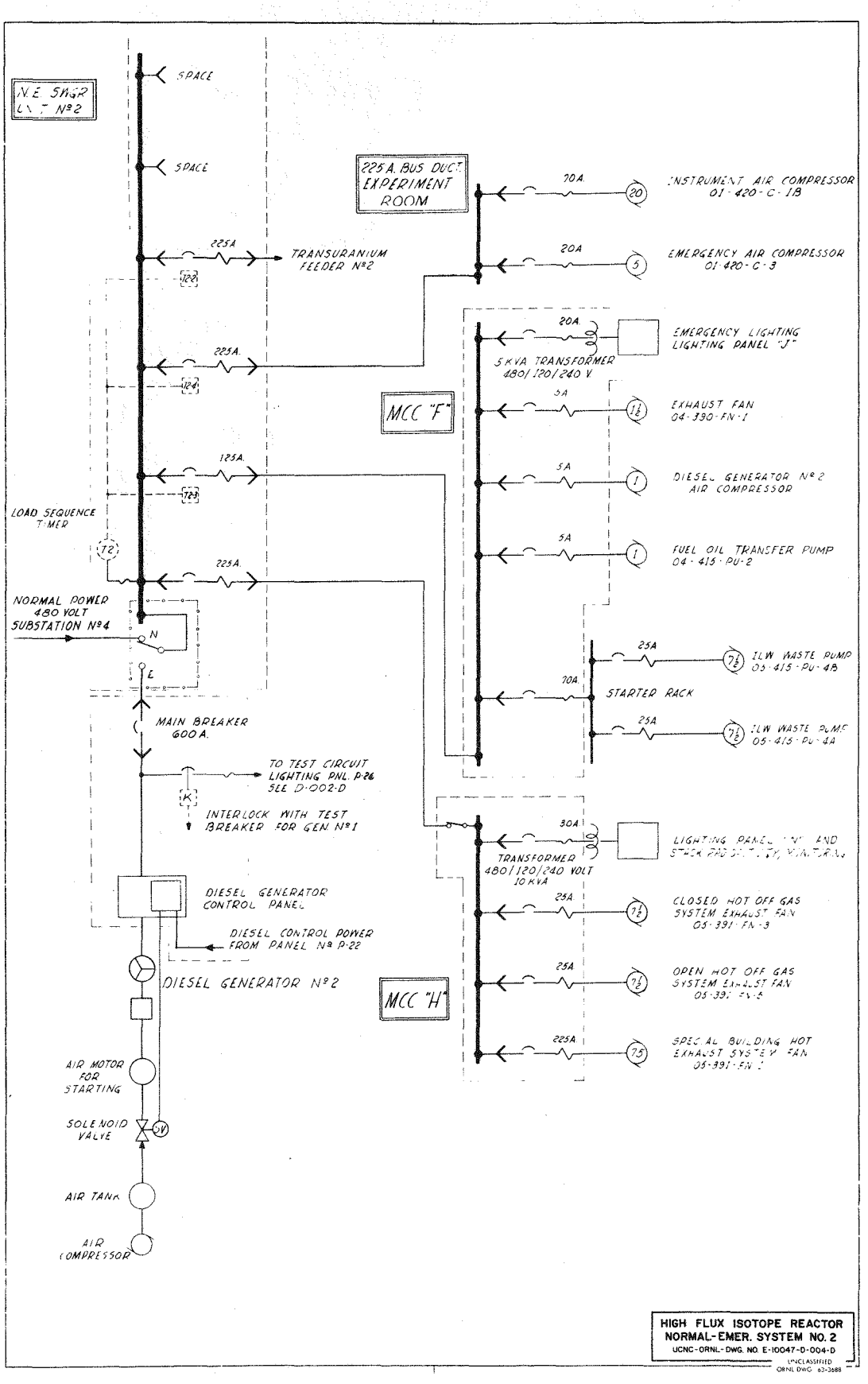


Fig. 10.12. Normal-emergency system No. 2.

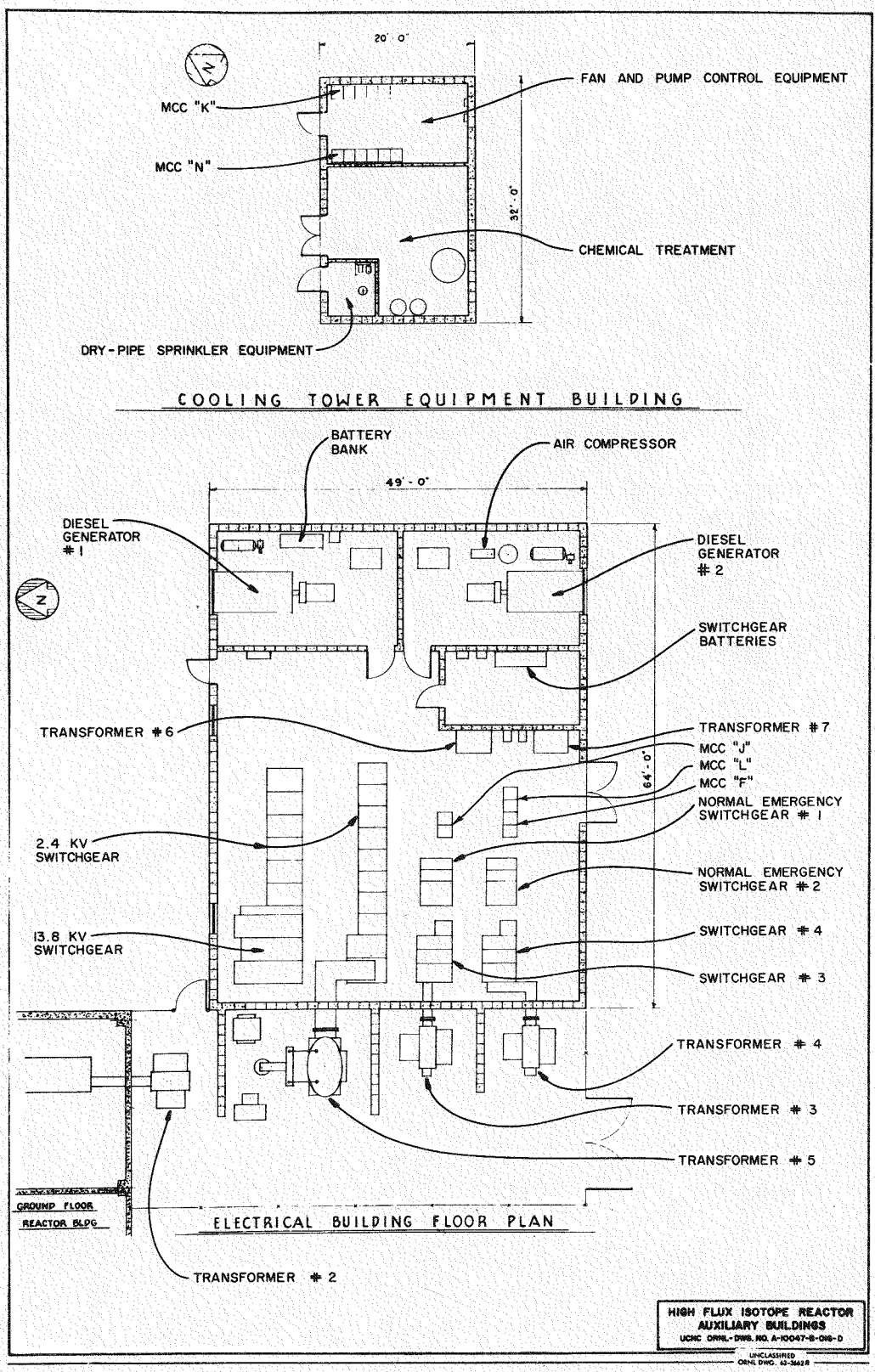


Fig. 10.13. Auxiliary buildings.

10.6.3 Operating procedures - 13.8-kV system

Closing an incoming line, 13.8-kV breaker. The following operations should be performed only by qualified personnel of the Plant and Equipment Division.

Prerequisites

1. Both 13.8-kV incoming line breakers must be open but racked into the operating position.
2. The preferred-feeder selector switch inside the auxiliary compartment of the 13.8-kV switching station must be in the "HFIR preferred" position. This designates the "HFIR" feeder as the preferred feeder. In the event that the "circuit No. 3" feeder is to be designated as the preferred feeder, place the switch in the "circuit No. 3 preferred" position. Due to the limitations in the load-carrying capabilities of the circuit No. 3 feeder, the HFIR feeder should always be selected as the preferred feeder.
3. The white indicating light on each breaker front door must be on to indicate that the closing mechanism spring is fully compressed.
4. The "power available" indicating light on the auxiliary compartment of the 13.8-kV switching station must be on to indicate that control power for the automatic transfer system is available.
5. The three incoming line potential indicating lights for the preferred feeder must be on to indicate that 13.8-kV power is available.

Procedure

1. Obtain clearance for the switching operation from the ORNL electrical operator.
2. Check the incoming line phase-to-phase voltages using the voltmeter located on the 13.8-kV switching breaker cubicle. The voltage should be 13.8 kV for all three phase-to-phase combinations.
3. Close the "HFIR" circuit breaker. The switch should be held in the closed position until the red breaker position indicating light comes on and the green light is extinguished.

Operation of the automatic 13.8-kV transfer system. Automatic transfer from the preferred feeder to the alternate feeder will occur upon loss of voltage on the preferred feeder. This transfer occurs, however, only if there is voltage available on the alternate feeder. If voltage is not available, the HFIR load will revert to the normal-emergency systems for power supplied by the diesel generators. When the transfer to the alternate feeder takes place, the red position-indicating light on the alternate feeder cabinet will be on. No operator action is required for the transfer to take place. However, the shift supervisor should contact the main ORNL electrical operator to determine the cause of the preferred feeder failure and to determine the anticipated delay in restoring service to the feeder.

Return to the preferred feeder. When power to the preferred 13.8-kV feeder is restored, indicating lights on panel "I" in the reactor control room will come on. Return to the preferred feeder should then be made.

1. Obtain clearance from the ORNL electrical operator for the transfer.
2. Check the phase-to-phase voltages on both incoming lines, using the voltmeters located on the 13.8-kV switching station breaker cubicles in the electrical building. These voltages should not deviate more than 500 V, action should be taken by the ORNL electrical operator to correct any deviation.
3. Turn the live bus transfer switch, No. 43-LB located on panel "I" in the reactor control room, to the "No. 3-to-HFIR" position. Hold the switch in this position until the circuit breaker position-indicating lights come on to indicate that the transfer has been completed.

Placing a 480- or 2400-V substation in operation

Prerequisites

1. The 13.8-kV bus is energized.
2. Both the substation 13.8-kV interrupter switch and the transformer secondary breaker are open.

Procedure:

1. Close the 13.8-kV interrupter switch at the switching station.
2. Check the transformer secondary voltage. This voltage should be within 2% of the rated voltage, 480 or 2400 V.
3. Close the transformer secondary breaker.

Removing a 480- or 2400-V substation from service.

1. Open the transformer secondary breaker.
2. Open the 13.8-kV interrupter switch at the switching station.

Replace a blown 13.8-kV fuse

1. Open the associated transformer secondary breaker.
2. Open the 13.8-kV interrupter switch.
3. Remove the key from the interlock key holder and unlock the fuse door.
4. Open the door, replace the fuse, and relock the door. Replace the key in the switch door interlock key holder.

Maintenance work on incoming 13.8-kV underground cables

1. Open the associated 13.8-kV incoming line breaker and remove the breaker draw-out mechanism from its cubicle.
2. Move the incoming line 13.8-kV-120-V potential transformers in the 13.8-kV switching station to the draw-out position.
3. Open and lock out the 13.8-kV isolating switch at the terminating pole.

10.6.4 Operating procedures - 2400-V system

Energize the 2400-V system

Prerequisites

1. The 13.8-kV bus is energized.
2. Both the substation 13.8-kV interrupter switch and the transformer secondary breaker are open.
3. The zigzag grounding transformer breaker is open.
4. The 2400-V starter, for disconnecting fused switches, is closed.

Procedure

1. Close the 13.8-kV interrupter switch at the switching station.
2. Check the transformer secondary voltage with the voltmeter at the 5000-kVA transformer secondary breaker. The voltage should be within 50 V of the rated 2400 V.
3. Close the transformer secondary breaker using the local control switch. Observe that the red indicating light should come on when the switching is completed.
4. Close the zigzag grounding transformer breaker with the local control switch. The red indicating light should come on as the breaker is closed.

10.6.5 Operating procedures - 460-V system

Energize the 460-V system

Prerequisites

1. The 13.8-kV bus is energized.
2. Both the substation 13.8-kV interrupter switch and the transformer secondary breaker are open.
3. The disconnect switch on the 1000-kVA transformer is closed.
4. The substation feeder breakers are open.

Procedure

1. Close the 13.8-kV-interrupter switch at the switching station.
2. Check the transformer secondary voltage using the voltmeter at the substation metering cubicle. The voltage should be approximately 460 V for substations No. 1 and

2 and 480 V for substations No. 3 and 4. If necessary, the voltage may be adjusted by using the tap changer control switch for substations No. 1 and 2 or the manual tap changer wheel for substations No. 3 and 4.

3. Close the transformer main breaker.

10.6.6 Routine checks

Daily checks

1. Check the electrical building for any unusual humming or chattering noises which would indicate faulty relays or contactors. Overheated transformers give off an odor of heated oil. Therefore, careful attention should be paid to odors of this type.
2. Check the ground detection system lights on panel "I" in the reactor control room. When one light is out and the other two more intense than usual, one phase of the system has become grounded. Report lights to the shift supervisor immediately.
3. Check the voltage and current flow for each system. Voltmeters and ammeters are located on the switching station breaker cubicles in the electrical building. Voltages should be within 2% of the rated capacity of the system. Current should vary only when the load is changed.

Shift checks

1. Check the battery charger current to the pony motors and pony motor batteries. This is the only reliable means to check the condition of the nickel-cadmium batteries since the specific gravity of the electrolyte changes very

little from fully discharged to full charged. Record these currents in the log book. If there is more than a slight deviation in charging current from normal, contact the shift supervisor.

2. Check the full load current to each pony motor by pressing the test button directly above the "on-off" switch for each primary coolant pump motor on control panel "F."
3. Record the output current of the battery chargers of each of the following battery systems:
   a. Switchgear batteries located in the electrical building.
   b. Diesel-generator No. 1 motor starter batteries, located in the electrical building.
   c. Instrument batteries located in the instrument battery room.
   d. Pony motor batteries, located on Room G-13.

10.6.7 Abnormal operating procedures

13.8-kV system. In the event of a relay trip of the 13.8-kV preferred incoming line breaker, all normal power will be lost and the automatic transfer system will not operate. This condition is distinguished from other 13.8-kV power failure by the following:

1. Both sets of incoming line potential indicating lights on panel "I" in the reactor control room will be on.
2. Both incoming line breaker's position indicating lights will show that the breakers are open; i.e., green lights will go on.

The 13.8-kV breaker relays will trip as a result of the following:

1. Fault on the 13.8-kV feeder to the 5000-kVa transformer or a fault in the high-voltage winding of the transformer.
2. Fault on the 13.8-kV bus.
3. Back-up operation resulting from failure of one of the 13.8-kV fuses to blow when overloaded.
4. A fault on the secondary side of the 5000-kVA transformer between the transformer and main secondary 2400-V breaker.
5. Back-up operation resulting from failure of the main secondary 2400-V breaker to trip when overloaded.

The 13.8-kV breaker overcurrent relays are located on the front doors of the breaker cubicles in the electrical building. In order to reclose a breaker after a relay trip, it is necessary to reset the relay or relays causing the tripout.

The ORNL electrical operator should be notified immediately in the event a 13.8-kV breaker relay trips out.

2400-V system

1. A relay trip of the main transformer secondary breaker is annunciated in the reactor control room on panel "HI" (2.4-kV main breaker trip). Since this causes the loss of all of the 2400-V motors, immediate corrective action is required. Possible causes for such a tripout are:
   a. A two-phase or three-phase fault on the 2400-V bus.
   b. Failure of motor-starter protective equipment to function in the event of defects in the windings.

   Unless the reactor is operating at power when the tripout occurs, no attempt to reclose the breaker should be made until the cause for the tripout is determined and corrected. Reclosing the breaker without correcting the

cause for the tripout could result in damage to expensive process equipment. However, in certain emergency situations, such as diesel-generator failure after full power operation, it may be necessary to risk damage to equipment in order to restart certain equipment. The relay or relays which caused the tripout must be reset before the breaker can be reclosed.

2. A relay trip of the zigzag grounding transformer breaker is annunciated in the reactor control room on panel "HI" (2.4-kV zigzag transformer trip). When the breaker opens, the 2400-V system is converted to a delta system with one phase grounded. Operation of the system may continue in this way. However, remedial action should be initiated immediately, since the occurrence of a second ground fault could cause serious damage to the electrical equipment.
3. A ground relay trip of a 2400-V motor starter is an electrical failure not related to equipment conditions. A check into the cause of the fault should be made before an attempt is made to reclose the starter.

460-V system. Operation of the emergency-tie feeders between substations No. 3 and 4 (dead bus transfer) is possible. A bus tie is provided between the 480-V switchgear of the No. 3 and 4 substations so that continuity of service can be maintained in the event of trouble in the transformers, fuses, or main breakers of one of the circuits.

CAUTION: Interconnection is desirable only when there is a fault in either No. 3 or 4 main transformer, breaker, or fuse.

Serious damage to equipment can result from interconnection between the two buses if both main transformers are energized and both main breakers are closed.

To interconnect No. 3 and 4 main buses:

1. Disconnect the main breaker of the faulty circuit.
2. Unlock and close the bus tie breaker located in the No. 3 substation, 480-V switchgear.
3. Unlock and close the bus tie breaker located in the No. 4 substation, 480-V switchgear. Both No. 3 and 4 main buses are now energized through one transformer.

To break the tie between the No. 3 and 4 main buses:

1. Open and lock the bus tie breaker located in the No. 3 substation, 480-V switchgear.
2. Open and lock the bus tie breaker located in the No. 4 substation, 480-V switchgear.
3. Close the main breaker of the feeder circuit which has been disconnected.

The buses are now isolated and back in normal service.

Normal-emergency system. During normal operation the following conditions exist.

1. Normal feeder breakers from substations No. 3 and No. 4 are closed and supplying power to normal-emergency systems No. 1 and 2.
2. The breaker in compartment 1-A of motor-control center "J" is closed and supplying power to the batteries and battery charger of diesel generator No. 1.
3. The breaker in compartment 1-B of motor control center "F" is closed and supplying power to the diesel-generator No.

2 air compressor. The compressor is maintaining air pressure at 150 psig in the engine-start up air receiver.

4. Breakers in compartments 1-B and 1-C of motor-control center "L" are closed and supplying power to the diesel-generator's jacket water heaters.
5. Breakers 1 and 7 in the 120-V dc panel, P-22, located in the electrical building battery room, are closed and supplying power to diesel generator No. 1 control circuits.
6. Breakers 2 and 8 in the 120-V dc panel, P-22, located in the electrical building battery room, are closed and supplying power for diesel generator No. 2 control circuits.
7. Main generator breakers are closed.
8. Generator test-loading breakers are open.

Loss of normal power. In the event of a loss of one or both of the two 460-V normal-power feeders, the appropriate diesel generator will automatically start and the normal-emergency system loads will be transferred to the diesel generators. This transfer of loads is sequenced at 10-s intervals.

The shift supervisor should attempt to determine the cause of the normal power failure and initiate corrective action if the cause is within the HFIR complex. If the cause is outside the HFIR area, the ORNL electrical operator will correct the situation.

If the indications are that the normal power outage will last for more than 2 h, steps should be taken to reduce the load on diesel generator No. 1. This can be done by selecting as preferred the SBHE and HOG fans which are on the normal-emergency system No. 2 and placing those fans which are on the normal-emergency system No. 1 on standby.

Upon a sustained return of normal power (approximately 60 s), the normal-emergency systems will automatically return to substation Nos. 3 and 4. No operator action is required for this return to normal power. The diesel-generators will continue to run until manually shut down. To shut down the diesel generators:

1. Turn the selector switch, located on the diesel generator control panel, to "stop."
2. When the diesel has stopped, return the selector switch to the "auto-start" position.
3. Reset the rack solenoid. Confirm with the control room that the diesel misoperation alarm has cleared.

10.6.8 Systems testing

Test loading of the diesel generators. Each diesel generator unit is tested for 30 min each week with the building lighting system serving as the test load. This procedure assumes that the reactor is operating and all auxiliary services are in normal condition.

1. Start the diesel generator to be tested by turning the four-position control switch on its panel from "auto start" to "engine start." Check for a normal diesel engine startup.
2. Close the key interlock test load breaker on the control panel of the operating diesel generator. A key is required for this operation. The interlock ensures that only one diesel generator can be test loaded at a time.
3. Note that the diesel generator being tested starts during the first starting cycle (within 15 s). Check the following instruments located on the diesel instrument panel for

normal readings:

Instrument	Normal Readings
ac V	480 (3 phase)
ac kilowatts	approximately 100 kW for the building lighting system test load
ac amperes	approximately 100 amps
Cycles	60 cps

Three instruments - fuel pressure, water temperature, and engine oil pressure - are located on the side of the diesel engine. Check these for normal operation conditions.

4. Allow the diesel-generator to carry the test load for a maximum of 1 h. The mechanical and electrical condition of the diesel-generator system should be checked while it is being tested.
5. When the test run has been completed, return the building lighting load to the normal-emergency power supply by opening the generator-test breaker.
6. Stop the diesel by turning the engine control switch to the "stop" position.
7. When the diesel stops, return the switch to the "automatic" position and reset the rack solenoid. Confirm with the control room that the diesel misoperation alarm has cleared.

Testing the normal-emergency system. This procedure is intended for use only when the reactor is shutdown and when no fuel moves are being made. It is performed approximately every three

months or every third reactor operational cycle. The reactor status must be such that operation of the emergency pressurizer pump, the emergency secondary water pump, and the cooling tower bypass valve can proceed without endangering personnel or equipment.

In this procedure it is assumed that the normal-emergency loads are in operation.

1. Open the 460-V normal-emergency system feeder breaker of substation No. 3 by turning the key switch to the "test" position and note that:
   a. All normal-emergency system feeder breakers, in normal-emergency switchgear No. 1, trip except the feeder to motor control center "G" and that the diesel test loading circuit breaker trips.
   b. Diesel-generator No. 1 starts up.
   c. The automatic transfer switch transfers the load over to the emergency generator.
   d. Normal-emergency switchgear No. 1 feeder breakers close in sequence.
   e. PU-11, emergency pressurizer pump, and PU-14, cooling tower emergency pump, start automatically.
2. Allow the load to remain on diesel-generator No. 1 for a few minutes. At the end of the test period, turn the key switch back to the "normal" position and note that after 60 s the load returns to the normal system.
3. Turn the selector switch to the "stop" position. After the engine has stopped, return the selector switch to the "auto start" position and reset the rack solenoid.

Normal-emergency system No. 2 may be tested concurrently with the No. 1 system.

1. Open the 460-V normal-emergency system feeder breaker of substation No. 4 by turning the key switch to the "test" position and note that:
   a. All normal-emergency system feeder breakers, in normal-emergency switchgear No. 2, trip except the feeder to motor control center "H."
   b. Diesel generator No. 2 starts up.
   c. The automatic transfer switch transfers the load to the emergency generator.
   d. Normal-emergency switchgear No. 2 feeder breakers close in proper 10-s interval sequence.
2. After the test period, close the 460-V normal feeder breaker in substation No. 4 and note that after 60 s the load returns to the normal system.
3. Open the diesel test-loading circuit breaker and stop the diesel engine by first turning the key interlock test breaker and moving its selector switch to "stop."
4. After the engine has stopped, return the diesel generator selector switch to the "auto start" position and reset the the rack solenoid.

Instrument Battery Chargers

Procedure to place "instrument battery spare charger" in service - to charge instrument battery.

NOTE: During the time that this work is being performed, rod withdrawal will not be permitted (with the exception of the

servo). Consequently, be sure that the regulating rod position indicator is at mid range to allow for any delay in returning the third channel to service.

1. De-energize the servo motor on the affected channel (breaker switch in control room).
2. Place the fission chamber control in the manual mode to prevent insertion (affected channel).
3. Scram the affected channel (one of the scram parameter modules).
4. De-energize the breaker switch located above the battery bank 9ex. P-33).
5. Have the shift electrician connect the output of the standby charger to the output of the malfunctioning charger.

NOTE: Sixty-ampere wires and the appropriate connections are located in the battery room. The terminals to be connected are at the bottom of the box (inside). Be sure that the polarity is not changed. It is preferable that the wires from the faulty charger be disconnected to allow repairs to be made to the charger.

6. Energize the standby charger (2 switches on face of box).
7. Allow the batteries to charge about 10 min then energize the breaker switch above the battery bank.
8. Clear the scram condition (module scram).
9. Observe the recorder readouts for equilibrium values.
10. Place the fission chamber controls in automatic.
11. When equilibrium values are attained, the servo demand on the affected channel is where it was originally (it will go to 0 MW when the breaker above the instrument batteries is de-energized), energize the servo motor.

11. RECORDS AND DATA ACCUMULATION

11.1. Daily Report Form

To facilitate the interpretation of accumulated operating data, uniformity in recording is of the utmost importance. The forms described in this section are used to collect, record, and aid in the interpretation of operating data. In general, the data are recorded by operators. The shift supervisor is responsible for making sure that all pertinent data are recorded. It is also his responsibility to check any data that may be questionable.

11.1.1 HFIR hourly readings (Example 11.1)

These data are recorded each hour on the half-hour by the control room operator. Information required on this report form is as follows:

1. Safety Heat Power (MW)
   This information is printed out on the safety system heat power recorders and is computed from flow and ΔT signals by the safety system heat power computers.
2. Servo Heat Power (MW)
   This information is printed out on the servo system heat power recorders and is computed from flow and ΔT signals by the servo system heat power computers.
3. Primary Coolant Flow (gpm)
   This information is printed out on the PDP 11/60 computer typewriter and is obtained by initiating function "RUN "Getdat." The signals are brought directly from the servo flow transmitters to the computer.

HFIR HOURLY READINGS

DATE		SHIFT			SUPERVISOR				
	TIME								
1. Safety Heat Power (MW)	Channel 1								
	2								
	3								
2. Servo Heat Power (MW)	Channel 1								
	2								
	3								
3. Primary Coolant Flow (gpm)	Channel 1								
	2								
	3								
	Average								
4. Primary Coolant ΔT ($^{\circ}$F)	Channel 1								
	2								
	3								
	Average								
5. Heat Power, Calculated (MW)									
6. Primary Coolant T In ($^{\circ}$F)	Channel 1								
	2								
	3								
7. Primary Coolant T Out ($^{\circ}$F)	Channel 1								
	2								
	3								
8. Flux-To-Flow Ratio	Channel 1								
	2								
	3								
9. Safety Reset Gain	Channel 1								
	2								
	3								
10. Servo Reset Gain	Channel 1								
	2								
	3								
11. FFED (% Flux)	Channel 1								
	2								
	3								

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Example 11.1.

TIME								
12. Reactor Pool Coolant Flow (GPM)								
13. Reactor Pool Coolant T Out (°F)								
14. Reactor Pool Coolant T In (°F)								
15. Reactor Pool Coolant ΔT (°F)								
16. Reactor Pool Heat Power (MW)								
17. Heat Power, Total (MW)								
18. Reactor Vessel ΔP (psi)								
19. Inlet Strainer ΔP (in. H_2O)								
20. Primary System Inlet Pressure (psig)								
21. Primary Cleanup System Flow (gpm)								
22. Secondary Flow Through Primary Heat Exchangers (gpm)								
23. Cladding Failure Detector (mr/hr)								
24. SBHE Flow (cfm) Experiment Area								
Reactor Bay								
25. Control Roo Position (inches withdrawn)								
Shim Plate No. 1								
Shim Plate No. 2								
Shim Plate No. 3								
Shim Plate No. 4								
Shim Cylinder No. 5								

Example 11.1. (continued).

4. Primary Coolant ΔT (°F)

   This information comes from the servo system temperature transmitters.

5. Heat Power, Calculated (MW)

   The PDP 11/60 computer calculates an average inlet temperature, outlet temperature, and flow rate for each of the three servo channels. From these the computer uses the equation

$$\text{Heat Power (MW)} = \frac{F[0.9957(T_o - T_i) - 0.255]}{2.2021\ Ti + 6636.1}$$

   where: F = average servo flow in gpm

   T_o = average servo exit temperature in °F

   T_i = average servo inlet temperature in °F

   to calculate the average heat power. In the event of computer failure, the above equation is used to manually calculate the heat power.

6. Primary Coolant Tin (°F)

   This information is printed out on the PDP 11/60 typewriter and originates at the servo flow sensors.

7. Primary Coolant T_o (°F)

   This information is printed out on the PDP 11/60 typewriter and originates at the servo temperature sensors.

8. Flux-to-Flow Ratio

   The ratio of flux-to-flow is displayed by recorders on each of the three safety channels. Neutron flux information has been corrected by heat power.

9. Safety Reset Gain

   The reset gain is the factor by which the safety system neutron flux signal is amplified to make it agree with the heat power.

10. Servo Reset Gain

    The reset gain is the factor by which the servo system neutron flux signal is amplified to make it agree with the heat power.

11. FFED (% Flux)

    This signal is the output of the FFED chambers while covered by the lead shields.

12. Reactor Pool Coolant Flow Rate (gpm)

    This reading is taken from flow indicator FI-425 on the graphic panel.

13. Reactor Pool Coolant T_o (°F)

    This reading is taken from point 5 of TR-129.

14. Reactor Pool Coolant T_i (°F)

    This reading is taken from point 9 of TR-129.

15. Reactor Pool Coolant ΔT (°F)

    Subtract item 14 from item 13 for this number.

16. Reactor Pool Heat Power (MW)

    Calculate the heat power absorbed by the reactor pool water using items 12 and 15.

    $$\text{Heat Power} = F \times 1.448 \times 10^{-4} \Delta T$$

17. Heat Power, Total (MW)

    Add items 16 and 5 for this number. At full power it should be 100 MW $\pm$ 0.5 MW.

18. Reactor Vessel ΔP (psi)
    Read PdI-103.
19. Inlet Strainer ΔP (in. water)
    Read PdI-106.
20. Primary System Inlet Pressure (psig)
    Read PRC-127.
21. Pressurizer Pump Discharge Flow (gpm)
    Read FT-216.
22. Primary Cleanup Ssytem Flow (gpm)
    Read FR-254.
23. Primary System pH
    Read point 2 on ApHR-1010. This signal comes from pH-203 system.
24. Secondary Flow through Primary Heat Exchangers (gpm)
    Read FI-300.
25. Secondary Pump Discharge Water Temperature (°F)
    Read point 18 on TR-1040.
26. Primary Deaerator Off-Gas Radiation Level (mr/h)
    Read even points on the off-gas activity recorder.
27. Pool Water Radioactivity (mr/h)
    Read point 6 on RR-1000.
28. Pool Cleanup Water Radioactivity (mr/h)
    Read point 3 on RR-1000.
29. Cladding Failure Detector (mr/h)
    Read point 1 on RR-1000.
30. SBHE Flow (cfm)
    Read one flow indicator in each branch.

31. Control Rod Position (in. withdrawn)

Read rod position indicators.

11.1.2 HFIR power changes and accumulated megawatt hours (Example 11.2)

This form is a record of the power level for a 24-h period. At constant power, the power level (as shown on the heat-power indicators) is recorded on the half hour. The total power accumulated (hours of operation times the power level) is recorded on the hour. If there are changes in power level, they are recorded after each power change, regardless of time.

11.1.3 Shift check sheet

There are many instruments to be checked and duties to be performed which are necessary to the operation of the reactor that cannot be done by the operator at the control desk. To make sure that these important jobs are done, daily check sheets have been prepared for each shift. When these duties are completed by the "roving" operators, they are checked off the check sheet. These check sheets are prepared for each shift (Example 11.3.) and for day shift (8 to 4) (Example 11.4.) and evening and midnight shifts (4 to 12 and 12 to 8) (Example 11.5.).

11.1.4 Daily summary (Example 11.6.)

The daily summary is compiled from the daily check sheets and is completed by, or under the supervision of, the shift supervisor of the 12 to 8 shift.

11.1.5 Load tests for diesel-generators (Example 11.7.)

The emergency power generators are tested weekly to insure their reliability. The test form is self-explantory.

HFIR POWER CHANGES AND ACCUMULATED MEGAWATT HOURS

DATE

DAY NO.

12-8 SHIFT		SUPERVISOR		8-4 SHIFT		SUPERVISOR		4-12 SHIFT		SUPERVISOR	
Time	Power Level	Incremental Mwh	Accumulated Mwh	Time	Power Level	Incremental Mwh	Accumulated Mwh	Time	Power Level	Incremental Mwh	Accumulated Mwh
Total Mwh for Shift				Total Mwh for Shift				Total Mwh for Shift			
Total MWD for Shift				Total MWD for Shift				Total MWD for Shift			

Power Level Units are Megawatts (Mw)

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Example 11.2.

SHIFT CHECK SHEET

DATE | SHIFT | SUPERVISOR

A. DIESEL GENERATOR AND DC POWER SYSTEMS

	No. 1	No. 2
1. Day Tank Fuel Oil Level		
2. Fusible Links Intact		
3. Diesel Mode Switches in 'Auto' and Rack Solenoids 'Reset'		
4. Diesel Engines Cooling Water Temperature		
5. Power Available on N-E Switchgear		
6. Fuel-Oil Transfer Pump in 'Automatic'		

7. No. 2 Diesel Starting Motor Air Pressure ____ psi

8. Pony Motor Batteries

a. AC Power to Changes

b. Charger Output, Volts	PU - 1A	PU - 1B
	PU - 1C	PU - 1D
c. Charger Output, Amperes	PU -1A	PU - 1B
	PU - 1C	PU - 1D
d. Battery, Amperes	PU - 1A	PU - 1B
	PU - 1C	PU - 1D

e. Liquid Level

9. Pony Motor Current, Amperes	PU-1E	Hi	Lo	PU-1G	Hi	Lo
	PU-1F	Hi	Lo	PU-1H	Hi	Lo

10. Instrument Batteries

a. AC Power to Chargers

b. Chargers Output, Volts	A-1	A-2	B-1
	B-2	C-1	C-2
c. Charger Output, Amperes	A-1	A-2	B-1
	B-2	C-1	C-2
d. Battery, Amperes	A-1	A-2	B-1
	B-2	C-1	C-2

e. Liquid Level

11. Building 7901 Batteries	No. 1 Diesel Starting	Switch Gear
a. Ac Power to Chargers		
b. Charger Output, Volts		
c. Charger Output, Amperes		
d. Battery, Amperes		
e. Liquid Level		

B. SBHE AND HOG SYSTEMS

1. Fan Shed Area Checked for Malfunctions	
2. Fan and Motor Bearing Housing Temperatures	
3. Oil or Grease Accumulations	
4. Fan Control Switches in Proper Position	
5. SBHE and HOG Drainage Sumps Filled with Water	

B. SBHE AND HOG SYSTEMS (CONT.)

6. Stack B- Particulate Activity (RR-907)		c/m
7. Stack Alpha Particulate Activity (RR-908)		c/m
8. Duct B- Particulate Activity (RR-909)		c/m
9. Stack Iodine Activity (RR-910)		c/m
10. Stack Inert Gas Activity (RR-911)		c/m
11. Stack High-Level Activity (RR-912)		mr/hr
12. Building Negative Pressures	CR	Local Manom.
a. Reactor Bay (Pd I-900), in. H_2O		
b. Experiment Area (Pd I-902), in. H_2O		
c. Beam Room (Pd I-901), in. H_2O		

13. SBHE Air Flow, cfm

a. Reactor Bay	FI-904B	FI-914B
b. Beam and Experiment Area	FI-903B	FI-913B
14. HOG Ducts Negative Pressure	CHOG	OHOG
a. Fan Shed, in. H_2O	PI-915	PI-916
b. Control Room, in. H_2O	PI-905	PI-906

C. SECONDARY COOLANT SYSTEM

1. H_2SO_4 Pump % Error Signal (ApHC-331)	
2. Chemical Addition Rate	cc/min
3. Secondary Water pH	
a. ApHI-331	c. ApHI-334
b. ApHR-1010-3	d. ApHR-1010-4
4. Makeup Rate (FI-336)	gpm
5. Blowdown Rate (FIC-325)	gpm
6. Chemical Addition Flow Rate (FI-320)	gpm
7. Tower Return Temp. (TI-337)	°F

D. MISCELLANEOUS

1. PWD Sump Level (LI-710)			%
2. SUBPILE ROOM CHECKS	a. High Pressure System	(1) PRESSURE - PI-302	Psi
		(2) FLOW - FI-302	gph
	b. Low Pressure System	(1) PRESSURE - PI-2352	Psi
		(2) FLOW - FI-2351	gph
		(3) FLOW FROM EACH HOUSING	gph

c. Push Rod Seal Leak Inspection

	△ P Indicator		Pressure		
d. Pressure Balance System	Pd I-270	Psi	H_2O	Pd I-267	Psi
	Pd I-272	Psi	Oil	Pd I-271	Psi
	Pd I-268	Psi	Oil	Pd I-269	Psi

e. Instrument Air Pressure (PI-256)	Psi
f. Control Rod Position	in.
3. Pool Level OK	

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Example 11.3.

8-4 SHIFT CHECK SHEET

DATE | SHIFT | SUPERVISOR

A. PRIMARY COOLANT SYSTEM

1. Pressurizer Pump Speed — PU-4A (SI-177) rpm; PU-4B (SI-179) rpm

2. Pressurizer Pump Discharge Water Temp. (TI-1040-8) °F

3. Primary Heat Exchanger Exit Temperatures

EX-1A(TI-1040-15) °F		EX-1C(TI-1040-17) °F	
EX-1B(TI-1040-16) °F		EX-1D(TI-1040-24) °F	

4. Primary Pump Bearing Shaft Temperatures

PU-1A(TR-1025-1) °F		PU-1C(TR-1025-5) °F	
PU-1A(TR-1025-2) °F		PU-1C(TR-1025-6) °F	
PU-1B(TR-1025-3) °F		PU-1D(TR-1025-7) °F	
PU-1B(TR-1025-4) °F		PU-1D(TR-1025-8) °F	

5. CLADDING FAILURE DETECTOR: (RR-200) cps.

6. DEMINERALIZER EXIT RADIATION LEVEL — (RR-1000-2) mr./hr.; (RI-213) mr./hr.

7. CLEANUP WATER pH

Inlet	(APHI-203)	
	(APHR-1010-4)	
Exit	(APHI-217A)	
	(APHR-1010-1)	

8. CLEANUP WATER RESISTIVITY — (CI-217A); (CR-1020-1)

9. WATER SAMPLES

		A (WEST)	B (EAST)
RESISTIVITY	CATION INLET ohm-cm		
	CATION EXIT ohm-cm		
	ANION EXIT ohm-cm		
pH	CATION INLET		
	CATION EXIT		
	ANION EXIT		
RADIO-ACTIVITY Alpha ____ d/m	CATION INLET c/m-ml		
	CATION EXIT c/m-ml		
	ANION EXIT c/m-ml		

PRESSURIZER PUMP DISCHARGE pH

10. pH (ApHRC-1200) 11. ApHI-1200

12. OXYGEN ADDITION — a. Cylinder Pressure psi; b. Flow Rate %

13. Prefilter in Service — FL-1A FL-1B

14. Prefilter Δ P psi

15. Cation Δ P psi

16. Anion Δ P psi

17. After filter Δ P psi

18. PRIMARY PUMP SEAL WATER SUPPLY

	Cell Inlet Pressure (psi)	Seal Inlet Pressures 1ST	2ND	3RD	SEAL FLOWS Inlet (gpm)	Exit (gph)
PU-1A						
PU-1B						
PU-1C						
PU-1D						

19. PRESSURIZER PUMPS

PUMP NUMBER	Motor Oil Temperature East	Motor Oil Temperature West	Pump Bearing Temp. East	Pump Bearing Temp. West

B. POOL CLEANUP SYSTEM

1. CLEANUP SYSTEM INLET TEMP. (TR-129-10) °F

2. CLEANUP SYSTEM RADIOACTIVITY

Inlet	(RI-427) mr./hr.	
	(RR-1000-3) mr./hr.	
Exit	(RI-498) mr./hr.	
	(RR-1000-14) mr./hr.	

3. DEMINERALIZER EXIT WATER RESISTIVITY — (CI-217) ohm-cm; (CR-1020-2) ohm-cm

4. PREFILTER INLET PRESSURE (PI-479) psi

5. PREFILTER EXIT PRESSURE (PI-415) psi

6. AFTER-FILTER INLET PRESSURE (PI-481) psi

7. AFTER-FILTER EXIT PRESSURE (PI-475) psi

8. CLEANUP SYSTEM FLOW RATE (FI-426) gpm.

9. INTEGRATOR (FQ-426) gal.

10. WATER SAMPLES

	RESISTIVITY	pH	RADIOACTIVITY
CATION INLET	ohm-cm		c/m-ml
CATION EXIT	ohm-cm		c/m-ml
ANION EXIT	ohm-cm		c/m-ml

11. BEAM TUBE COOLANT FLOW NORMAL

REMARKS:

Example 11.4.

C. POOL COOLANT SYSTEM					
1. REACTOR POOL EXIT WATER TEMP. (TR-129-5)					
2. POOL INLET-WATER TEMP. (TR-129-9)					
D. SECONDARY COOLANT SYSTEM					
1. PRIMARY COOLANT HEAT EXCHANGER EXIT TEMPERATURES					
EX-1A(TI-1040-19) °F		EX-1C(TI-1040-21) °F			
EX-1B(TI-1040-20) °F		EX-1D(TI-1040-25) °F			
2. WATER SAMPLES	pH				
	CHROMATE CONTENT ppm				
	CALCIUM CONTENT ppm				
	RADIOACTIVITY c/m-ml				
3. POOL HEAT EXCHANGER FLOW RATE (FI-306) gpm					
E. INSTRUMENT AIR SYSTEM					
1. COMPRESSOR			CIA	CIB	CIC
a. Comp. Cooling Water T Out	°F				
b. Aircooler Air Temp.	°F				
c. Oil Pressure	psi				
d. Oil Level					
e. Water Trap Condition					
f. Moisture Content (AMI-627) ppm					
2. INSTRUMENT AIR PRESSURE	PI-625A psi				

F. MISCELLANEOUS	
1. PLANT DEMINERALIZED WATER SYSTEM	
a. STORAGE TANK LEVEL (LI-605-2)	% Full
b. RESISTIVITY	ohm-cm
c. pH	
d. INTEGRATOR READING	gal.
2. ILW TANK LEVEL (LR-704)	% Full
3. OFF-GAS DILUTION FLOW RATE (FI-917)	cfm
4. H&V ROOM EQUIPMENT	
a. Equipment Condition	
b. Chilled H2O Temperature	°F

Example 11.4. (continued).

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4-12 AND 12-8 SHIFT CHECK SHEET

DATE | SHIFT | SUPERVISOR

A. PRIMARY COOLANT SYSTEM

1. PRESSURIZER PUMP DISCHARGE WATER TEMP. (TI-1040-8) °F
2. CLADDING FAILURE DETECTOR (RR-200) cps.
3. DEMINERALIZER OUTLET RADIATION LEVEL
   - (RR-1000-2 & 12) mr./hr.
   - (RI-213) mr./hr.
4. CLEANUP WATER pH

Inlet	(APHI-203)	(APHR-1010-5 & 9)
Outlet	(APHI-217A)	(APHR-1010-1 & 7)

5. CLEANUP WATER RESISTIVITY (CI-217A) (CR-1020-1 & 4)
6. WATER SAMPLES

West _____
East _____
Alpha _____ d/m

RESISTIVITY	CATION INLET ohm-cm
	CATION EXIT ohm-cm
	ANION EXIT ohm-cm
pH	CATION INLET
	CATION EXIT
	ANION EXIT

pH: PRESS PUMP DISCH. | APHRC-1200 | APHI-1200

7. OXYGEN SYSTEM — Cyl. Pressure psi | Flow Rate %
8. PRIMARY PUMP SEAL WATER SUPPLY:

	CELL INLET PRESSURE (psi)	SEAL INLET PRESSURES 1st	2nd	3rd	SEAL FLOWS Inlet (gpm)	Outlet (gph)
PU-1A						
PU-1B						
PU-1C						
PU-1D						

9. PRESSURIZER PUMPS

	MOTOR OIL TEMP. East	West	PUMP BEARING TEMP. East	West
PU-4A				
PU-4B				

B. POOL CLEANUP SYSTEM

1. CLEANUP SYSTEM INLET TEMP. (TR-129-10) °F
2. DEMINERALIZER OUTLET WATER RESISTIVITY
   - (CI-217B) ohm-cm
   - (CR-1020-2 & 5) ohm-cm
3. CLEANUP SYSTEM FLOW RATE
   - (FI-460) gpm.
   - (FI-426) gpm.
4. WATER SAMPLES

LOCATION	Resistivity	pH
CATION INLET	ohm-cm	
CATION EXIT	ohm-cm	
ANION EXIT	ohm-cm	

C. SECONDARY COOLANT SYSTEM

1. SECONDARY WATER RADIOACTIVITY (RR-1000-4 & 18) mr./hr.
2. WATER SAMPLES
   - a. Chromate ppm
   - b. Calcium ppm
   - c. pH ppm
   - Total Hardness ppm

D. INSTRUMENT AIR SYSTEM

1. COMPRESSOR	CIA	CIB	CIC
a. Compressor Cooling Water T out °F			
b. Aftercooler Air Temperature °F			
c. Oil Pressure psi			
d. Oil Level			
e. Water Trap Condition			

2. MOISTURE CONTENT (AMI-627) ppm
3. INSTRUMENT AIR PRESSURE
   - PI-625A psi
   - PI-625B psi

E. MISCELLANEOUS

1. PLANT DEMINERALIZED WATER SYSTEM
   - a. Storage Tank Level (LI-605-2) % Full
   - b. Resistivity ohm-cm
   - c. pH
2. ILW Tank Level (LR-704) % Full
3. High Bay Radiation Monitor (RK-1001A) R/hr.
4. Off-Gas Dilution Flow Rate (FI-917) Cfm
5. H&V Room Equipment
   - a. Equipment Condition
   - b. Chilled Water Temperature °F

CLEANUP SYSTEM DIFFERENTIAL PRESSURES

PDI – 280
PDI – 281
PDI – 282
PDI – 283
PDI – 284
PDI – 285

REMARKS: _____

Example 11.5.

HFIR DAILY SUMMARY

DAY NO.	DATE	SUPERVISOR

POWER

SHIFT	HOURS OPERATED	HOURS DOWN	POWER	ACCUMULATED POWER (MwD)
12-8				PREVIOUS TOTAL:
8-4				DAY'S TOTAL:
4-12				CURRENT TOTAL:
TOTAL				

DEMINERALIZERS (Data are average)

	WEST PRIMARY			EAST PRIMARY			POOL		
	pH	RES.	c/m-ml	pH	RES.	c/m-ml	pH	RES.	c/m-ml
INLET									
CATION									
ANION									
	DAY'S THROUGHPUT: _____ GAL.			DAY'S THROUGHPUT: _____ GAL.			DAY'S THROUGHPUT: _____ GAL.		

WATER SYSTEMS

	PRIMARY COOLANT	REACTOR POOL	SECONDARY	
MAX. pH/RES.			pH	
MIN. pH/RES.			CrO_4	ppm
			CALCIUM	ppm
			c/m-ml	

Example 11.6.

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SBHE FILTERS

WEST FILTERS		CENTER FILTERS		EAST FILTERS	
Pd I	△ P (in. H_2O)	Pd I	△ P (in. H_2O)	Pd I	△ P (in. H_2O)
1		2		3	
4		5		6	
7		8		9	
10		11		12	

WEST SBHE FLOW (AV.) _____ cfm. EAST SBHE FLOW (AV.) _____ cfm.

HOG FILTERS

CHOG FILTERS		CENTER FILTERS		OHOG FILTERS	
Pd I	△ P (in. H_2O)	Pd I	△ P (in. H_2O)	Pd I	△ P (in. H_2O)
13		14		15	
16		17		18	
19		20		21	
22		23		24	

FILTER INTAKE VACUUM	FILTER EXHAUST VACUUM
CHOG	CHOG
OHOG	OHOG

Note: Filter data should be read on 4-12 shift.

Example 11.6. (continued).

LOAD TESTS FOR DIESEL-GENERATORS

DATE	SHIFT ENGINEER	ELECTRICIAN

The electrician who performs these tests is responsible for the proper completion of the form. He will initial each step of the procedure after its completion and record the appropriate data. Upon completion of the testing, he will return the completed test to the shift engineer in the reactor control room. He will also report any abnormalities to the shift engineer so that corrective action may be initiated. If any abnormality is discovered during the testing, the electrician must notify the shift engineer immediately and receive his approval before maintenance can begin.

PROCEDURE - - DIESEL - GENERATOR NO. 1	
1. Unlock the guard over the control switch and place the switch in the "Engine Test" position. Record the time required for starting. _____ seconds.	
2. After the engine is at full speed, record the output voltage and frequency. _____ volts, _____ cps	
3. Unlock the test load breaker and place it in the "Close" position. _____ (NOTE: Only one test load breaker can be closed at any time.)	
4. Place the toggle switch on the diesel test load auto switch to the "Test" position. _____	
5. Record: Output volts _____ , kw _____ , amps _____ cps _____	
6. Allow the unit to run for one hour. _____	
7. Record: Oil pressure _____ psi, Highest engine temperature _____ °F.	
8. Place the toggle switch on the diesel test load auto switch to the "Normal" position. _____	
9. Open the generator test load breaker. _____	
10. Place the engine control switch in the "Auto" position. _____	
11. Reset the fuel rack solenoid switch and confirm the clearing of the alarm with Control Room Operator.	
12. Replace the lock on the diesel control panel. _____	
13. Test run the fuel oil pump and leave the control switch in the "Auto" position. _____	
14. Inspect the fuel level in the day tank (leave it full). _____	
15. Note any misoperation of the equipment. _____	
16. Check diesel oil level. _____	

PROCEDURE - - DIESEL - GENERATOR NO. 2	
1. Record the air receiver pressure. _____ psig	
2. Unlock the cover over the control switch and place it in the "Engine Test" position. _____	
3. Record the time required for the engine to start. _____	
4. Record the air receiver pressure. _____ psig	
5. After the engine is at full speed, record the output voltage and frequency. _____ volts, _____ cps ____	
6. Unlock the test load breaker and place it in the "Close" position.	
7. Place the toggle switch on the diesel test load auto switch to the "Test" position. _____	
8. Record: Volts _____ , kw _____ , amps _____, cps _____	
9. Allow the unit to run one hour. _____	
10. Run the air compressor until the pressure is greater than 225 psig. Return the compressor control switch to "Auto". _____	
11. Record: Oil pressure _____ psig, Highest engine temperature _____ °F.	
12. Place the toggle switch on diesel test load auto switch to the "Normal" position. _____	
13. Open the generator test load breaker. _____	
14. Place the engine control switch in the "Auto" position. _____	
15. Reset the fuel rack solenoid switch and confirm the clearing of the alarm with Control Room Operator.	
16. Replace the lock on the diesel control panel. _____	
17. Test run the fuel oil pump and leave the control switch in the "Auto" position. _____	
18. Inspect the fuel level in the day tank (leave it full) _____	
19. Note any misoperation of the equipment. _____	
20. Check diesel oil level. _____	
21. Check the fuel oil level in the underground storage tank. If it is less than one-half full, make arrangements to have it refilled. _____	
22. Deliver the test form to the shift engineer. _____	

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Example 11.7.

11.2. Cyclic Report Forms

11.2.1 Startup checklist (Example 11.8.)

All tiems on this list must be checked and initialed by the responsible shift engineer prior to each reactor startup.

11.2.2 Reactor restart checklist (Example 11.9.)

11.2.3 HFIR weekly checks (Example 11.10.)

Weekly checks are performed each Saturday by the 8 to 4 shift.

11.2.4 Radiation background survey (Example 11.11.)

The areas indicated on this form should be monitored by Health Physics personnel after each reactor startup following an extended shutdown. A routine check is made by reactor operating personnel each Friday on the 8 to 4 shift.

11.2.5 Shutdown checklist (Example 11.12.)

Items on this checklist are completed and initialed after each shutdown.

HFIR STARTUP CHECK LIST

Since it is recognized that prestartup conditions may vary, strict adherence to the order in which items are performed is not necessary. Deviation, as applicable, is permissible at the discretion of the startup supervisor.

The CHECK LIST SUPPLEMENT, used by the field operator performing checks in areas other than the control room, is to be acknowledged by the startup supervisor as part of this check list.

DATE:	INITIALS
1. Pressure Vessel Work and Bay-Area Activities	
a. Target work completed and bundle reinstalled.	
b. Experiments reinstalled.	
c. Core region inspected and satisfactory.	
d. Refueling check list completed.	
e. Vacuum break valve closed.	
f. Reactor pool level normal.	
2. Preliminary Control Room Activities	
Some items may be performed during the latter part of the refueling procedures; some items are to be performed in conjunction with the field operator's activities.	
a. Standby-start features of instrument air compressors checked.	
b. Instrument air system pressure normal.	
c. Power supplied to all control room instruments at least 1/2 hr before startup.	
d. Area power supplied by "Preferred HFIR Feeder".	
e. Electrical distribution panel normal.	
f. Control service breakers in order:	
(1) Panel 1A: L-1 through L-39 ON (exclude L-7, L-22, and L-33; and L-36 through L-38.	
(2) Panel 1B: L-1 through L-24 ON (exclude L-22).	
(3) Panel 29: L-1 ON	
(4) Panel 31: L-1, 2, 9, 10, 11, and 12 ON.	
(5) Panel 32: L-1, 2, 9, 10, 11, and 12 ON.	
(6) Panel 33: L-1, 2, 9, 10, 11, and 12 ON.	
(7) Regulating rod motor breakers closed.	

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Example 11.8.

HFIR STARTUP CHECK LIST Page 2 of 6

	INITIALS
g. Process panel I normal.	
h. Pool coolant system:	
(1) Circulation established.	
(2) Flow readouts normal.	
i. Pool cleanup system:	
(1) Pool deaerator operating.	
(2) Circulation established.	
(3) Demineralizer in service.	
(4) No. EF-2 alarm.	
3. Preparation of Reactor Coolant, Cleanup and Pressurization Systems	
a. Any maintenance work performed on system components that had required DO NOT OPERATE tags understood and present status of systems satisfactory for required checks and subsequent startup of the reactor.	
b. Temperature of reactor primary coolant above 70°F.	
c. Primary inlet and exit block valves for heat exchangers and pumps to be used for this cycle open and combination selected on AUTO START switch.	
d. Cleanup-system pump to be used this cycle selected.	
e. Field information for pressurizing primary system satisfactory.	
f. Pressurize system:	
(1) PRC-127 at minimum value and in AUTO.	
(2) Key switch in UNBLOCK.	
(3) With speed controller at minimum value, the pressurizer pump to be used for this cycle energized.	
(4) PRC-127 setpoint raised to 750 psig.	
(5) RPM's increased until pressure setpoint attained.	
g. Initial operation of deaerator satisfactory.	
h. Flow readouts (258 and 216) equilibrated.	

Example 11.8. (continued).

HFIR STARTUP CHECK LIST

		INITIALS
i.	Standby-start features of pressurizer pumps checks:	
	(1) With RPM's at minimum value, second pressurizer pump energized; letdown flow increased slightly above present value; pump de-energized and placed in STANDBY.	
	(2) Operating pump de-energized; pressure maintained by STANDBY pump.	
	(3) With PU-11 in REMOTE CONTROL, the STANDBY (operating) pump de-energized and pressure maintained by PU-11.[1,2]	
j.	Pressurizer pump to be used for this cycle returned to operation; others returned to STANDBY and REMOTE CONTROL.	
k.	Key switch in NORMAL and key removed.	
l.	Operating pressurizer pump selected for Auto Process Start.	
m.	Vent valve in NORMAL.	
n.	Inlet temperature setpoints set at 120°F.	
o.	Field information satisfactory for establishing primary flow (i.e., pony-motor reliability data obtained, pipe tunnel, deaerator cell, demineralizer cell, and three heat exchanger cells leak checked and flow to pump seals normal).	
p.	Primary flow established and readouts normal.	
q.	Three pony motors in service and readouts normal.	
r.	Tower fans in AUTO.	
s.	Secondary system valves satisfactory (FCV-377 in MANUAL; FCV-377A in AUTO).	
t.	PU-14 status satisfactory (top switch in NEUTRAL; bottom in AUTO).	
u.	Battery systems normal.	
4.	Rod Drive Performance Data and Safety System Checks CAUTION: Ensure that the four control plates remain on SEAT during the performance checks of the No. 5 cylinder AND ensure that the No. 5 cylinder remains on SEAT during the performance check of the four control plates.	
a.	Computer ready for service and S-4 drawer switches in TEST.	
b.	WRCC's in AUTO and ready for service.	
	(1) FC Channel No. 1 satisfactory.	

[1]This feature checked only on cycles ending in 1, 5, and 8.
[2]Place key switch in NORMAL for test of PU-11.

Example 11.8. (continued).

HFIR STARTUP CHECK LIST

	INITIALS
(2) FC Channel No. 2 satisfactory.	
(3) FC Channel No. 3 satisfactory.	
c. No. 5 inner control cylinder raised to upper limit and returned to SEAT satisfactorily.	
d. Rod-drop data obtained and satisfactory. (Ensure that all magnet currents are 1.85 amperes before and after these tests.)	
e. S-4 drawer switches returned to NORMAL.	
f. Scram tests (raise four control rods 10" and check for proper scrams by each of Items (1), (2), and (3); check individual scrams on remainder without raising plates):	
(1) Rate trip - Channels 1 and 2, satisfactory.	
(2) Rate trip - Channels 1 and 3, satisfactory.	
(3) Rate trip - Channels 2 and 3, satisfactory.	
(4) Current trip - Channel 1, satisfactory.	
(5) Current trip - Channel 2, satisfactory.	
(6) Current trip - Channel 3, satisfactory.	
(7) High heat power - Channel 1, satisfactory.	
(8) High heat power - Channel 2, satisfactory.	
(9) High heat power - Channel 3, satisfactory.	
(10) High inlet temperature - Channel 1, satisfactory.	
(11) High inlet temperature - Channel 2, satisfactory.	
(12) High inlet temperature - Channel 3, satisfactory.	
(13) Low pressure - Channel 1, satisfactory.	
(14) Low pressure - Channel 2, satisfactory.	
(15) Low pressure - Channel 3, satisfactory.	
(16) Low flow - Channel 1, satisfactory.	
(17) Low flow - Channel 2, satisfactory.	
(18) Low flow - Channel 3, satisfactory.	
g. Any abnormalities detected during this phase of the startup procedure noted. Specify:	

Example 11.8. (continued).

HFIR STARTUP CHECK LIST

	INITIALS
6. Final Surveillance Before Startup of Reactor At this time, the startup supervisor should have possesseion of the field operator's check list; the pages are to be reviewed and signed by the supervisor prior to startup.	
a. All items on the HFIR Startup Check List Supplement satisfactory and systems ready for startup. Items needing additional checks that may be performed at a later time specified:	
b. Any special tests required prior to startup (Yes ☐ No ☐) performed. If yes, state nature of tests:	
c. Any special requests by HFIR experimenters (Yes ☐ No ☐) performed. If yes, state nature of requests:	
d. Containment system normal.	
e. FRCAS normal.	
f. Process radiation monitor readouts normal.	
g. All annunciators cleared or acknowledged.	
h. All unnecessary people cleared from control room.	
i. Public-address system normal.	
j. Startup warning given.	
k. Secondary block valves open on selected heat exchangers.	
l. Initial opening of FCV-377 made.	
7. Post-Startup Checks	
a. At 10 MW:	
(1) WRCC's responded properly.	
(2) Control and safety instruments responded properly.	
(3) Control rod position data:	
(a) No. 1: Selsyn _____; Subpile room _____	
(b) No. 2: Selsyn _____; Subpile room _____	
(c) No. 3: Selsyn _____; Subpile room _____	

Example 11.8. (continued).

HFIR STARTUP CHECK LIST

		INITIALS
	(d) No. 4: Selsyn _____; Subpile room _____	
	(e) No. 5: Selsyn _____; Subpile room _____	
(4)	Any further checks in subpile room (seal flows and leak status) satisfactory.	
(5)	Flows to primary pump seals normal.	
(6)	Oxygen addition to primary system started.	
(7)	Acid addition to tower basin started.	
(8)	Chemical addition to tower basin started, as applicable.	
(9)	Heat-power data satisfactory.	
b.	Full power checks:	
(1)	Single channel trips performed:	
	(a) Chamber add: Channels 1, 2, and 3, satisfactory.	
	(b) FFED: Channels 1, 2, and 3, satisfactory.	
	(c) Flux/flow: Channels 1, 2, and 3, satisfactory.	
(2)	All off-gas monitors normal.	
(3)	All process radiation monitors normal.	
(4)	The 200 radiation monitor normal.	
(5)	FRCAS normal.	
(6)	Temperatures equilibrated, as applicable.	
(7)	Water-level indicators normal.	
(8)	Water-makeup indicators normal.	
(9)	Heat power data satisfactory.	

Signature of Supervisor: _____

Example 11.8. (continued).

CHECKLIST FOR HFIR REACTOR RESTART

Date _____

1. The cause of the shutdown is understood. _____
2. At least two safety channels are normal. _____
3. All wide-range counting channels are responsive. _____
4. All servo demands are at 10 MW. _____
5. Primary system coolant flow is normal. _____
6. Pressurization pumps and system pressure are OK. _____
7. Secondary flow is OK; the tower bypass is closed. _____
8. Electric power supply to the area is normal. _____
9. Building containment systems are normal. _____
10. Follow the Reactor Startup Procedure (page 2-8). _____
11. Before the reactor power is raised above 10 MW, compare the meter stick readings in the subpile room with the selsyn readings. _____
12. Follow the Power Escalation After Restart Procedure (page 2-14), if applicable. _____

Time down _____ Time up _____ Time lost _____

Reason for shutdown _____

_____

_____

Remarks _____

_____

_____

Shift Supervisor _____

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HFIR WEEKLY CHECK SHEET

DATE	SHIFT	ENGINEER

1. INTERCOM SYSTEM

		Staff No.	
A. AUXILIARY CONTROL ROOM	Column C-4	4	
	Computer	24	
B. REACTOR BAY	NW Corner, Reactor Pool	5	
	North Wall	6	
	Rabbit Loading Station	7	
	SW Corner, Reactor Pool	8	
C. EXPERIMENT AREA	Column D-9	9-1	
	HRB Experiment	9-2	
	Column B-7	10-1	
	Monitor Platform	10-2	
D. 1st FLOOR WATER WING	Room 103-D	11	
	Column E-3	12	
E. BEAM ROOM	Column D-10	13	
	West Wall	14	
F. GROUND FLOOR	Water Wing (Col. E-2)	15	
	Pipe Corridor (Rm. G-5)	16	
G. Subpile Room		17	
H. Electrical Equipment Building		18-1	
I. Pony Motor Battery Room		18-2	
J. COOLING TOWER	Chem. Treat. Room	19-1	
	TOP	19-2	
K. Fan Shed		20	
L. Staff Shop (Room G-6)		21-1	
M. Counting Room		21-2	
N. Health Physics Office		22	
O. Truck Air Lock Entrance		23	

2. PUBLIC-ADDRESS SYSTEM

A. Third Floor - Control Wing		
B. SECOND FLOOR	Auxiliary Control Wing	
	Reactor Bay	
C. FIRST FLOOR	Water Wing	
	Experiment Room	
D. GROUND FLOOR	Water Wing	
	Beam Room	
E. Subpile Room		
F. Outside Area Incl. Secondary		
G. O & M Building		

3. MISCELLANEOUS

A. Underwater Lights Checked			
B. Oper. Check - C-3 Air Comp. (Do Not Load)			
C. Calcium Hardness (Process Water)			
D. Cadmium Nitrate SP.G.	At		°F
E. CONTROL PLATE DRIVE SEAL WATER COUNTS (cpm)	Composite	1	
	2	3	
	4	5	
F. REACTOR BUILDING SUPPLIES	(1) Acid, Nitric		gal
	(2) Caustic		gal
	(3) Oxygen		cyl
	(4)		
	(5)		
G. SECONDARY WATER TREATMENT SUPPLIES	(1) Acid, Sulphuric		gal
	(2) Inhibitor		gal
	(3) Biocide		drums
	(4) Chem. Anal. Supplies		
	(5) Sodium Hyperchlorite		drums
H. CATHODIC PROTECTION SYSTEM	Manhole No. 3	Amp.	Volts
	Power Pole	Amp.	Volts

I. RUNNING TIME METERS				
	PRIMARY COOLANT PUMP			
	PU-1A		PU-1B	
	PU-1C		PU-1D	
	PRESSURIZER PUMP			
	PU-4A		PU-4B	
	SECONDARY COOLANT PUMP			
	PU-6A		PU-6B	
	PU-6C			

J. Electrical KWH

K. Buffer and Standardize all Portable pH Meters

L. Steam Integrator

M. Cadmium Nitrate Tank Level

N. REMARKS:

Example 11.10.

BACKGROUND SURVEY

DATE	SHIFT	SUPERVISOR

This survey is to be performed once per week. A survey meter (G-M Counter) shall be used for this survey, with a Cutie Pie used when survey meter goes off scale.

AREA	MAXIMUM DOSE RATE (mr/hr)	PRE-SET LOCATION (mr/hr)
1. Reactor Bay:		
a. Reactor pool		
b. West clean pool		
c. East clean pool		
d. Critical pool		
e. Top of bridge		
f. Rolling work bridge		
g. Above hydraulic tube loading station		
h. Above tool storage rack		
i. Decontamination pad		
2. Heat Exchanger Cell Entrances:		
a. Cell 110		
b. Cell 111		
c. Cell 112		
d. Cell 113		
3. Water Wing (Room 103):		
a. East wall		
b. North wall		
c. South wall		
d. Pool filter compartment entrance		
e. Pool deaerator compartment		
f. Pool demineralizer cation		
g. Pool demineralizer anion		
h. Pool demineralizer filter		
i. Pool surge tank		
j. Primary head tank		

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Example 11.11.

AREA	MAXIMUM DOSE RATE (mr/hr)	PRE-SET LOCATION (mr/hr)
4. Experiment Area:		
a. Monitoring platform		
b. EF-1		
c. EF-2		
d. EF-3		
e. EF-4		
f. Near critical facility		
g. South side of pool wall		
5. Ground Floor:		
a. Staff shop		
6. Beam Room:		
a. HB-1		
b. HB-2		
c. HB-3		
d. HB-4		
e. Transmitter rack		
7. Water Wing (Room G-1):		
a. Primary cleanup pump compartment entrance		
b. East PC demineralizer compartment entrance		
c. West PC demineralizer compartment entrance		
d. Pipe corridor (Room G-5)		
e. Pool demineralizer pump compartment		
f. Pressurizer pump		
g. Water sample sink		
h. Sample counting room		
i. Wall behind pool coolant pumps		
8. Subpile Room:		
a. Near drive rod motors		
b. Wall (east)		
9. Fan Shed:		
a. FN-1 suction		
b. FN-2 suction		
c. SBHE No. 3 suction		
d. FN-3 suction		
e. FN-4 suction		
f. FN-5 suction		
g. FN-6 suction		

Example 11.11. (continued).

HFIR SHUTDOWN CHECK LIST

Preparatory Conditions: Computer (or digital timers) readied for rod-performance test and switches in S-4 instrument cabinets in TEST. Shutdown will be initiated manually from the computer (or timers) when the No. 5 cylinder reaches the withdraw limit on the servo indicator.

DATE:	INITIALS
1. Initial Control Room Activities	
a. Two of the three secondary cooling pumps de-energized.	
b. Secondary valve FCV-377 closed.	
c. The selected pressurizer pump (only) in operation and system pressure normal. (NOTE: De-energize standby pump if it came on due to pressure decrease.)	
d. Inlet temperature setpoints set at ∿90°F.	
e. Cooldown rate satisfactory.	
f. All rods showed SEAT light on initial scram.	
g. No. 5 cylinder inserted.	
h. All servo demands at N_L.	
i. Rod performance tests completed and data recorded.	
j. Magnet-drop-current tests completed and data recorded.	
k. Any special tests requiring console operation: Yes ☐ No ☐ If yes, specify:	
l. Scram handle in SCRAM position.	
m. Key switch in OFF and key returned to locked box.	
2. Field Work	
a. Hydraulic-tube samples removed to loading station.	
b. Primary acid-addition system off.	
c. Oxygen-addition system off.	
d. Blowdown valve closed.	
e. Controller 325 in MANUAL.	
f. Tower bypass valve open: Yes ☐ No ☐	
g. Secondary acid-addition system off.	
h. Other chemical-addition system off, as applicable.	

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Example 11.12.

HFIR SHUTDOWN CHECK LIST

	INITIALS
i. Chemical-addition water reduced to 10 gpm.	
j. Rod drives locked; keys returned to locked box.	
k. Subpile room leak check satisfactory.	
NOTE: Approximately 1 hr should have elapsed by this time. Inform the control room personnel that the AC primary pumps may be de-energized. Start pony motor test.	
CAUTION: Ensure that two pony motors not undergoing test remain in service. Perform leak check in between recording data.	
1. Pony-motor reliability test started (Unit _____).	
m. Leak checks performed:	
(1) Heat-exchanger-cells check satisfactory.	
(2) Primary-deaerator-cell check satisfactory.	
(3) Demineralizer-cells check satisfactory.	
(4) Pipe-tunnel check satisfactory.	
o. Any abnormalities detected during this phase of the shutdown work noted. Specify:	
p. Prior to system depressurization, cation inlet water samples obtained.	
3. Control Room Work During and Following 4-Hr Cooldown Time	
a. After ∿1 hr, and preceding the pony-motor reliability test, de-energize the three AC primary pumps. (CAUTION: Ensure that at least two pony motors are operating properly.)	
b. Core exit temperatures monitored and satisfactory. (NOTE: If not equilibrated at ∿90°F, close secondary inlet valves to heat exchangers and/or open the tower bypass valve.	
c. After 4 hrs, primary system depressurized. (Standby pump off; key in UNBLOCK; operating pump off; allow PU-11 to operate.)	
d. Controller 127 in MANUAL; setpoint adjusted to maintain constant level in deaerator.	
e. System pressure verified by instrumentation in the control room and at transmitter rack.	
f. Control room status satisfactory to allow to be unmanned (temperatures satisfactory; no overflows to waste systems).	
g. Vacuum break valve open.	

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Signature of Supervisor: _____

Example 11.12. (continued).

11.3. Data Summation

11.3.1 Weekly report (Example 11.13.)

The HFIR weekly report is completed each Monday on the 12 to 8 shift by the shift supervisor. It summarizes and averages the operating data collected during the previous week. Most of the data required are taken from the "HFIR Daily Summary." Addiditonal general information on troubles experienced, maintenance performed, and experiment changes is obtained from the supervisor's log book.

11.3.2 Quarterly report

A typical HFIR quarterly report includes

1. summary of plant operations;
2. listing and classification of all plant shutdowns;
3. list of all "unusual occurrances;"
4. tabulation of major items of plant maintenance;
5. tabulation of major items of instrumentation and control work;
6. summary of required surveillance tests and results;
7. discussion and justification of significant changes in plant design; and
8. discussion and justification of significant changes in plant operating procedures.

HFIR WEEKLY REPORT

WEEK ENDING

A. OPERATING DATA (FROM LOG BOOK)

MwD AT END OF WEEK	
MwD AT BEGINNING OF WEEK	
MwD FOR WEEK	

DATE	DAY NO.	ACC. ENERGY - MWD	HOURS OPERATED	HOURS DOWN	NO. OF SHUTDOWNS		NO. OF POWER REDUCTIONS	
					SCHEDULED	UNSCHEDULED	SCHEDULED	UNSCHEDULED
TOTAL								

B. SHUTDOWNS

DATE	DURATION (HR.)		REMARKS
	SCHEDULED	UNSCHEDULED	
TOTAL HOURS			TOTAL DOWNTIME SCHEDULED AND UNSCHEDULED HOURS

C. REACTOR CONTROLS (LIST CHANGES, MODIFICATIONS, TROUBLES, ETC.)

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Example 11.13.

D. DEMINERALIZER DATA

COLUMN	RUN NO.	DATE STARTED	DATE ENDED	TOTAL THROUGH-PUT (GALLONS)	AVERAGE c/m/ml		AVERAGE SPECIFIC RES. & pH	
					INLET	OUTLET	DEMIN. INFLUENT	DEMIN. EFFLUENT
PRIMARY COOLANT CLEANUP								
'W' CATION								
'W' ANION								
'E' CATION								
'E' ANION								
POOL COOLANT CLEANUP								
CATION								
ANION								

E. WATER SYSTEMS	**PRIMARY COOLANT**	**POOL COOLANT**
1. MAXIMUM pH AND RESISTANCE FOR WEEK		
2. AVERAGE pH AND RESISTANCE FOR WEEK		
3. MINIMUM pH AND RESISTANCE FOR WEEK		
4. AVERAGE GROSS GAMMA ACTIVITY c/m/ml		

SECONDARY SYSTEM (AV) pH _____ CALCIUM _____ CHROMATE _____

F. SBHE FILTERS

WEST FILTERS		CENTER FILTERS		EAST FILTERS	
Pd I	ΔP (in. H_2O)	Pd I	ΔP (in. H_2O)	Pd I	ΔP (in. H_2O)
1		2		3	
4		5		6	
7		8		9	
10		11		12	

WEST SBHE FLOW (AVE.)_____ cfm EAST SBHE FLOW (AVE.)_____ cfm

G. HOG FILTERS

CHOG FILTERS		CENTER FILTERS		OHOG FILTERS	
Pd I	ΔP (in. H_2O)	Pd I	ΔP (in. H_2O)	Pd I	ΔP (in H_2O)
13		14		15	
16		17		18	
19		20		21	
22		23		24	

FILTER INTAKE VACUUM	FILTER EXHAUST VACUUM
CHOG	CHOG
OHOG	OHOG

H. FACILITY CHANGES

FACILITY	DATE IN	DATE OUT	NATURE OF EXPERIMENT	SPONSOR

Example 11.13. (continued).

11.4. Change Memoranda

During the course of normal operation, it is necessary to make routine checks, tests, adjustments, and changes to equipment and/or systems to ensure smooth and reliable operation. This work is performed according to established procedures and may be done by verbal agreement between Reactor Operations personnel and the individual performing the work.

Important mechanical and instrumentation and controls design changes are documented by issuing a change memorandum. A formalized system is used in processing the change memorandum to ensure that the proposed change is reviewed and approved by the designated senior staff members. A permanent record of all change memoranda is kept in the Operations Division office. Copies of all change memoranda shall be sent to the Reactor Operations Review Committee and DOE-ORO.

11.4.1 Mechanical design change memoranda

Mechanical design changes are documented by mechanical design change memoranda (Example 11.14) which may be prepared by anyone knowledgeable of the proposed change; such memoranda are identified by number and title. Each memo states the reason for the change, briefly describes the change, and lists the new drawings and procedures and the revised drawings and procedures required. Spaces are provided for the appropriate approval signatures. Space also is provided for acknowledging completion of the drawings, procedures, and field work.

OPERATIONS DIVISION
MECHANICAL DESIGN CHANGE MEMO

1. FACILITY	CHANGE NO.
2. CHANGE MEMO PREPARED BY	DATE
3. TITLE OF CHANGE	
4. REASON FOR CHANGE	
5. BRIEF DESCRIPTION OF CHANGE (ATTACH ADDITIONAL DETAILS IF NECESSARY)	

6. DRAWINGS REQUIRING CHANGE	8. PROCEDURES REQUIRING CHANGE
7. NEW DRAWINGS REQUIRED	9. NEW PROCEDURES REQUIRED
10.	

This modification does ☐ does not ☐ involve a change in the technical specifications. If a change is involved, explain:

11. APPROVAL SIGNATURES		12. NEW DRAWINGS AND DRAWING CHANGES COMPLETED	
FACILITY SUPERVISOR	DATE	(ACKNOWLEDGED BY)	DATE
DEPARTMENT HEAD	DATE	13. NEW PROCEDURES AND PROCEDURE CHANGES COMPLETED	
		(ACKNOWLEDGED BY)	DATE
OTHER	DATE		
		14. FIELD CHANGE COMPLETED	
OPERATIONS DIVISION DIR.	DATE	(ACKNOWLEDGED BY)	DATE
15. ORNL Safety Committee Review Required ☐ No ☐		ORNL Safety Committee Review By	Date
16. DOE Review Required ☐ No ☐		DOE Review By	Date

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Example 11.14.

11.4.2 Instrumentation and controls design change memoranda

Instrumentation and control design changes are documented by instrumentation and controls change memoranda (Example 11.15). An I&C change memo is prepared by an I&C engineer knowledgeable of the proposed change. Instrumentation and controls change memoranda are identified by number and title. Each change memo states the reason for the change, briefly describes the change, and lists the new drawings and procedures and the revised drawings and procedures required. Space is provided for the appropriate approval signatures. Space also is provided for acknowledging completion of the drawings, procedures, and field work.

OPERATIONS DIVISION
INSTRUMENTATION AND CONTROLS DESIGN CHANGE MEMO

	CHANGE MEMO NO.
1. FACILITY	DESIGN REQUEST NO.
2. CHANGE MEMO PREPARED BY	DATE
3. TITLE OF CHANGE	
4. REASON FOR CHANGE	
5. GENERAL DESCRIPTION OF CHANGE	

6. DRAWINGS REQUIRING CHANGE	8. PROCEDURES REQUIRING CHANGE
7. NEW DRAWINGS REQUIRED	9. NEW PROCEDURES REQUIRED

10. This modification does ☐ does not ☐ involve a change in the technical specifications. If a change is involved, explain:

11. APPROVAL SIGNATURES		12. NEW DRAWINGS AND DRAWING CHANGES COMPLETED	
I&C REPRESENTATIVE	DATE	(ACKNOWLEDGED BY)	DATE
I & C DEPARTMENT HEAD	DATE	13. NEW PROCEDURES AND PROCEDURE CHANGES COMPLETED	
		(ACKNOWLEDGED BY)	DATE
OTHER	DATE	14. FIELD CHANGE COMPLETED	
OPERATIONS DIVISION DIR.	DATE	(ACKNOWLEDGED BY)	DATE
		(ACKNOWLEDGED BY) OPERATIONS DIVISION	DATE
15. ORNL Safety Committee Review Required ☐ Yes ☐ No		ORNL Safety Committee Review By	DATE
16. DOE Review Required ☐ Yes ☐ No		DOE Review By	DATE

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Example 11.15.

11.5. "Do Not Operate" Tags

"Do not operate" tags are used to tag out various pieces of equipment including valves, switches, instruments, etc., while they are out of service for maintenance and testing. They are not intended to replace the locks and lockout procedures used by maintenance personnel as outlined in the ORNL Safety Manual, Procedure No. 1.9.

11.5.1. Procedure

1. The shift supervisor should ensure that all necessary valves are closed, appropriate electrical circuits are de-energized, and the equipment is tagged out with "do not operate" tags.
2. The "do not operate" tags should be filled out appropriately, signed, and dated. The tear-off information sheet should be taken to the control room and placed in the box provided.
3. When the equipment is placed back in service or the valves opened, the "do not operate" tag should be removed the information sheet removed from its storage box in the control room. Both should then be discarded. No system should be placed back in service without removing the tag along with its information sheet from the control room.

12. AUXILIARY EQUIPMENT

12.1. Reactor Bay Crane

12.1.1 References

Equipment File - Northern Crane

12.1.2 Operation

A bridge crane is provided in the reactor bay to facilitate the movement of heavy components. The tracks of the bridge, which run in the east-west direction, are located at elevation 889 ft, 6 in. and run along column lines 5 and 9. East-west movement is possible between column lines B and G. The bridge of the crane spans a distance of 72 ft between column lines 5 and 9.

One of the jobs which must be performed by the crane is the removal of the main circulating pump and heat exchanger cell hatch covers, as well as the possible removal of the cell equipment. Anticipation of this job placed a very severe design requirement on the crane vendor because the center of the pump hatch in Cell 113 is only 8 ft, 11 1/4 in. from column line G. Measurements made after installation of the crane show that the center of the main hook comes to within 9 ft, 1/4 in. of column line G. Therefore, the crane hook will be misaligned by 1 in. when this pump hatch is moved. No difficulty is expected, but this misalignment should be kept in mind and more than normal caution exercised when this hatch is moved.

The bridge crane contains two hoists, designated main and auxiliary. The main hoist was designed to handle a 50-ton load at a maximum speed of approximately 12 fpm up or down. It was tested with

62.5 tons, a 25% overload, and was found acceptable. The auxiliary hoist was designed to handle a 3-ton load at a maximum speed of approximately 43 fpm up or down. It was also tested with a 25% overload (3.75 tons) and found acceptable.

The bridge of the crane moves in an east-west direction at a maximum speed of approximately 50 fpm. The trolley, which contains the hoists, moves in a north-south direction at a maximum speed of approximately 52 fpm. Great care must be exercised when either the bridge or trolley approaches the limits of its travel. A switch is provided to sound the crane horn when the north-south limit is approached. Spring-loaded wooden bumpers stop the movement of the bridge at each end of the building. Metal plates welded to the tracks stop the movement of the trolley at each end of the bridge. <u>These permanent stops should never be hit at full speed</u>.

The crane is operated from the controls mounted on a pendant. The pendant is attached to the bridge and is suspended at a convenient operating height above the reactor bay floor (851-ft level). Controls mounted on the pendant are as follows (listed from top to bottom):

Red light- Indicates the status of the main breaker supplying power to the crane. When the red light in on, the main breaker is closed and power is available to operate the crane.

Reset button- Resets the control circuits. The reset button must be pushed to activate the control circuits after (1) crane power has been interrupted or (2) control circuit power has been interrupted.

Light switch-	Controls overhead lights mounted on the crane. The crane light can be turned on and off with this switch.
Horn button-	Blows the crane horn, when pushed.
Bridge "east" button-	Moves crane bridge in the east direction.
Bridge "west" button*-	Moves crane bridge in the west direction.
Trolley "north" button*-	Moves trolley in the north direction.
Trolley "south" button*-	Moves trolley in the south direction.
Main "up" button*-	Moves main hoist up.
Auxiliary "up" button*-	Moves auxiliary hoist up.
Auxiliary "down" button*-	Moves auxiliary hoist down.
"On-off" switch-	Turns crane control-circuit power on and off.

*Multi-contact button - speed is increased as button is depressed.

The convenience and flexibility of the bridge crane make it well suited to most lifting jobs in the reactor-bay area. However, these assets sometimes lead to using the crane in potentially hazardous situations. Although each job must be individually evaluated by the supervisor, the following general rules should be observed.

1. The crane must never be attached directly to any component of the reactor vessel or reactor core. When it is necessary to use the crane to handle any such component, a chain hoist must be used between the crane hook and the component. The chain hoist is used for the initial movement of the component. This prevents the full power of the crane from being applied to the vessel or core should any sticking occur.
2. Extreme caution must be exercised when the crane is being used to move radioactive material under water. The hazard in the situation is that a crane motor contact may stick and allow the crane to withdraw the radioactive material from the water. To guard against this occurrence, a man must be stationed at the crane's main electrical breaker and be prepared to disconnect the crane's electrical power should a contact stick while radioactive material is being moved in the pools. This main electrical breaker for the crane is located in the reactor bay on the east side of column 5D.

12.1.3 Personnel responsibilities

Supervision is responsible for the overall safety of hoisting equipment under their jurisdiction. They shall ensure that all employees who operate, maintain, or inspect such equipment are properly instructed and trained in the use of safe practices.

The operator of a piece of hoisting equipment is reponsible for operating the equipment in compliance with safe operating practices and for performing safety inspections as outlined in Example 12.1.

HOISTING EQUIPMENT CHECK LIST

BLDG. No._____ Dept._____ Equip._____ Equip. No._____ Supv._____

The equipment operator shall perform the following checks daily or before the use of the equipment whichever is less frequent. *Any* deviations from the normal operation shall be reported to the responsible supervisor before proceeding.

Check the following specific items for correct operation prior to using.

a. Operate trolley mechanism in both directions.
b. Operate bridge mechanism in both directions.
c. Inspect rope for proper reeving in drum.
d. Operate hoisting and lowering mechanism. (Includes auxiliary hoist if attached).
e. Lift load till it clears floor and stop to check the hoist brake.
f. Note: The upper limit switch on the hoisting mechanism is to be checked prior to the limit switch's functional use with a load, or daily, whichever is less frequent. Check upper limit switch by operating hoist at low speed and maximum speed.

Check the following, visually, before each use:

a. Slings or cables for excessive wear, broken wires, unstranding, or severe kinking or twisting.
b. Chains for excessive wear, bent links, scars or cuts, corrosion, or elongation.
c. Hooks for any deformation.

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Example 12.1.

12.1.4 Personnel requirements

1. A supervisor who is responsible for the overall safety of the operation.
2. An operator who is responsible for the routine operation and inspection of the equipment.
3. Inspection Engineering personnel who are responsible for conducting periodic inspections and tests of the equipment.

12.1.5 Routine checks

1. The overhead crane shall be tested as outlined on the Hoisting Equipment Checklist (Examples 12.1. and 12.2).

SIGN-OFF

Initial daily sign-off to indicate appropriate checks were made prior to use.

INSPECTION/TESTING OF HOISTING EQUIP.

Area_____ Equip._____ Resp. Supv._____

	July Jan.	Aug. Feb.	Sept. March	Oct. April	Nov. May	Dec. June
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

Example 12.2.

12.2. Freight Elevator

12.2.1 References

Equipment File - Dover Elevator

12.2.2 Operation

A freight elevator is provided to facilitate transfer of material between floors in the Reactor Building. It is located on the west side of the building just north of column line 5. Landings are located on the ground, first, second, and third floors.

The freight elevator is hydraulically powered and has a capacity of 10,000 lbs. It has a speed of 75 fpm in the up direction and either 60 or 100 fpm in the down direction, depending on whether it is empty or loaded. A 40-hp motor and pump, located on the ground floor, supply oil to the hydraulic cylinder.

A "call" pushbutton is located at each landing as well as an "in use" light and a "door closing" light. The "call" pushbutton summons the elevator, if it is not is use. The doors open automatically when the car reaches the landing from which the call originated. Pushbuttons within the car are marked "G - 1 - 2 - 3" to designate the various floors.

12.3. Reactor Bay Air Locks

12.3.1 References

Drawings:

1546-01-A-1004 Reactor Building Second Floor Plan

12.3.2 Introduction

The reactor bay is equipped with two personnel air locks - one leading to the roof on the southwest corner of the building; the other leading to the hallway between the reactor bay and the control wing. A truck air lock is located at the northeast end of the reactor bay. Two other doors penetrate the reactor bay enclosure on the north side. These two doors lead into the hallway between the reactor bay and the control wing.

12.3.3 Precautions

There is no ventilation in the truck air lock when both vehicle doors are closed. It is, therefore, important that no internal combustion engines be operated when both these doors are closed. The outside air lock door is normally locked. It is the responsibility of the person unlocking this door to admit a vehicle to inform the driver of the vehicle not to operate the engine when both air lock doors are closed.

12.3.4 Operation

To assure maximum containment of the reactor bay the following regulations and design features are provided:

1. Truck air lock

   An interlock between the inside and outside truck air lock doors prevents the opening of both doors at the same time. One door must be completely closed before the other

can be opened. An interlock override allows the opening of both doors simultaneously. The interlock override control switch is located inside a normally locked box at the west end of the air lock. The key which allows access to the control switch is kept in the main control room inside a special key cabinet. Access to the key is controlled by the shift supervisor. The interlock override must not be used during reactor operation or when freshly irradiated fuel elements are being moved.

2. Personnel air locks

   Under normal circumstances, personnel entering the reactor bay must enter and leave through the personnel air lock. An alternate entrance is through the air lock at the southwest corner of the reactor bay from the roof. This access, which should seldom be used, is provided primarily as an emergency exit.

3. Other entrances

   The two remaining doors, on the north side of the reactor bay, are locked during reactor operation and should not be used while the reactor is in operation. They can be opened during emergencies, however, from inside the reactor bay.

13. TECHNICAL SPECIFICATIONS REQUIREMENT

Adoption of the HFIR Technical Specifications requires additional surveillance with auditable records of many operating parameters. This chapter lists the safety limits and limiting safety system settings as well as the limiting conditions for operation. Procedures used to maintain surveillance necessary to prevent violation of the specifications are listed or referenced.

13.1. Safety Limits

During steady-state operation and slow transients, neither the ratio of reset neutron flux-to-flow nor reactor power shall exceed the values shown in Table 13.1. The reactor shall be shut down: (1) prior to exceeding an inlet temperature of 140°F; and (2) prior to the time the flow rate decreases below 1,350 gpm.

Table 13.1. Safety limits on process variables

Process Variable	Safety limits		
	Mode 1	Mode 2	Mode 3
Reset neutron flux (power) to flow ratio[1]	1.37 (@ 16,000 gpm) 2.40 (@ 1,500 gpm)	None	None
Neutron power	None	4 MW	175 kW
Inlet coolant temperature	140°F	140°F	None
Coolant pressure[2,3]	550 psig	None	None
Coolant flow[2]	1,350 gpm	1,350 gpm	None

[1]"Flux-to-flow" ratio is the ratio of percent nominal full power (100 MW) to percent nominal full flow (16,000 gpm).

[2]Minimum values.

[3]At the location of PS-128A, B, and C.

13.2. Limiting Safety System Settings

Scram and other corrective action setpoints for the process variables, reactor power, coolant flow and temperature, and system pressure shall be set at values at least as conservative as specified in Table 13.2.

Table 13.2. Limiting safety system settings for process variables

Process Variable	Limiting safety system settings		
	Mode 1	Mode 2	Mode 3
Reset neutron flux (power) to flow ratio[1]	1.3 (all flow rates)	None	None
Neutron power	None	3.25 MW	130 kW
Inlet coolant temperature	135°F	135°F	135°F
Coolant pressure[2,3]	575 psig	None	None
Coolant flow[2]	1,500 gpm	1,500 gpm	None
Rate of rise of power	20 MW/s	None	None
Main pump cutoff	315 psig	N/A	N/A
FFED	1000% full power background	1000% full power background	

[1]"Flux-to-flow" ratio is the ratio of percent nominal full power (100 MW) to percent nominal full flow (16,000 gpm).

[2]Minimum values.

[3]At the location of PS-128A, B, and C.

13.3. Limiting Conditions for Operation

13.3.1 System reactivity

The reactor shall not be operated unless the system reactivity is limited such that the reactor can be maintained in a subcritical condition even when any two of the following independent events occur simultaneously:

1. Occurrence of an optimum void in the flux trap region.
2. Removal of the target.
3. Complete withdrawal of any one control element.
4. Failure to scram of one shim-safety plate.
5. Occurrence of a startup accident.

Surveillance. Shutdown capability shall be checked for the Case IV configuration (a combination of 3 and 4) by demonstrating that the reactor is just critical in a configuation known to be more reactive than the Case IV configuration:

1. Prior to continued operation, for an anticipated or achieved start-of-cycle symmetric critical rod position of less than 16.3 in.; and/or
2. When the water immersed shutdown margin of the fuel element is less than $1.15.

A reactivity measurement shall be made on every new HFIR fuel element in which the shutdown margin in the water-immersed condition is measured.

The start-of-cycle symmetric critical rod position will be predicted within $\pm$ 0.5 in. for each fuel cycle using a new fuel element. This requirement will not apply to infrequent fuel cycles using partially burned fuel elements. Failure to predict the start-of-cycle

symmetric critical rod position to within ± 0.5 in. will not constitute a violation of the technical specifications but will impose a further requirement that the situation be evaluated in order to continue operation of the reactor.

Case IV Shutdown Margin Procedure

1. Complete Mode 3 startup checks with a new fuel element in the reactor.
2. Station an operator at the control plate drive transformer electrical breaker in the electrical equipment room. Establish two-way communications.
3. Make the reactor critical at approximately 100 kW with the control plates at a symmetric position.

   Symmetric Control Plate Position _____

4. Inhibit the No. 5 cylinder at the symmetric critical position.
5. Drop control plates 2, 3, and 4 to their seats by scramming them. Hold No. 1 plate at the symmetric critical position.
6. Withdraw control rods 1, 2, 3, and 4 as a group until No. 1 is at the withdraw limit and the reactor is again critical at approximately 100 kW with rods 2, 3, and 4 at the same position. If there is any indication of a rod runaway during this step, notify the man at the control plate drive electrical transformer breaker to open the breaker and the operator at the console should insert all rods with the air motors.

   Position of Control Plates 2, 3, and 4 _____

7. Insert all rods to their seats.

13.3.2 Control system

The reactor shall not be operated unless the positive reactivity available to the control system is limited to the following values:

1. The amount of positive reactivity that the servo system is permitted to control is limited to 0.015 $\Delta k/k$.
2. The maximum rate of reactivity addition by the servo system (regulating motor only) is limited to 0.00375 $\Delta k/k\ s^{-1}$.
3. The maximum reactivity addition rate of all five shim elements is limited to 0.003 $\Delta k/k\ s^{-1}$.

Surveillance. The speeds of the shim and regulating drive motors will be measured at least annually.

Shim drive speed measurement procedure. During startup check completion, measure each of five shim drive speeds in the withdraw direction as follows:

1. Use a stop watch and the shim drive position indicators to measure their travel during a 1 min period of time.
   a. No. 1: _____ in./min.
   b. No. 2: _____ in./min.
   c. No. 3: _____ in./min.
   d. No. 4: _____ in./min.
   e. No. 5: _____ in./min.

13.3.3 Shim-safety plates

The reactor shall not be operated if the maximum time-of-flight for any shim-safety plate exceeds 450 ms or if the maximum magnet release time using three-out-of-three channel trip tests exceeds 12.0 ms.

Surveillance

1. Shim-safety plate time-of-flight (from the fully withdrawn position to seating of the plate) must be measured prior to startup following each refueling of the reactor and following any shim-safety plate maintenance which might affect the time-of-flight.
2. Magnet release time must be measured prior to startup for each fuel cycle and following any shim-safety plate maintenance which might affect the magnet release time. The test prior to the startup for each fuel cycle may be conducted either before or after refueling the reactor.

Procedure. See Section 3.1.3.

13.3.4 Reactor control and safety systems

The minimum complement of reactor safety and measuring instrumentation required for a reactor startup in the various modes of operation is specified in Table 13.3.

The minimum complement of reactor safety and measuring instrumentation required for reactor operation in the various modes is specified in Table 13.4.

Table 13.3. Minimum reactor instrumentation required for startup

Description	Number Required		
	Mode 1	Mode 2	Mode 3
Safety Instrumentation			
Neutron flux channel	2	2	2
Primary coolant flow channel	2	2	0
Heat power channel	2	0	0
Reactor inlet temperature channel	2	2	0
Primary coolant pressure channel	2	0	0
Failed-fuel-element detector channel	2	2	0
Power rate-of-rise channel	2	0	0
Main pump cut-off	2	0	0
Measuring Instrumentation			
Counting rate channel	2	2	2
Servo channel	2	0	0
Reactor bay containment flow monitor	1	1	1
Closed off-gas system vacuum monitor	1	0	0
Instrument air system pressure monitor	1	1	1

Table 13.4. Minimum reactor instrumentation required for operation

Description	Number Required		
	Mode 1	Mode 2	Mode 3
Safety Instrumentation			
Neutron flux channel	2	2	2
Primary coolant flow channel	2	2	0
Heat power channel	2	0	0
Reactor inlet temperature channel	2	2	0
Primary coolant pressure channel	2	0	0
Failed-fuel-element detector channel	2	2	0
Power rate-of-rise channel	2	0	0
Main pump cut-off	2	0	0
Measuring Instrumentation			
Counting rate channel	0	2	2
Servo channel	0	0	0
Reactor bay containment flow monitor	1	1	1
Closed off-gas system vacuum monitor	1	0	0
Instrument air system pressure monitor	1	1	1

Surveillance

1. Safety system tests shall be required:
   a. Prior to each startup following refueling (except for the "chamber add," "flux-to-flow," and "FFED" tests which cannot be made until the reactor is at power).
   b. Immediately after any change or maintenance involving any component of the safety system.
   c. During operation, once per week.
2. Each safety channel shall be calibrated at least annually.
3. The count rate channels shall be under continuous electronic surveillance during operating modes where operability of these channels is required. These channels shall be calibrated annually.
4. Continuous surveillance of the servo channels is maintained by interlocks which require that all three servo channels be operable in order to obtain "start" in Mode 1 operation. These channels shall be calibrated annually.
5. A channel check of the reactor bay containment flow monitor shall be made at least once per shift during reactor operation.
6. A channel check of the closed off-gas system vacuum monitor shall be made at least once per shift during reactor operation in Mode 1.
7. A channel check of the instrument air system pressure monitor shall be made daily during reactor operation.

13.3.5 Special building hot exhaust (SBHE) filter efficiency

The minimum efficiency for the filter system which filters the HFIR effluent shall be 99.5% for particles larger than 0.3 μ and 99% for elemental iodine.

Surveillance. The efficiency of the filters shall be measured by Quality Assurance and Inspection Department personnel at least semiannually and after any filter replacement before use of the replaced filter.

Procedure. See ORNL Quality Assurance Manual, Section 16.

13.3.6 Containment

The following containment system requirements are necessary for reactor operation in Modes 1, 2, and 3 and during in-pool handling of irradiated fuel elements:

1. In-leakage into the reactor bay will be maintained during normal operation by means of the SBHE system consisting of fans, ducts, filters, and the 250-ft-high stack.
2. The minimum exhaust rate from the reactor bay shall be sufficient to maintain in-leakage through all building openings but shall not be less than 6,000 cfm.
3. There must be at least one operating SBHE fan and at least one standby SBHE fan.
4. Emergency power from a start-on-demand diesel-electric generator must be available to the fans.
5. The minimum number of operable letdown block valves shall be one for each of the three heat exchangers in operation. (This applies to Mode 1 operation only.)

Surveillance

1. Operation of the automatic block valves in the primary system pressure letdown lines shall be given a functional test at least annually.
2. Reactor bay in-leakage shall be measured at least annually.
3. Checks shall be made at least daily to ensure that at least one SBHE fan is in operation and one is in standby. Low flow alarms indicate any failure of the operating fan.
4. Checks shall be made at least daily to ensure that one start-on-demand diesel generator is available for use.

Procedure

1. See Example 11.3.
2. Radiation Block Valve Test

   A test of the radiation block valves is run to ensure adequate leak tightness of the primary system under emergency conditions. This test is run as follows:

   a. Pressurize primary system to 750 psig in Mode 1 with one of the main pressurizer pumps.
   b. Open inlet and exit block valves on all heat-exchanger cells and establish a letdown flow of 150 gpm.
   c. Turn switch of the emergency pressurizer pump PU-11 to the "off" position. All main circulating pumps and pony motors should be turned off.
   d. Manually trip two FFED modules.
   e. Turn off the operating pressurizer pump.
   f. Observe the primary system pressure. It should remain >600 psig for at least 1 min.

3. Building In-Leakage Measurement

The reactor must be shutdown and there must be no fuel movements being made during the completion of this procedure.

a. Close all doors leading into the reactor bay and the primary heat-exchanger cells.

b. Throttle the SBHE filter outlet damper in the reactor bay branch slowly and obtain the minimum flow rate through this branch while maintaining a reactor bay ΔP reading of 0.1 in. H_2O.

ΔP

Local Manometer _____ in. H_2O

Control Room _____ in. H_2O

Reactor Bay SBHE Flow

Control Room _____ in. H_2O

Fan Shed _____ in. H_2O

13.3.7 Primary coolant system

The following conditions are limits on the operation of the primary coolant system:

1. Maximum allowable operating pressure: 1,000 psig

2. Minimum number of operable pressure relief valves:

No. of valves	Spring setting (psig)	Relief pressure (psig)	Minimum capacity (gpm)
1	1,025	1,100	250
1	975	1,050	30

3. Maximum vessel bulk outlet water temperature: 200°F
4. Maximum differential pressure across reactor vessel: 150 psi
5. Minimum water temperature with system pressurized: 70°F

Surveillance

1. Pressure safety valves shall be tested annually by the Quality Assurance and Inspection Department.
2. Bulk outlet water temperature shall be under continuous surveillance by at least one instrument channel.
3. Bulk inlet water temperature shall be under continuous electronic surveillance.

Procedures

1. See Section 2.4.5.
2. See Section 2.4.6.

13.3.8 Limitations on experiments

Surveillance

1. The Technical Assistance Group of the Operations Division shall review and examine all experiments proposed for insertion into the reactor for safety, potential hazards, and compatability with the operation of the reactor and other experiments.
2. New or unusual experiments shall be submitted with recommendations of the Technical Assistance Group to the Reactor Experiment Committee (RERC) for review in accordance with the provisions of Section 6.11 of the HFIR Technical Specifications.
3. Tried experiments may be approved by the Technical Assistance Group without further review by the RERC.

13.3.9 Emergency core cooling

At least two battery-powered pony motor pumps must be in service at all times during reactor operation in Mode 1. Each must be capable of pumping 1,000 gpm for at least 2 h.

Surveillance. Each pony motor battery bank shall be checked at least semiannually by load testing and monitoring the battery voltage as a function of time.

Procedure. See Section 8.1.2.

13.3.10 Emergency shutdown system

A backup shutdown system using cadmium nitrate will be operable any time the reactor is operating at power levels above 10 MW.

1. Operating procedures governing recovery from power reductions shall be such that the power level will not exceed 130 MW as a result of xenon burnout if the control rods become immobilized during the recovery. The procedures shall be based on normal Mode 1 operating conditions.
2. Operating procedures covering recovery from power reductions shall allow the operator a minimum of 1 1/2 min from the time the power level exceeds the desired power level by 2% for investigation of the reason and, if necessary, actuation of the control valves for the poison injection system. This time allowance is in addition to that required for the backup system to operate.
3. The quantity of cadmium available for injecting into the primary system shall be at least 276 lbs.

Surveillance. A functional test of all valves and controls in the emergency shutdown system will be performed at least annually.

The specific gravity, temperature, and tank level of the cadmium nitrate solution will be checked at least monthly to determine the poison amount available for emergency shutdown.

Procedure. See Section 8.6.6.

13.3.11 Water height above core

The following minimum heights of water shall be maintained above the core centerline in the various modes of operation:

Mode 1	25-ft
Mode 2	25-ft
Mode 3	10-ft

Surveillance. Surveillance of the pool water level shall be made at each reactor startup using the Startup Checklist.

Surveillance of the pool water level shall be made daily during reactor operation (see Example 11.3., Shift Check Sheet).

13.3.12 Installation of target or its equivalent in the flux trap

The reactor shall not be operated unless the target or its equivalent is installed in the flux trap.

Surveillance. A visual core inspection to verify the installation of the target or its equivalent shall be made prior to each startup subsequent to a shutdown in which the target is removed (see Example 11.8., Startup Checklist).

13.3.13 Radiation monitoring equipment

The reactor shall not be operated unless the following minimum requirements for operable area radiation monitors are met or backup measures suitable to the reactor supervisor or his designated alternate are provided:

1. At least one operable constant air monitor shall be

located on each of the three lower floors of the reactor building.

2. At least one operable monitron shall be located on each of the three lower floors of the reactor building.
3. The above mentioned equipment shall provide remote indication in the reactor control room.

Surveillance. There are two monitrons and two CAMs located on each of the three lower floors. In the event of failure of both monitrons or both CAMs on the same floor, the reactor must be shut down or alternate equipment provided.

The reactor must also be shut down or alternate equipment provided in the event of failure of the control room monitoring system.

13.3.14 Core components

The reactor shall not be operated with known structurally unsafe reactor components.

Surveillance. Reactor components and reactor vessel top head studs shall be inpsected for physical deformation, mechanical wear, or radiation damage at least annually.

13.3.15 Emergency power

1. The reactor shall not be operated unless at least one emergency diesel generator is operable.
2. The reactor shall not be operated unless the switchgear battery bank is operable.

Surveillance

1. Each of the two standby diesel generators shall be started and operated for a minimum of 30 min under 30% of nominal full load at least monthly. A checklist of diesel test performance shall be recorded and filed.

2. Should one of the two standby diesel generators become inoperable, the operable diesel generator shall be tested as specified above at least weekly.
3. The normal-emergency system test, which provides a load test on the diesel generators, shall be performed at least annually.
4. During reactor operation, the status of the switchgear battery system shall be checked each day (see Example 11.3).
5. The switchgear battery bank shall be load tested annually.

Procedure

1. See Example 11.7 for the diesel generator load test procedure.
2. See Section 8.1.1 for the normal-emergency system test procedure.
3. Switchgear Battery Load Test Procedure
   a. The test has two parts:
      (1) 110 A for 5-s test, followed by
      (2) 6 A for 2-hr test

      NOTE: Do not discharge batteries below 1.14 V per cell (1.14 V x 92 = 104.88 V).
   b. Test equipment required:
      (1) Resistive load for 110-A, 5-s test (R = E/I = 125/110 = 1.14 ohm)
      (2) dc ammeter 0-150 A (calibrated)
      (3) Resistive load for 6-A, 2-h test (R = E/I = 125/6 = 20.83 ohm with provision to decrease

resistance in order to maintain 6-A test load)

(4) Calibrated - dc ammeter 0-25 A

(5) Calibrated - dc voltmeter 0-150 V

c. Notify and obtain permission from HFIR shift supervisor to perform test.

d. Calibrate charger ammeter and voltmeter (using calibrated "standard" instruments).

e. Test procedure for 110-A, 5-s test:

(1) Disable start sequence of diesel-generator No. 2

(a) Shut off air valve from receiver

(b) "Bleed" air line between receiver and air start motors

(c) Place diesel-generator No. 2 selector switch in stop position

(2) Disconnect charger and isolate batter

(a) Turn off ac supply breaker

(b) Turn off dc breaker

(c) Remove (+) and (-) battery cables

(d) Record battery voltage _____

(3) Connect 1.14 ohm (approximate) load through a breaker to the battery terminals

(4) Close load breaker for 5 s

(5) Record

(a) The initial voltage drop _____

(b) Voltage recovery under load _____

(c) Load amps _____

(6) Remove load and record recovery voltage _____

This completes the 110-A, 5-s test.

f. Test procedure for 6-A, 2-h test:

(1) Connect 6-A resistive load [approximately 21 ohms, see b (3) above] through a breaker and in series with a 0-25 dc ammeter

(2) Close the load breaker

(3) Record volts and amps at 15-min intervals

NOTES:

(a) Discontinue test if voltage drops below 105 V

(b) Adjust resistance to maintain 6-A load

Minutes	Amps	Volts
0		
15		
30		
45		
60		
75		
90		
105		
120		

(4) Open load breaker and record recovery volts _____

(5) Disconnect test load

g. Place battery and charger back in normal service:

(1) Reconnect battery to charger

(2) Close charger ac and dc breakers

(3) Charge battery at "equalize rate" (1.55 V per cell)

Example: 1.55 V per cell x 92 cells = 142.60 V

(4) Adjust automatic timer for 8-h period and adjust equalize voltage to 142.6 V

(5) Record charge volts and amps

Hours	Amps	Volts
0		
1		
2		
3		
4		
5		
6		
7		
8		

h. Restore all emergency equipment to operating condition:

(1) Diesel selector switch in "automatic" position

(2) Open receiver air valve

(3) Check both diesel rooms - equipment

(4) Check switchgear battery room - equipment

(5) Check control and indicating lights on NE No. 1 and NE No. 2 switchgear

(6) Check indicating lights in control room

i. Notify HFIR shift supervisor that test is completed.

j. Comments - visual and test observations.