ORNL/TM-506/R1&P2

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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Operating Manual for the Oak Ridge Research Reactor

Part 2

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/TM-506/R1&P2

Operations Division
Reactor Operations Section

OPERATING MANUAL FOR THE OAK RIDGE RESEARCH REACTOR

Part 2

Compiled by

Oak Ridge Research 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.

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5. ORR WATER COOLING SYSTEM

5.1. Introduction

There are two distinct, yet integrated, parts of the ORR cooling system. The first, the reactor cooling system, Fig. 5.1, consists of the reactor tank and all of the auxiliary equipment required to circulate the cooling water and maintain it in good condition. The second, the pool system, Fig. 5.2, consists of three large pools and all of the auxiliary equipment required to cool the water in the pools and to keep it in good condition.

In the first system, the heat generated in the reactor is eventually dissipated to the atmosphere. Reactor cooling water which flows through the core removes heat from the fuel elements and undergoes a temperature rise. A temperature drop of approximately the same magnitude occurs when the primary water flows through the heat exchangers and transfers its heat load to the reactor secondary cooling system. The secondary system then dissipates the heat to the atmosphere by evaporating water in a cooling tower.

Reference

Dwg. C-24645

5.1.1. Water Pressure Limits for the Reactor and Experiment Facilities

The ORR reactor vessel and associated experiment facilities which penetrate the reactor vessel are subjected to a variety of water pressures during normal operation and during the shut-down period. Particularly during the shut-down period when a multitude of activities are in progress, administrative control is the only means to ensure that design pressures are not exceeded. It is, therefore, imperative that exact procedures be followed in establishing water-flow conditions to ensure that pressures do not exceed the maximum allowable.

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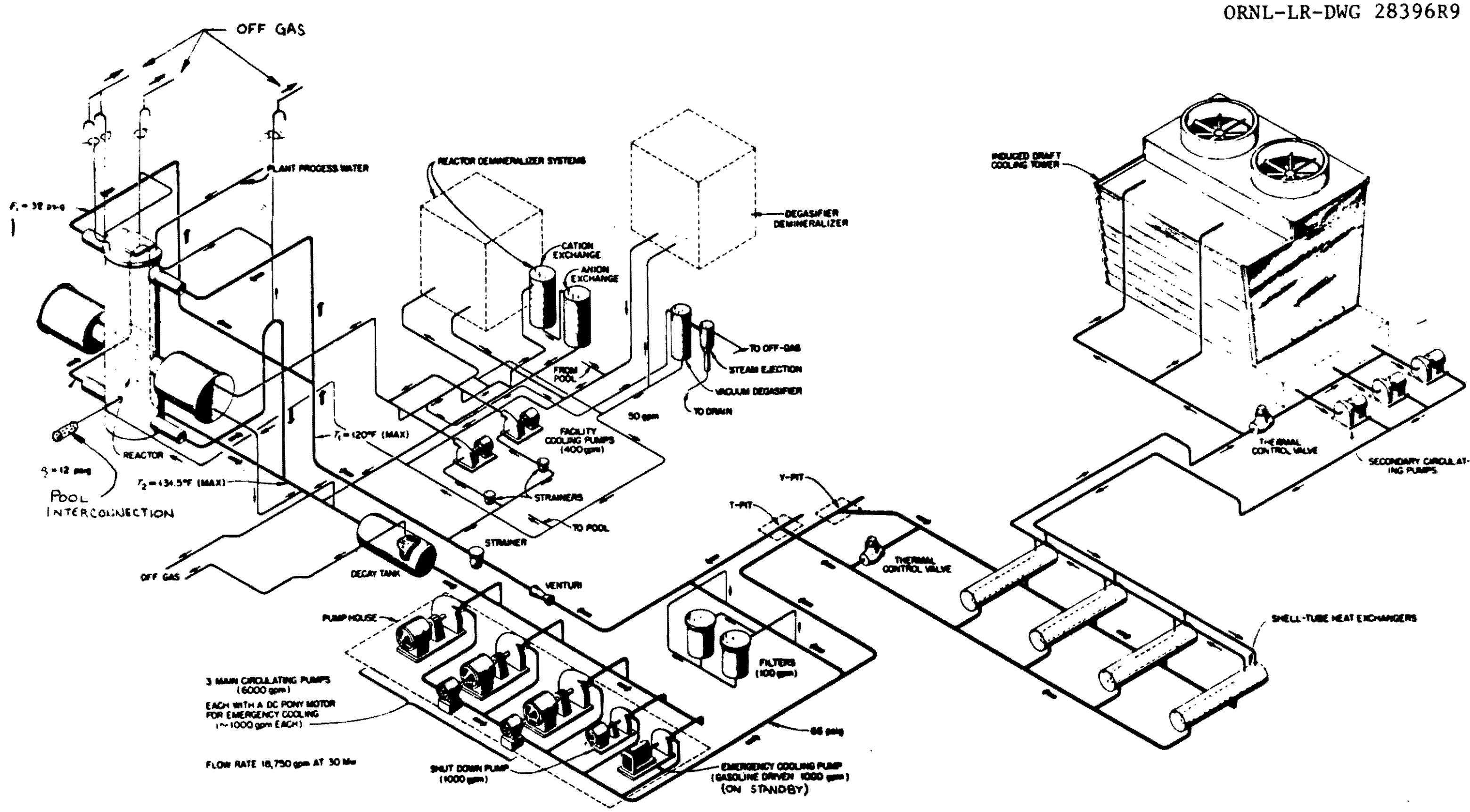


Fig. 5.1. Reactor cooling system.

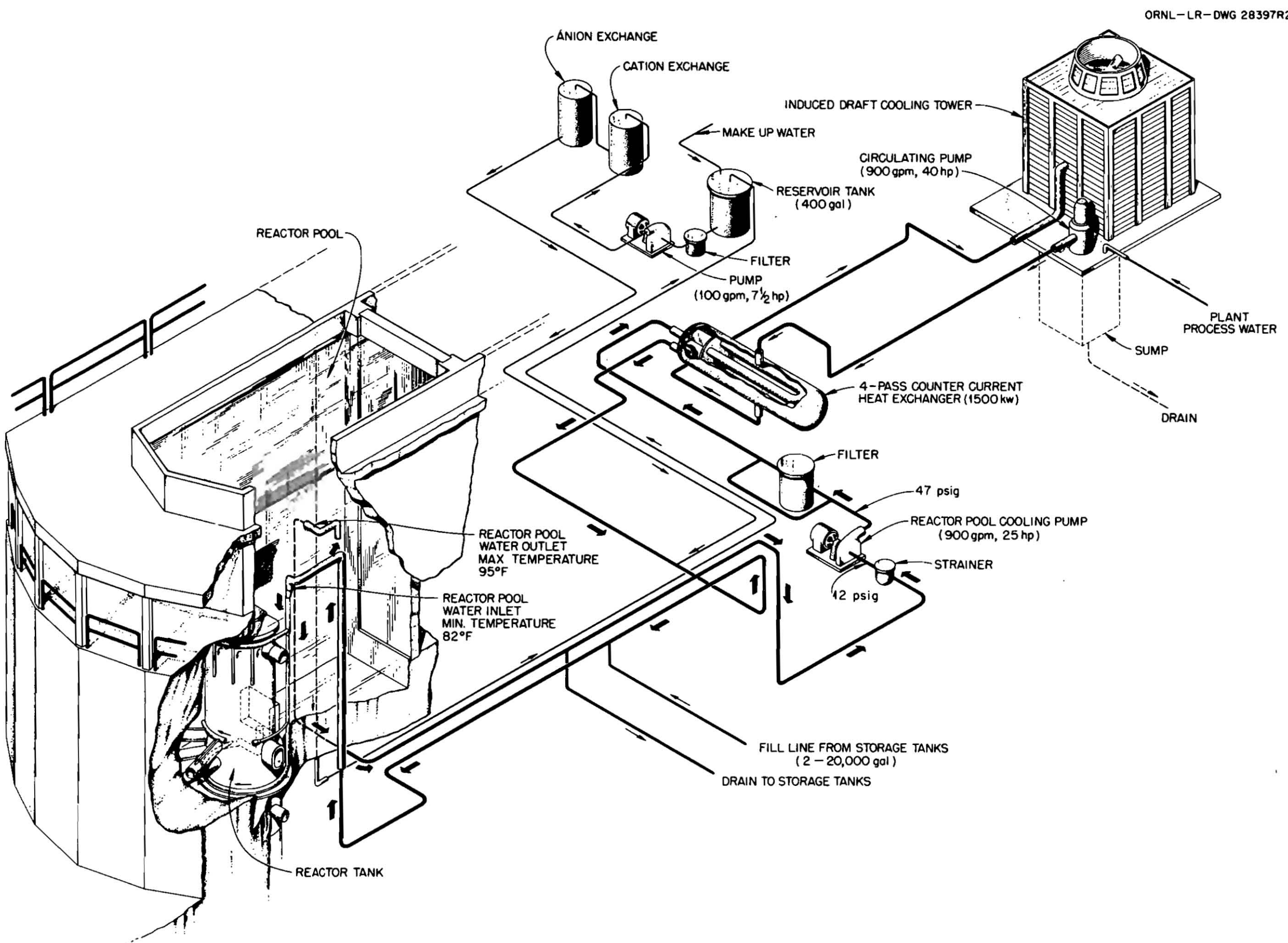
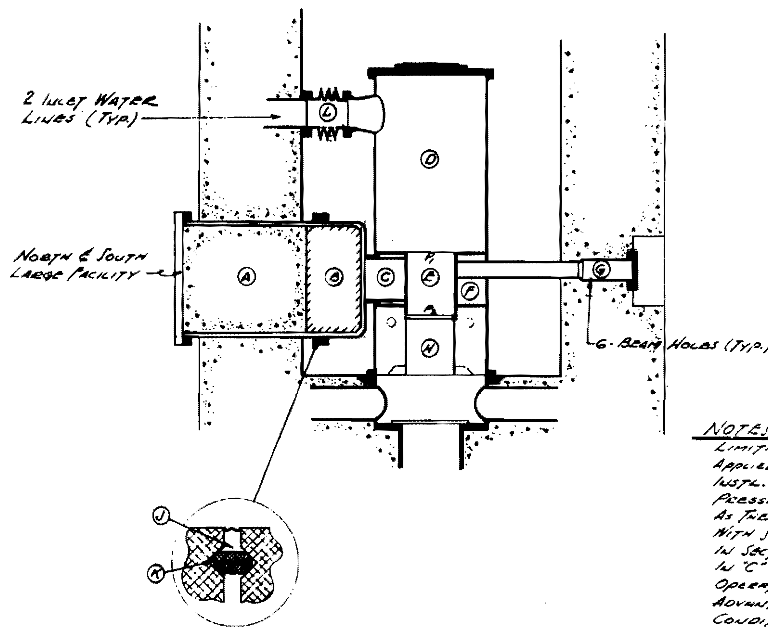


Fig. 5.2. Reactor pool cooling system.

The reactor vessel and related facilities were designed, fabricated, and hydraulically tested to meet conditions as listed in Fig. 5.3. Normal practices in the operation of the systems should comply with the operational limits as specified in Fig. 5.3.



PARTS LIST

PART NO.	DWG. NO.	NO. REQD	DESCRIPTION (NAME, SIZE, ETC.)	MATERIAL

TABLE OF PRESSURES

LETTER	LOCATION	DESIGN	HYD. TEST	OPER. LIMITS
A	LARGE FACILITY PLUG, COLL. SECT.	30	45	30
B	LARGE FAC. PLUG PEBBLE ZONE	30	45	30
C	LARGE FAC. COMPARTMENT	30	35	25
D	UPPER TANK SECTION	40	60	40
E	TANK LATTICE SECTION	*28	38	*25
F	TANK D_2O COMPARTMENT	—	20	14
G	BEAM HOLE TUBES	30	45	30
H	LOWER TANK SECTION	—	38	25
J	DISHED HEAD SEAL RING	—	20	15
K	DISHED HEAD "O" RING	30	150	100
L	INLET WATER LINES	60	60	40

* AVERAGE $\left(\frac{P_1+P_2}{2}\right)$

ALL PRESSURES IN POUNDS PER SQUARE INCH GAGE

NOTES:-

LIMITING OPERATING PRESSURES HAVE BEEN SET AT 2/3 OF THE HYDROSTATIC TEST APPLIED INDEPENDENTLY ON EACH COMPARTMENT DURING THE FABRICATION OR INSTL. (ADJ. OR SURROUNDING COMPARTMENTS REMAINED AT ATMOSPHERIC PRESSURE) HIGHER OPER. PRESSURES CAN IN MOST CASES BE TOLERATED, AS LONG AS THE DIFFERENTIAL PRESSURE ON MEMBERS IS NOT EXCEEDED. FOR EXAMPLE:- WITH SECT. "C" OPERATING AT 25 PSI. A PRESSURE OF 40 PSI. COULD BE TOLERATED IN SECT. "J", ALTHOUGH DAMAGE WOULD OCCUR TO THE SEAL IF THE PRESSURE IN "C" IS INADVERTENTLY REDUCED. CONSIDERATION SHOULD BE GIVEN TO THE OPERATING LIMITATIONS PRIOR TO TAKING ADVANTAGE OF THESE CONSERVATIVE CONDITIONS.

GENERAL SPECIFICATIONS:

1. Break all sharp edges 1/64 max., unless otherwise specified.
2. The fabricator may choose the type, grade or finish of material unless otherwise specified.

MACHINE FINISH SPECIFICATIONS:

1. Finish symbols are in accordance with ASA Standard B46.1 - 1947.
2. Roughness height values are the maximum arithmetical average deviation from the mean surface, expressed in microinches.
3. For surfaces not otherwise indicated, roughness height shall not exceed √.

THIS DRAWING CLASSIFIED AS NOT CLASSIFIED

LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED
FRACTIONS: ±
DECIMALS: ±
ANGLES: ±
SCALE: NONE

LTR	REVISIONS	DATE	APPD	APPD

DRAWING NO. C-

DRAWN H.L. WATTS, DATE 4/7/58 — DESIGNED, DATE, CHECKED, SUBMITTED, APPROVED, DATE

REFERENCE DRAWINGS | DWG. NO.

ORNL RESEARCH REACTOR — BLDG. NO. 3042
REACTOR & EXP. FACILITIES DESIGN, TEST & OPERATIONAL LIMITS

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
OAK RIDGE, TENNESSEE

SUBMITTED — ACCEPTED — APPROVED

C-24645

Fig. 5.3. Reactor and experiment facilities operational limits.

5.2 Reactor Primary System

References

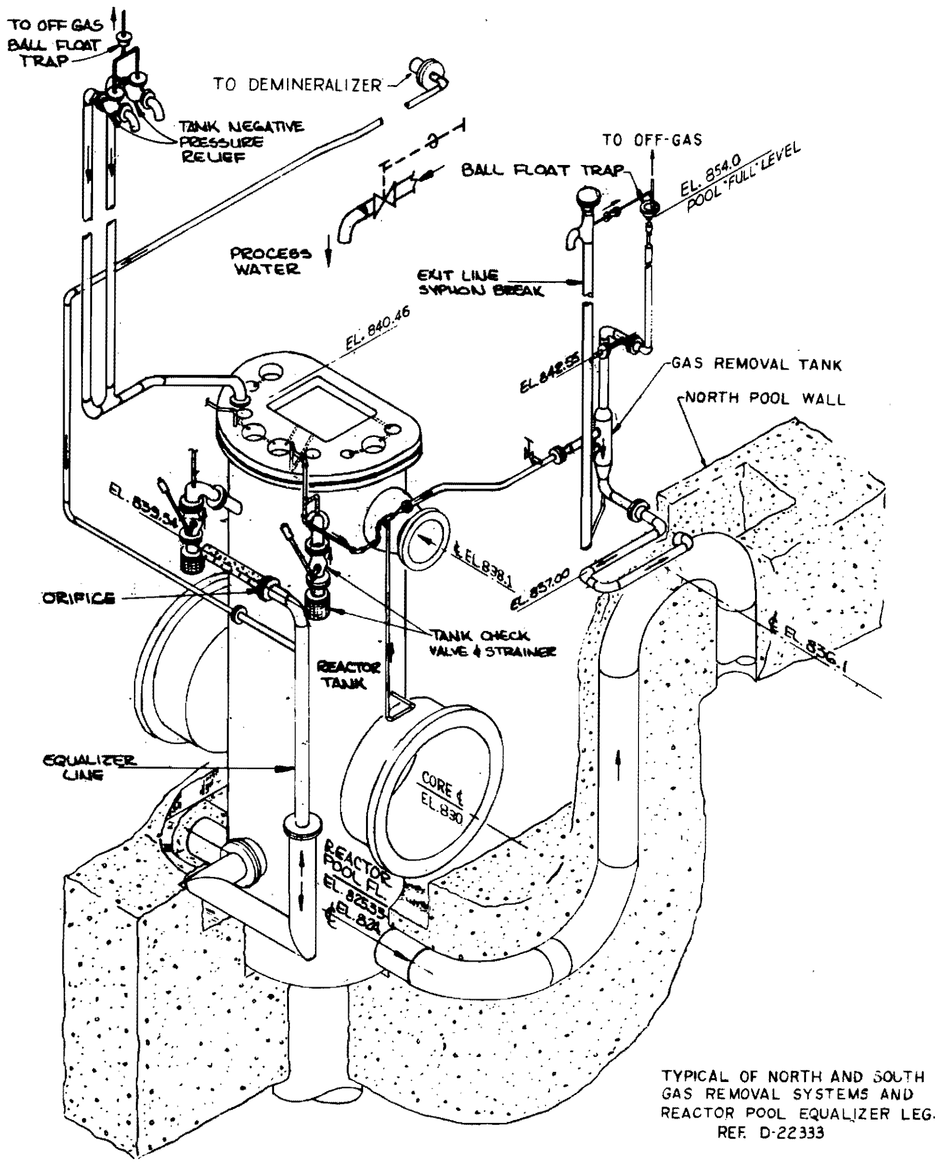
Dwgs. D-44117 and D-44118

5.2.1. Description of the System

The reactor tank is located in the east pool about 15 ft below the surface of the pool water. Demineralized water enters the reactor tank through two 18-in. pipes near the top of the tank. The rate of entry is approximately 18,000 gpm when the reactor power is 30 MW. This water flows down through the core, cooling it. The downward motion of the water helps to ensure that the fuel elements remain seated and does not oppose the scramming mechanism.

Water flows out of the bottom of the tank through two 18-in. pipes. These pipes run into the concrete shielding, turn west until they are beyond the large facility holes, and then turn upward. They continue upward in the concrete shield until they are above the level of the core, then they make a 180° turn and go to the basement. A pipe leading to a gas-removal tank is tied into each of the 18-in. pipes at the top of the 180° bend. Any entrapped gases move to the gas-removal tanks, up to ball-float traps, and from there to the off-gas-removal tank to destroy any syphoning action in the event of a severe leak (Fig. 5.4).

The two 18-in. exit lines proceed to the pipe chase in the basement where they join a common 24-in. line. This line runs out of the basement, increases to a 36-in. line, and proceeds in a northeasterly direction for several hundred feet. It changes size once more, back to a 24-in. line, before entering a 10,000-gal decay tank. The purpose of the tank is to delay the water for a short period to allow any ^{16}N that may be present to decay.



P11542-PF-001B

Fig. 5.4. Gas removal system of ORR.

After leaving the decay tank, the water proceeds through a 24-in. line to the pump house. About three-fourths of the way under the pump house, the 24-in. line becomes a manifold which feeds three 16-in. lines and two 8-in. lines. Each of the 16-in. lines leads to the inlet of a 6000-gpm pump. These pumps provide the power to circulate the cooling water through the system. There are dc pony motors directly coupled to the 6000-gpm pumps which continue rotation of the pumps, during a power outage, to provide afterheat cooling. The operation of the dc units is described in Section 7.3 of this manual.

The two 8-in. lines leaving the manifold are for emergency cooling. One of these goes to a 1000-gpm electrically driven pump which is used to provide afterheat cooling. The other line goes to a 1000-gpm gasoline-motor driven pump which was originally provided to supply cooling water through the reactor in the event that all of the dc pony motors and the electrically driven shutdown pump fail to provide adequate flow. The gasoline-engine driven pump is currently in standby condition.

The discharge from the main pumps travels through a 24-in. line under the north wall of the pump house then travels northeast to the heat-exchanger pit, Fig. 5.5. Here the heat generated in the core is transferred from the primary system to the secondary system by means of four stainless steel, shell-and-tube heat exchangers, connected in parallel. The reactor cooling water passes from east to west through the shell side of the exchangers.

A 24-in. wafer-type, butterfly control valve with an air-motor positioner is installed in parallel with the four heat exchangers. This valve allows a portion of the cooling water to bypass the heat exchangers, depending on the cooling demand.

Photo 50321

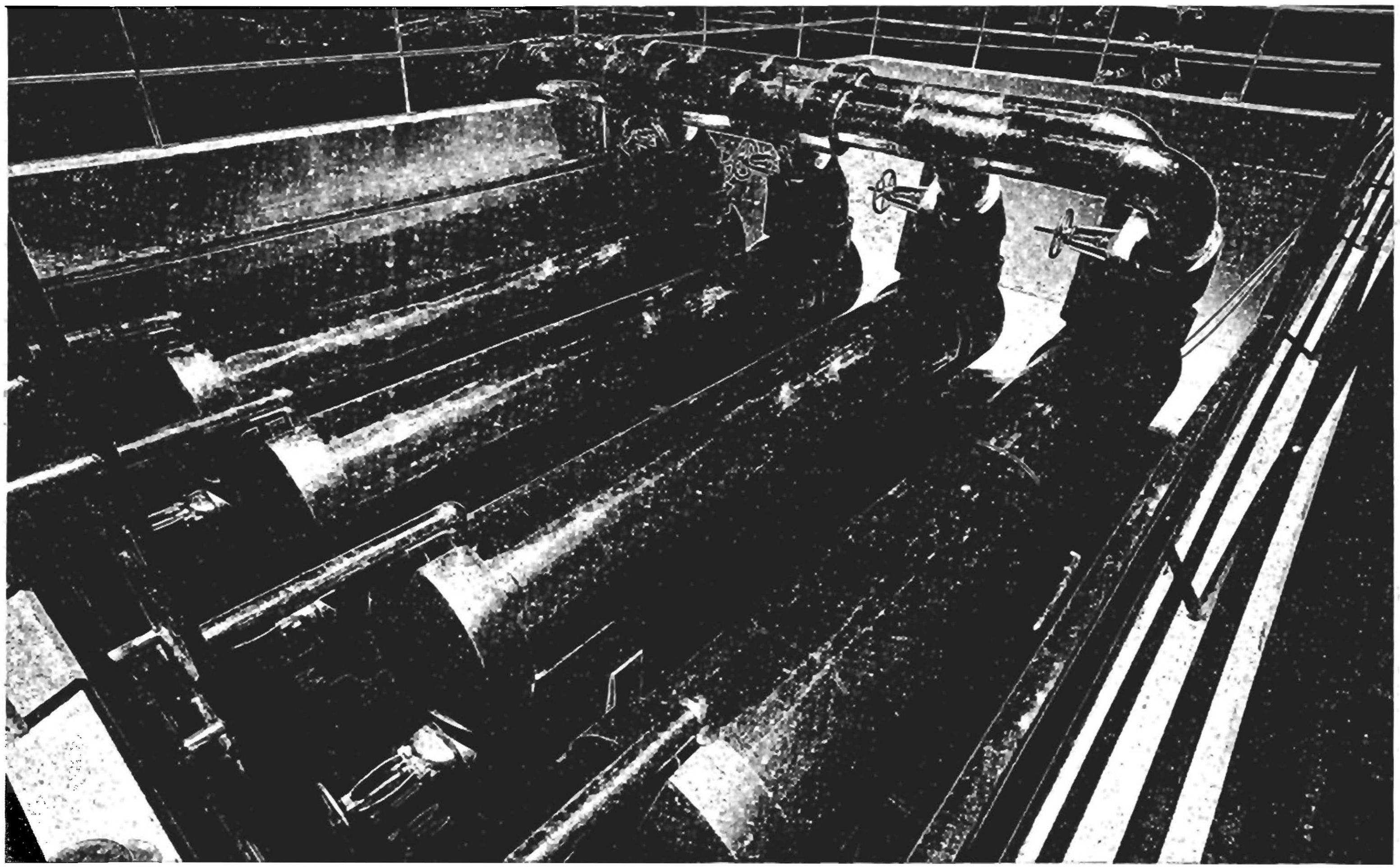


Fig. 5.5. Heat-exchanger pit.

After leaving the heat exchanger bypass valve arrangement, the water flows through a single 24-in. line south under the porch of the pumphouse. A venturi in this section allows the flow to be monitored in the control room. The line then proceeds southwest and enters the pipe chase where it branches into the two 18-in. lines that carry the cooling water through the concrete shield and up to the reactor inlets.

Two large storage tanks, located southeast of the pump house, are connected to a 300-gpm fill-and-drain pump in the basement of the ORR. When these tanks are full, they provide a positive head on the suction leg of the 300-gpm pump. As will be shown in the procedures, there are several ways that these storage tanks may be used to assist in filling or draining either the reactor or pool primary system.

1. Establishing Normal Reactor Primary Cooling Flow

   The normal procedure for establishing the reactor primary cooling flow shall be:

   a. Ensure that the water level in the reactor pool is at least 6 ft. above grating level. This step will preclude the possibility of drawing air into the primary system via the syphon-break standpipes.

      NOTE: Should conditions require the operation of the primary pumps with the reactor pool water level at the vessel top (grating level), the pressure-equalization valves on the off-gas lines from the vessel to the north and south gas-removal tanks must be opened to prevent drawing air into the primary system via the syphon-break standpipes.

   b. Start the pumps in the following sequence to reduce vibration on the exit manifold to a minimum: No. 1, No. 2, and No. 3. Do not start the next pump until the pump being started is at full flow, i.e., the motorized valve fully opened.

(1) Place the No. 1 pump discharge valve controller in AUTOMATIC, then energize the No. 1 main cooling pump. The discharge valve should open after the pump is started.

NOTE: The discharge valve may be opened manually either in the control room or in the pump house; however, do not open the discharge valve until the pump has been started.

(2) Similarly, start the No. 2 main cooling pump next and the No. 3 main cooling pump last using the procedure given in step (1) above.

2. Stopping Normal Reactor Primary Cooling Flow

The normal procedure for stopping the reactor primary cooling flow to reduce vibration on the exit water manifold shall be in the sequence of No. 3, No. 2, and No. 1.

a. Place the No. 3 pump discharge valve controller in MANUAL, shut the No. 3 discharge valve, and then de-energize the main pump.

NOTE: The discharge valve may be shut manually either in the control room or in the pump house.

b. Similarly, stop the No. 2 main cooling pump next and the No. 1 main cooling pump last using the same procedure given in step "a" above.

5.2.2. Draining the Reactor Primary System

Some preliminary comments must be made about the reactor primary system. It is so constructed that most of the water cannot be gravity drained to the storage tanks. There are two reasons for this: (1) only the reactor tank has elevations above that of the entrance to the storage tanks; and (2) there is a syphon-breaking device on the exit line from the reactor tank at a level above the top of the core. However, the reactor system can be drained, partially or completely, as the occasion demands.

1. <u>To Storage Tanks</u>:

If it is desirable to lower the water level in the reactor tank, it will normally be accomplished by sending it to the storage tanks. Prior arrangements to have adequate personnel available to monitor the areas, e.g., a Health Physics representative and Operations representative at poolside, should be made. Reactor water can be drained from the system with the reactor pool full for flushing the reactor tank; however, the reactor pool must be at approximately the same elevation as the reactor tank top in order to lower the water in the reactor tank because of the action of the equalizer leg.

To make the transfer from the reactor system to the storage tanks:

a. Open valves 147a, 148b, 158a, 159b, 160a, 161b, 162a, 163b, 101a, 106a, 109a, 109b, and 109Xa.

b. Close valve 115b.

2. <u>To the Sump</u>:

The lowest point in the system is located at the floor of the pipe chase. The large lines between the decay tank and the pipe chase will remain full after using the above procedures. Small valves have been placed in lines Nos. 110 and 101 on the floor of the pipe chase. When open, these valves will drain the reactor lines, through a drain in the floor of the pipe chase, to the sump.

<u>NOTE</u>: It is important that these valves be closed and secured when the operation has been completed since an open or leaking valve here would continuously drain water from the reactor system.

The pipe chase in entered through the south side of the reactor substructure in the basement of Building 3042.

The procedure for draining is as follows:

a. This operation requires the presence of a member of the Health Physics Division. He will determine the necessary precautions to be taken.

b. Remove the shielding at the entrance to the pipe chase.

c. Descend and, using the handrail, walk across the west 18-in. line (No. 110) about 15 ft. Open the 1 1/2-in. valve protruding west from the bottom of line No. 110.

d. A similar valve exists in the same position of the east 18-in. line (No. 101) and is to be opened also.

e. These two 1 1/2-in. valves will drain the reactor cooling lines.

f. After cooling lines have been drained, close the two valves.

3. Draining the Shell-and-Tube Heat Exchangers

At times it is necessary to drain the shell-and-tube heat exchangers for routine or emergency maintenance. Prior to draining the primary side, water counts should be taken in order to decide where to dump the water. Health Physics and the Tank Farm operator should be notified of the activity and volume involved (some 2500 gal for all four exchangers; some 10,000 gal for exchangers plus pumps and lines). The water in the primary side can be drained to the creek or pumped to the process drain using portable pumps.

Two 1 1/2-in. drain lines are provided for draining the primary side of the exchangers. The valves, 520a and 529a, are located on the south wall of the heat exchanger pit, three feet above floor level. The drain lines go beneath the floor level and attach directly to the inlet and exit 24-in. primary coolant lines. Opening these drain valves will drain the primary water to the level of the eight primary coolant cut-off valves (inlet and exit on the four heat exchangers). Procedures are as follows:

a. Close valves:

(1) 110e, 24-in. return line in the strainer pit

(2) 147a, 158a, 160a, 162a, and 101a on suction sides of the five primary pumps

b. Open valves:

(1) 121a, 122a, 123a, 124a, 125a, 126a, 127a, and 128a on the inlet and exit sides of heat exchangers and

(2) the vent valve on each exchanger at the west top.

(3) Then open valves 520a and 529a - this allows the water to drain from the exchangers to the floor drains and thence to the creek or to the process drain via a portable pump.

NOTE: A 3-in. valve about 12 ft from the creek end of the drain should normally be opened. (If the water is to be pumped from the heat exchanger basin floor to the process drain, this valve must be closed.) This valve is located on the west side of the creek under the HB-6 flight tube. When the water is drained from the exchangers, the eight cut-off valves should then be closed.

5.2.3. Filling the Reactor Primary System

1. Filling the Reactor Tank

When filling any part of the reactor primary system, the pools are a convenient and quick source of supply. One may then fill the pools by a number of available methods. Before any filling is begun, it should be ascertained that the water is sufficiently above the grating level to complete the filling without undue draining of the reactor pool. The preferred situation exists when the reactor pool is completely full before any filling is attempted. If the dam is in place between the reactor pool and the remaining two pools, which is usually the case when major work is performed, the fill-and-drain pump is used to keep the reactor pool supplied with more water as the filling proceeds. This can be done by making the valve changes listed next.

a. The following valves should be closed:

209a, 4-in. gate valve, north bank in basement
502a, 4-in. gate valve, north bank in basement
228a, 3-in. gate valve, north bank in basement
204b, 4-in. gate valve, north bank in basement
217a, 4-in. gate valve, north bank in basement
227b, 3-in. gate valve, north bank in basement
216b, 3-in. gate valve, north bank in basement
208a, 4-in. gate valve, south bank in basement
205c, 4-in. gate valve, south bank in basement
207a, 4-in. gate valve, south bank in basement

b. The following valves must be opened:

204a, 2-in. gate valve, north bank in basement
206a, 2-in. gate valve, north bank in basement
218a, 4-in. gate valve, north bank in basement
219b, 4-in. gate valve, suction line of the fill-and-drain pump
143a, 4-in. gate valve, south bank in basement
205b, 4-in. gate valve, discharge line of the fill-and-drain pump. NOTE: This valve is not to be opened until the pump is started. It is used to throttle the flow to the desired rate.

c. After the desired amount of water has been obtained for the reactor system, stop the pump and return the valves to their normal positions.

2. Supplying Water from the Storage Tanks

If the reactor system should require additional water, the storage tanks provide an obvious source of supply. The fill-and-drain pump is used to move the water from the storage tanks to the reactor system by way of the reactor pool. This is done in the following manner:

a. Estimate the amount of water needed for the reactor system.

b. Check the storage tanks to see if this amount of water exists, Fig. 5.6. If it does not, an additional source must be used.

   NOTE: Do not pump the storage tanks dry because the pump will cavitate and damage may result.

c. The following valves must be closed:

   218a, 4-in. gate valve, north bank in basement
   217a, 4-in. gate valve, north bank in basement
   227b, 3-in. gate valve, north bank in basement
   216b, 3-in. gate valve, north bank in basement
   208a, 4-in. gate valve, south bank in basement
   205c, 4-in. gate valve, south bank in basement
   207a, 4-in. gate valve, south bank in basement

d. The following valves must be opened:

   220a and/or 219a, at the storage area
   219b, 4-in. gate valve, suction line of the fill-and-drain pump
   143a, 4-in. gate valve, south bank in basement
   205b, 4-in. gate valve, discharge line of the fill-and-drain pump.

   NOTE: Valve 205b is not to be opened until the pump is started. It is used to throttle the flow to the desired rate.

e. After the desired amount of water has been obtained for the reactor system, stop the pump and return the valves to their normal positions.

Reversal of the draining procedures will usually work in filling the various components. In general, the reactor pool should be full if possible; in any case, it should contain sufficient water to fill the desired component. The tank access cover should be off. The vent valves on the component should be open, the drain valves closed, and the inlet and exit valves on the component should be open.

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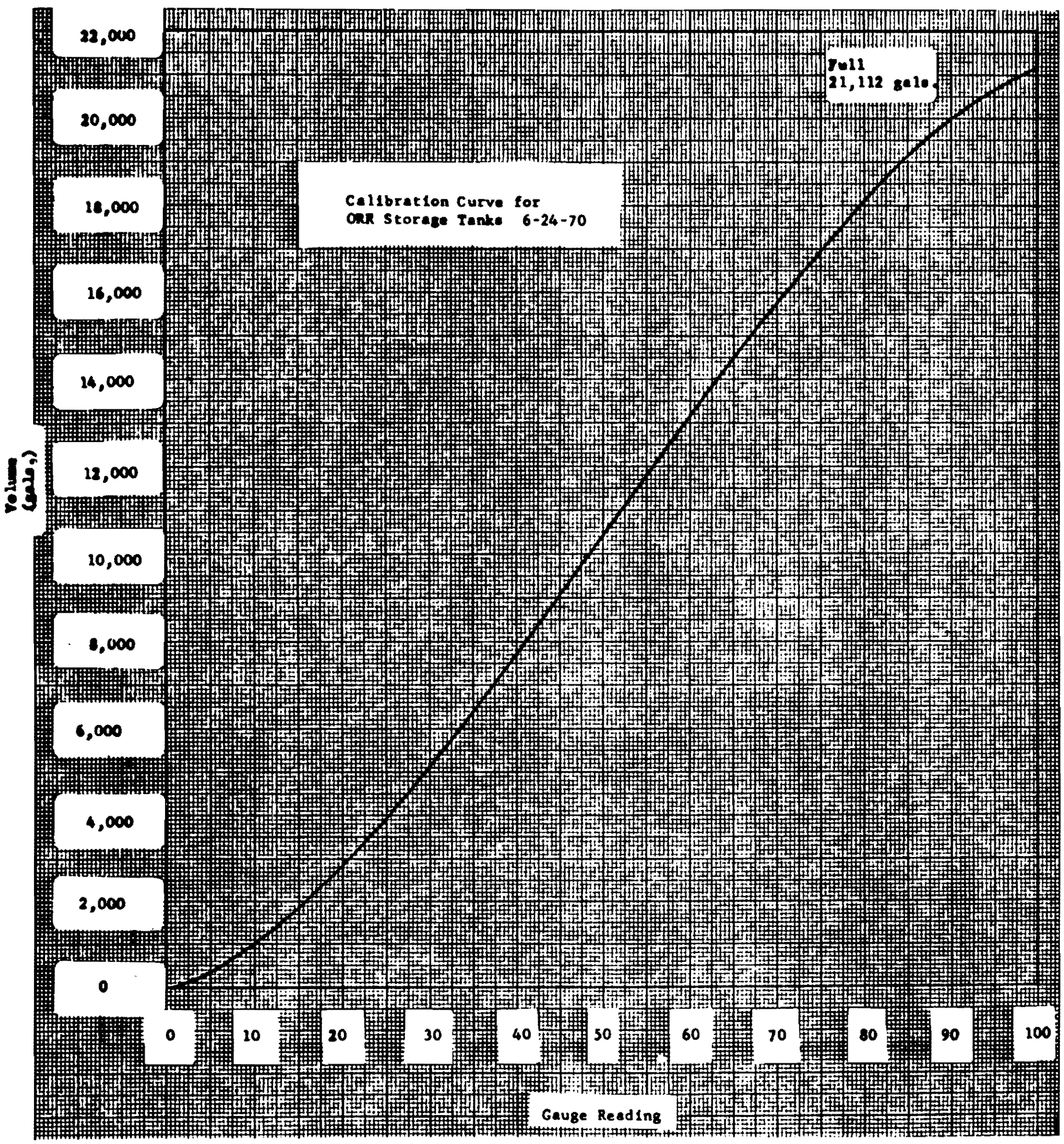

Fig. 5.6. Calibration curve for ORR storage tanks.

3. Filling the Shell-and-Tube Heat Exchangers

   a. Open the vent valves.

   b. Close drain valve 520a.

   c. Open the inlet and exit valves to the heat exchangers, 121a, 122a, 123a, 124a, 125a, 126a, 127a, and 128a.

   d. Partially opening one of the 8-in. pump-suction valves, 162a or 101a, will allow water from the reactor tank to fill the exchangers.

   e. Close the vent valves when water pours out in a steady stream.

5.2.4. Demineralizers for the Reactor System

In a reactor cooling system, the radioactivity level, the rate of corrosion, and the rate of deposit formation must be closely controlled. At the ORR, these objectives are met by demineralizing the cooling water with dual-bed, ion-exchange resins. There are two reactor demineralizer systems: one "on-stream" and the other kept on standby, regenerated and ready for service; and one degasifier demineralizer which is normally "on-stream" on a continuous basis.

Most of the components in the reactor cooling loop are made of aluminum, although some of the smaller items are stainless steel. The portion of these materials which dissolves in the water, dissolved gases, ^{24}Na, and occasional fission products from minor fuel cladding defects constitute most of the impurities found in the primary loop. A slight amount of demineralized water is added to the system continuously during normal operation to supplement that lost through cooling and sealing various bearings and glands. It is essential that the primary water have as few impurities as possible since it passes through the high-neutron-flux core region where impurities become highly activated; so some cooling water is continually bypassed through the demineralizers to remove trace impurities.

Three checks are available for judging the purity of the water in the reactor system. The first is the radioactivity level measured in cpm/ml The second is pH, a measure of the acidic or basic quality of the water. The third is the electrical resistance or resistivity of the water. Measures of pH, resistance, and water radioactivity are made once each day shift. Resistivities and activities are also recorded continuously in the control room. In general practice, the water resistivity and the water activity checks have been the best guides to the effectiveness of a demineralizer unit and the need for regeneration.

The demineralizers are located in the basement at the west end of the building. The columns of the two reactor demineralizer systems are separated from each other and enclosed behind 6-in. solid concrete block walls while the degasifier demineralizer shares the space with each. In addition to the concrete shielding, the cation columns are shielded with approximately 4 in. of lead. Extension handles on all valves extend through the block walls so that remote operation is possible although it is not normally required by the radiation level. Each reactor demineralizer system consists of two resin columns: a cation column 30 in. in diameter with 72-in. straight sides containing 10 cu ft of resin and an anion column 40 in. in diameter with 96-in. straight sides containing 37 cu ft of resin. The degasifier demineralizer system consists of two resin columns with each unit 36 in. in diameter with 96-in. straight sides. The cation column contains 12 cu ft of resin while the anion contains 18 cu ft. All resins are standard commercial types; namely, they are Rohm & Haas Company Amberlite IR-120 cation resin and Amberlite IRA-401 anion resin or approved equals.

The driving force causing the water to pass through the demineralizers comes from the facility cooling pumps and the reactor primary pumps. The system is so arranged that either pump, north or south, can be used to feed either demineralizer by use of the special crossover valve 112Xa. However, it is preferred that this valve remain closed and the flow be directed from the north pump to north demineralizer or south pump to south demineralizer.

Since there are three primary coolant demineralizer systems at the reactor, designated north, south, and degasifier, some confusion might exist concerning the valve numbers of each system. To avoid this, valves in both systems are numbered similarly: for the south system, the letter "S" is used immediately before the valve number; for the north system, the letter "N" is used; and for the degasifier, the letter "D" is used.

The third demineralizer system, identified as the "degasifier deminalizer," is normally in service in the reactor system. This demineralizer is a dual-bed system using the tanks formerly in use as mono-bed (mixed-bed) demineralizers. The tank in prior use as the north mono-bed demineralizer is now the degasifier cation tank, while the south mono-bed tank is now the degasifier anion tank. The driving force for the flow through this demineralizer is the degasifier pump. The reactor primary water is routed so that the degasifier effluent is the demineralizer's influent.

In addition to a continuous demineralizing function, the water volume gained in the primary system due to thermal expansion is passed through the demineralizer before being discharged to the reactor pool. The effluent from the demineralizer is returned to the reactor system by way of the equalizer line on the reactor tank.

Since the driving force for the flow through the demineralizer is the degasifier pump, the demineralizer cannot be placed in service without the degasifier; however, the degasifier can operate without the demineralizer. This can be accomplished by use of valve No. D-12 on the bypass to line No. 233.

5.2.5. Regeneration Procedures

Detailed procedures are provided for the method of regeneration to be used on each resin column. It is imperative that the procedure be followed in detail since serious damage could be inflicted upon the components of the reactor system if regenerant solutions were to be injected into the system.

Since the cation resins are used in the hydrogen state, HNO_3 is used as the regenerant agent; while the anion resins which are used in the hydroxal state require NaOH as the regenerant agent.

When a resin column is unable to effectively remove the radioactive ions from the reactor cooling water, it is removed from service, regenerated, and placed on "standby."

Procedural checklists for regenerating the resin columns are included in Examples 5.1 through 5.8. An individual copy of the procedure, to be completed and initialed by the responsible party as the regeneration progresses in sequential steps, will be furnished for each regeneration. These examples are identified as follows:

- Example 5.1. Procedural checklist for preparing acid regenerant solution in mix tank, Building 3004
- Example 5.2. Procedure for rinsing caustic lines and overhead caustic measuring tanks after use
- Example 5.3. Procedural checklist for regenerating the reactor's north cation column
- Example 5.4. Procedural checklist for regenerating the reactor's north anion column
- Example 5.5. Procedural checklist for regenerating the reactor's south cation column
- Example 5.6. Procedural checklist for regenerating the reactor's south anion column
- Example 5.7. Procedural checklist for regenerating the degasifier's cation column
- Example 5.8. Procedural checklist for regenerating the degasifier's anion column

Example 5.1. Procedural checklist for preparing acid regenerant solution in mix tank, Building 3004

Objective	Procedure	Remarks
1. Filling acid measuring tank	Close valves 206-W, A-1, A-12, and V-1. Open valves 205-C and 210-C. When measuring tank sight glass shows tank is full, close 210-C and 205-C. Open V-1.	Wear protective clothing (face shield, gloves, and apron).
This step completed by: ____________		Date ______
2. Adding process water to mix tank	Check that valves A-3, A-4, A-5, A-6, A-7, A-8, A-9, A-10, A-11, and W-2 are closed. Open TV-1 and W-3. When 44.8% has been added as indicated by tank level gauge, close W-3 and TV-1.	
This step completed by: ____________		Date ______
3. Transferring acid from measuring tank to mix tank	Valves 206-W, A-12, A-2, A-3, A-4, A-5, A-8, and TV-1 closed. Open V-1, A-1, and 1. Using valve 2, adjust air to jet to 22.5 psi. When transfer is completed, close valves 2, 1, and A-1.	Wear protective clothing (face shield, gloves, and apron).
This step completed by: ____________		Date ______
4. To mix solution in mix tank	Open valves TV-1, 1, and, using valve 3, adjust air to sparge to 10 psi. To stop sparging, close valves 3 and 1.	Sparge for 30 min.
This step completed by: ____________		Date ______
5. Recirculating solution in mix tank	Valves A-6, W-2, A-7, A-9, A-4, A-8, A-10, A-11, 1, 2, 3, and W-3 closed. Open A-3, A-5, and energize pump.	Pump on and off switch is located on west wall opposite No. 1 unit.
This step completed by: ____________		Date ______

Example 5.1. (Continued)

	Objective	Procedure	Remarks
6.	Checking specific gravity of solution in mix tank	While solution is recirculating, draw sample by opening valve A-8. After sample is obtained, close A-8.	Desired specific gravity is 1.030 to 1.060.
	This step completed by: ______________________________		Date_________
7.	To stop recirculation of solution in mix tank	De-energize pump and close A-3 and A-5.	
	This step completed by: ______________________________		Date________

Example 5.2. Procedure for rinsing caustic lines and overhead caustic measuring tanks after use

West caustic measuring tank (No. 1 unit)

Objective	Procedure	Remarks
1. Preparation for rinsing west measuring tank and lines	Close valves 236E, 235W, 29, 234C, 239C, 241C, 19W, 230W, and 238C. Open valves 240C, 237C, 236W, and 235C.	Refer to Fig. 5.7 for a schematic diagram of the caustic system regeneration facility.
	Connect process water hose to valve 235C (inlet to NaOH storage tank fill pump, northwest area of Building 3004).	Improper valving could send water into the 750-gal caustic storage tank.
2. Rinsing the west measuring tank and lines	Turn on process water which supplies water to valve 235C thereby filling the measuring tank with water. Then turn the process water "off" and close valve 235C.	
3. Draining water from the measuring tank to the neutralization tank	Open valves 235W, 232W, and 231W. When the water has been drained from the measuring and mix tanks, close valves 235W, 232W, 231W, 236W, 237C, and 240C.	Water will drain to the waste sump from the measuring tank via the mix tank.

This procedure completed by: ______________________ Date ________

1. Preparation for rinsing east measuring tank and lines	Close valves 236W, 235E, 234C, 239C, 241C, 19W, 230W, and 238C. Open valves 240C, 237C, 336E, and 235C.	Refer to Fig. 5.8 for a schematic diagram of the caustic system regeneration facility.
	Connect process water hose to valve 235C (inlet to NaOH storage tank fill pump, northwest area of Building 3004).	Improper valving could send water into the 750-gal caustic storage tank.

Example 5.2. (Continued)

Objective	Procedure	Remarks
2. Rinsing the east measuring tank and lines	Turn on process water which supplies water to valve 235C thereby filling the measuring tank with water. Then turn the process water "off" and close valve 235C.	
3. Draining water from the measuring tank to the neutralization tank	Open valves 235E, 232E, and 231E. When the water has been drained from the measuring and mix tanks, close valves 235E, 232E, 231E, 240C, 237C, and 236E.	Water will drain to the waste sump from the measuring tank via the mix tank.

This procedure completed by: ______________________________ Date ________

ORNL-DWG 84-8150

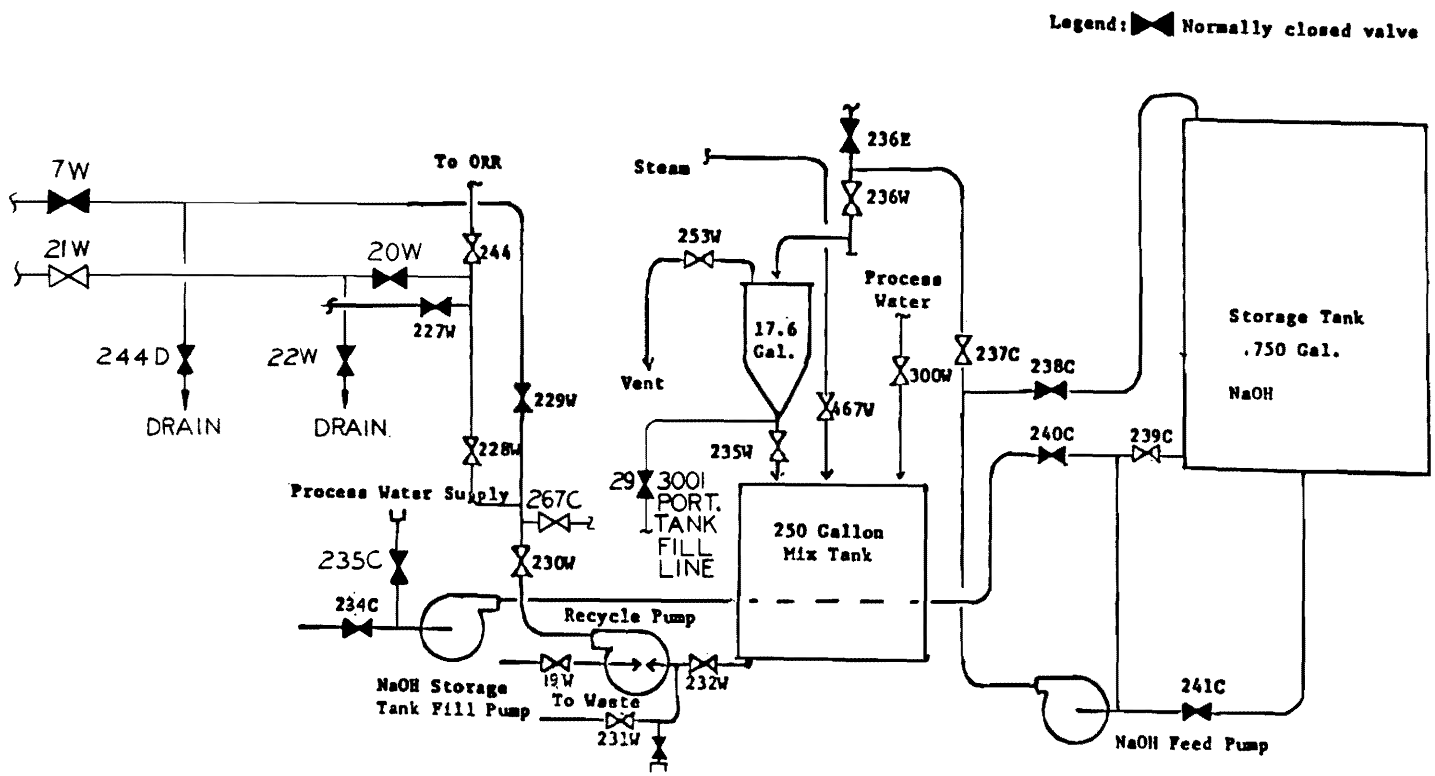

Fig. 5.7. Caustic system regenerating facility, Building 3004, west unit.

ORNL-DWG 84-8151

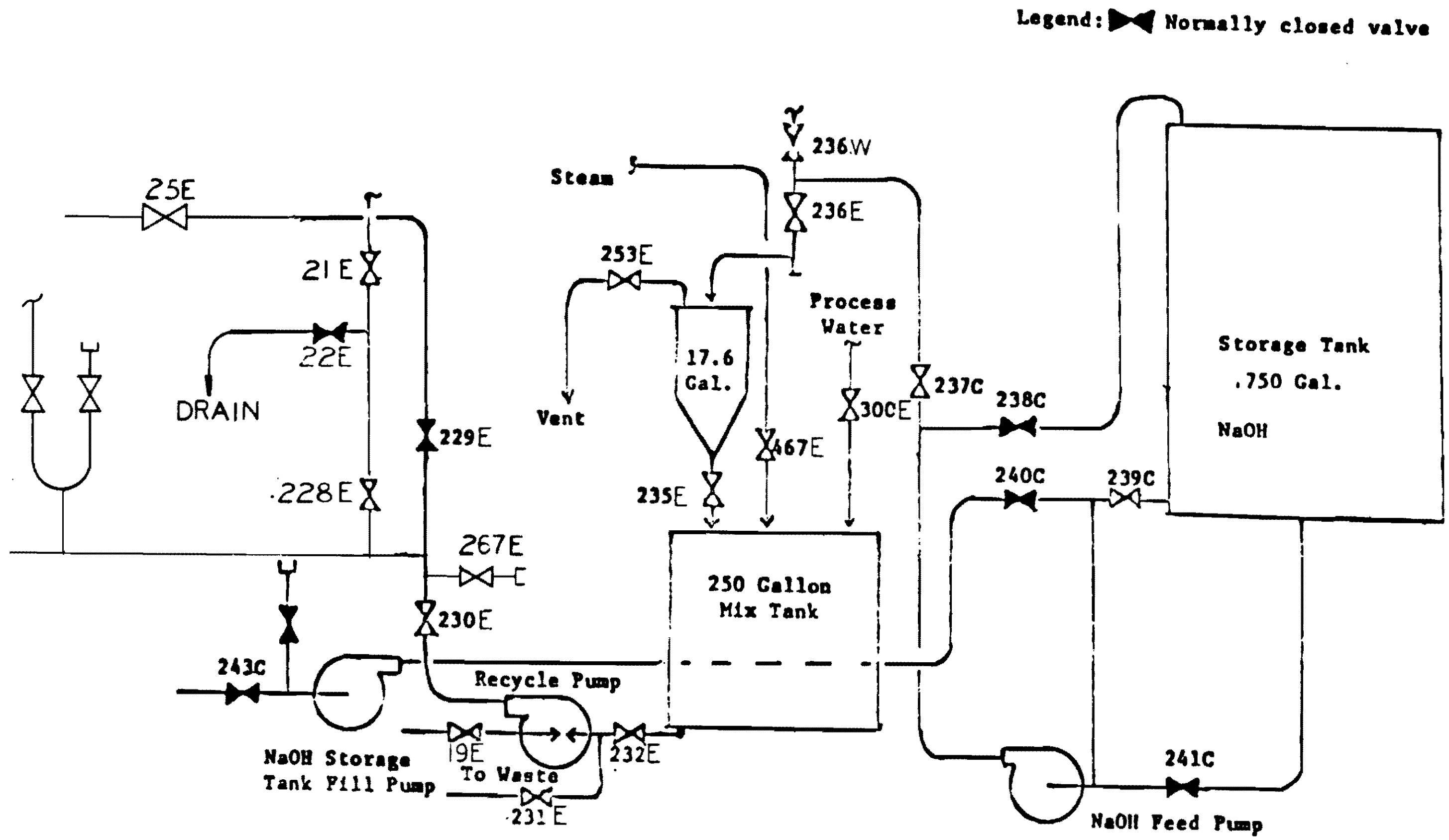

Fig. 5.8. Caustic system regnerating facility, Building 3004, east unit.

Example 5.3. Procedural checklist for regenerating the reactor's north cation column

Objective	Procedure	Remarks
1. Prepare for regeneration.	Determine the status of the demineralized water supply in Building 3004. Inform the reactor shift supervisor that the north demineralizer will be removed from service for regeneration. Have the Health Physicist survey the cell and prepare a Radiation Work Permit; post the permit at the entrance to the cell. (NOTE: The radiation levels in some of the pipes will vary during the regeneration procedure, e.g., when the regenerant exits from the resin and is routed to the waste system.)	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 50 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow rate indicators for the reactor demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or back of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.9 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.10 for a schematic diagram of the regenerant-preparation equipment in Building 3004. Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration. NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.

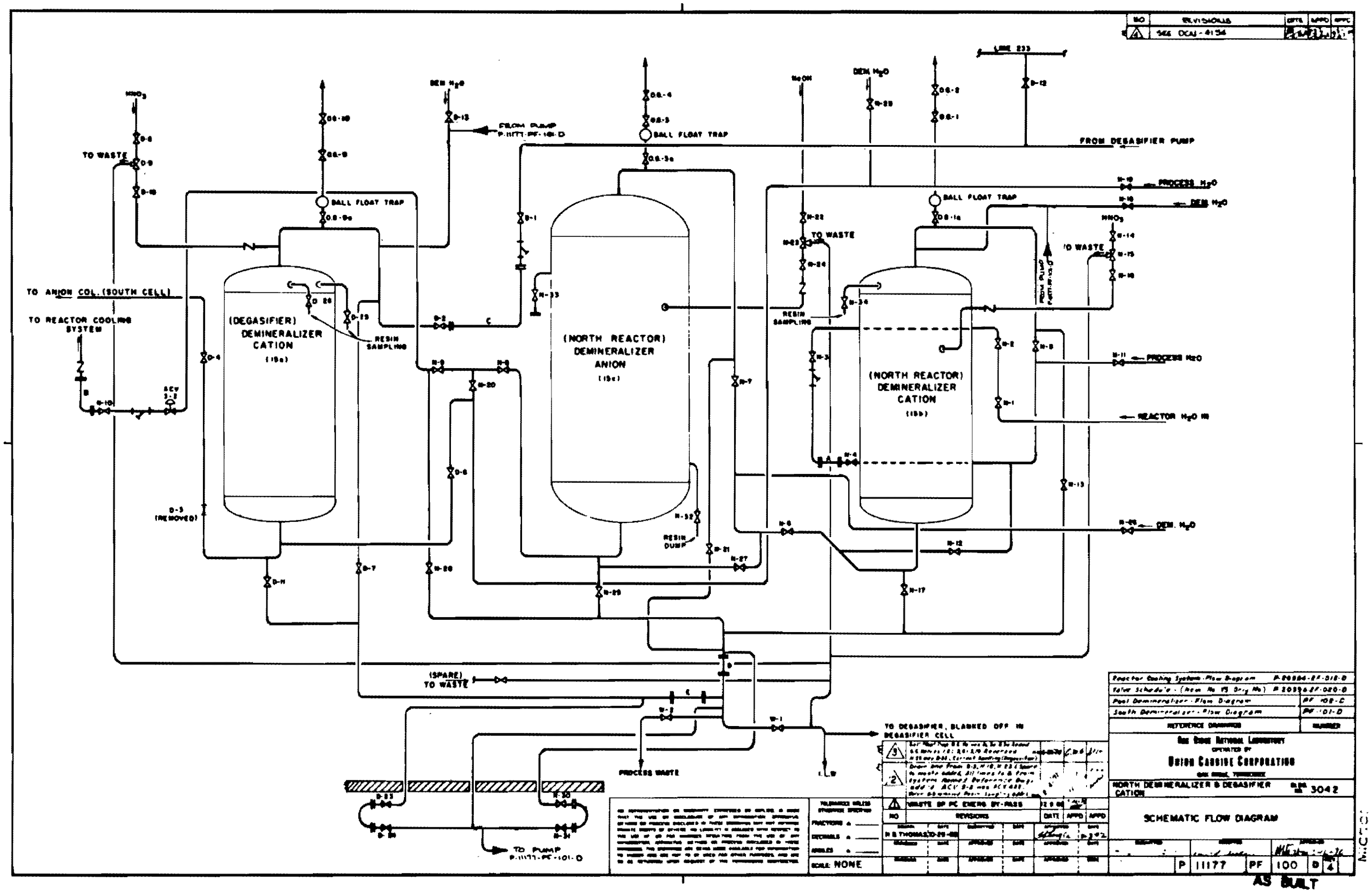

Fig. 5.9. North demineralizer.

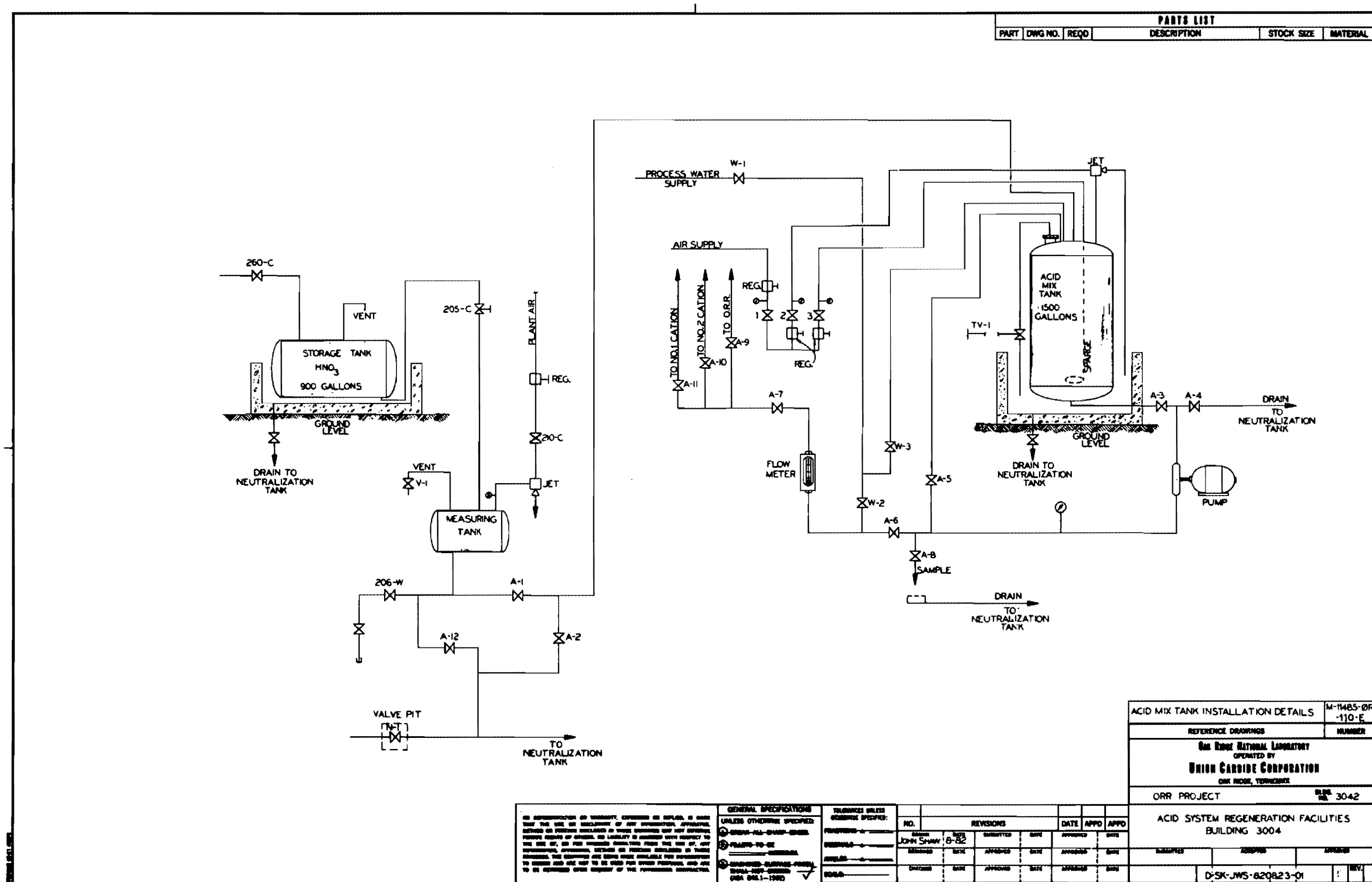

Fig. 5.10. Acid system regeneration facilities, Building 3004.

Example 5.3. (Continued)

Objective	Procedure	Remarks
1. (continued)	Prepare and place in service the reactor's south demineralizer. (See Example 5.6, Objective 18.)	Placing the standby demineralizer in service while the depleted unit is regenerated ensures the continuous demineralization of the reactor primary water.
	Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to the WC-19 waste system.	Liquid waste material may be routed to either of two retention-type waste systems. These are: (1) the Intermediate Level Waste (ILW) System (this is also referred to as the "hot" drain) and (2) the Process Waste System (also referred to as the "warm" drain). Activity levels of 1000 cpm or above must be routed to the ILW. (WC-19 is part of this system.)

This step completed by: ________________________________ Date__________

Example 5.3. (Continued)

Objective	Procedure	Remarks
2. Remove the north demineralizer from service.	In Building 3042 Stop the water flow to the north unit by closing the following valves: N-10, N-7, N-5, N-6, N-2, N-1, N-8, N-9, N-3, and N-4. Close the following valves: N-14, N-15, N-16, W-1, W-2, N-19, N-22, N-23, N-25, D-8, D-9, D-10, D-11, D-14, D-16, D-17, D-18, D-19, S-22, S-23, S-24, S-25, S-14, S-15, S-16, S-17, W-3, W-4, D-19, P-9, P-10, P-11, P-12, P-13, P-14, P-17, P-18, P-19, P-20, P-21, P-22, P-23, P-24, and P-25. Date ________ Time ________ Int. _____ x 1.5 = _____ This step was completed by: ______________	Since it is recognized that the radiation level of the demineralizer may be considerably higher than normal (e.g., due to a failure of the fuel element cladding), a provision has been made to allow the unit to be regenerated without requiring entry into the cell. The provision is the "emergency bypass system"; it allows access to the two drain systems (Process and ILW) while the dummy spool pieces inside the cell remain in place. The only changes required in the procedures are: (1) replace the dummy spool pieces between valves N-30 and N-31 (outside the cell) with a flow-through spool piece; and (2) open valves N-30 and N-31 instead of replacing the dummy spool piece, D (inside the cell). NOTE: The "emergency bypass system" must not be used without receiving authorization from the Reactor Supervisor.
	Ensure that dummy spool pieces I and J (in the south cell) are installed and dummy spool piece E (in the north cell) is also in place. (NOTE: Dummy spool pieces are color-coded - the bodies are painted	Dummy spool pieces are "no-flow" pipe channels. They are flanged at both ends to facilitate removal and/or installataion. (For normal operation, dummy spool pieces

Example 5.3. (Continued)

Objective	Procedure	Remarks
2. (continued)	blue.) In addition, check that all valves on the emergency bypass system in the pipe tunnel on the north, south, and degasifier demineralizer emergency system are closed: valves N-30 and N-31, S-30 and S-31, D-21, D-22, D-23, and D-24. Also, the blank dummy spool pieces must be in place between valves N-30 and N-31, S-30 and S-31, and D-21 and D-22.	remain installed so that each of the demineralizers is isolated from the waste systems.)

This step was completed by: ______________________ Date: __________

Objective	Procedure	Remarks
3. Compute the gallons throughput for the run completed.	Multiply the integrator reading by 1.5 and record the data in the ORR logbook. Gal. through________________	The difference between this reading and the one recorded at the completion of the previous run will be the gallon throughput.

This step was completed by: ______________________ Date: __________

Objective	Procedure	Remarks
4. Remove the spool pieces.	Remove spool pieces A and B. Replace the dummy spool piece, D, with the flow-through spool piece provided. This step was completed by: ______________Date:________ <u>NOTE: If the "emergency bypass system" is used, replace the dummy spool piece between valves N-30 and N-31 with a flow-through spool piece; and open valves N-30 and N-31 instead of replacing the dummy spool piece, D.)</u>	<u>NOTE: Ensure that the spool pieces are removed; this action will prevent regenerant solutions from entering the reactor cooling system.</u> (Spool pieces A and B are in the main flow stream and D is in the waste system.) <u>CAUTION:</u> While the regenerant solution is being routed to the waste system, valves N-30 and N-31 (and associated piping) will have an extremely high radiation level. This level will be sustained for approximately 15 min.

This alternate step was completed by: _________________ Date: __________

Example 5.3. (Continued)

Objective	Procedure	Remarks
5. Backwash the cation column using process water (or demineralized water).	In Building 3042 Open, in sequence, the following valves: N-11, N-12, W-1, and N-13. Close valve O.G.1. Using valve N-13, adjust the backwash flow rate to 30 gpm (as indicated by FE-12). Maintain this flow rate for 10 min. Time ________ Rate ________gpm This step was completed by: ________ Date:______	Process water (used in this phase of the procedure) enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed. (The manufacturer, Rohm & Haas Co., recommends a 50% expansion of the resin bed for an efficient backwash; and a flow rate of 6 gpm/sq ft of flow area is required to effect this expansion. Since the cation column consists of a tank 2.5 ft in diameter and 6 ft high, containing 10 cu ft of IR-120 resin, the 30-gpm flow rate satisfies the requirement.)
6. Stop the backwash.	In Building 3042 Close, in sequence, the following valves: N-13, N-12, N-11, and W-1. Time ________ Gal WC-19 ________ This step was completed by: ________ Date:______	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.

Example 5.3. (Continued)

Objective	Procedure	Remarks
7. Check the acid-supply lines and valves for leaks.	In Building 3042	
	Open the following valves: N-14, N-15, N-16, and W-1, then open N-17 about two turns.	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by: ________________ Date: ________	NOTE: To open the three-way acid-supply valve, N-15, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	In Building 3004	
	Close the following valves: A-3, A-6, A-10, and A-11.	
	Open valves W-2, A-7, and A-9.	
	Energize the acid pump.	The electrical controls for the acid pump are located on the west wall electrical panel.
	Using valve A-7, adjust the process-water flow rate to 9.0 gpm (as indicated by the rotameter).	

This step completed by: ______________________________ Date__________

	In Building 3042	
	Check the following valves and associated piping for leaks: N-14, N-15, N-16, D-8, D-9, D-10, S-14, S-15, S-16, P-9, P-10, and P-11.	
	If leaks have developed, stop the water flow, close W-2, and have the valves and piping repaired as needed. When there are no leaks in the system, proceed with the regeneration.	

This step completed by: ______________________________ Date__________

Example 5.3. (Continued)

Objective	Procedure	Remarks
8. Prepare the regenerant solution (nitric acid, HNO_3).	In Building 3004 Complete procedural checklist for preparing acid regenerant solution in mix tank, Building 3004, Example 5.1.	

This step completed by: ______________________ Date__________

Objective	Procedure	Remarks
9. Establish regenerant flow to the cation column.	In Building 3004 Open the following valves: A-3, A-6, A-7, and A-9	
	Energize the acid pump. Using valve A-7, adjust the regenerant rate to 13 gpm on rotameter for 22 min.	The electrical controls for the acid pump are located on the west wall electrical panel.
	The specific gravity of the solution should now be between 1.03 and 1.06; however, it should be verified.	A sample may be obtained at the "sampling valve," A-8.
	Time __________ Rate __________ gpm Sp gr__________	

This step completed by: ______________________ Date__________

Objective	Procedure	Remarks
10. Stop the regenerant flow to the cation column.	In Building 3004 Close valves A-3, A-6, open W-2 (process water). Continue the process water flow for approximately 5 min to rinse the acid from the acid pump and lines.	

Example 5.3. (Continued)

Objective	Procedure	Remarks
10. (continued)	De-energize the acid pump and close valves W-2, A-7, and A-9 Time ________________ Gal to WC-19 _________	

This step completed by: ______________________________ Date_________

	In Building 3042 Close, in sequence, the following valves: N-17, W-1, N-14, N-15, and N-16. This step was completed by: _______________Date:________	NOTE: The three-way acid-supply valve, N-15, is to be locked in the CLOSED position. (The handle will be in the horizontal position.)
11. Rinse the cation column (using demineralized water).	In Building 3042 Open, in sequence, the following valves: N-18, W-1, and N-17. Open valves O.G.1 and O.G.2. Using valve N-17, adjust the flow rate to 15 gpm (indicated by FE-13). Rinse for about 15 min; then increase the flow rate to 30 gpm.	This valving arrangement keeps the column filled with water (to minimize channeling) and routes the effluent to the ILW system.
	During the rinsing procedure, obtain a sample of the rinse effluent about every 10 min and determine the pH. When the pH increases to 3.8, stop the rinse.	A sample may be obtained at the "cation exit" sampling valve.

Time on 15 gpm ___________________ Time off 15 gpm ___________________

Gal to WC-19 ___________________ Time on 28 gpm ___________________

This step completed by: ______________________________ Date_________

Example 5.3. (Continued)

Objective	Procedure	Remarks
12. Stop the cation column rinse.	In Building 3042 Close, in sequence, the following valves: N-17, N-18, and W-1. Time ________ pH ________ gal to WC-19 ________	Closing the valves in this order will avoid pressurizing the waste system and will leave the cation column filled with demineralized water.
This step completed by: ______________________________ Date__________		
	NOTE: If the "emergency bypass system" was used, close valves N-30 and N-31 before closing W-1; and replace the flow-through spool piece with the dummy spool piece.	This alternate step is applicable only after the anion column has been regenerated.
This alternate step completed by: ______________________________ Date______		
	NOTE: If the north anion demineralizer resin is to be regenerated, omit the remaining steps (Nos. 13, 14, 15, and 16) of this procedure. The next step is the start of the north anion regeneration.	
13. Rinse the cation and anion columns in series.	In Building 3042 Open, in sequence, the following valves: N-18, N-6, N-7, W-1, and N-25. Using valve N-25, adjust the flow rate to 30 gpm (as indicated by FE-13).	This valving arrangement will allow both the cation and anion columns to be rinsed in series.

Example 5.3. (Continued)

Objective	Procedure	Remarks
	When the activity level of the effluent decreases to 1000 cpm/ml, close valve W-1 and open W-2; this will divert the flow from the ILW drain to the process drain.	If practical, monitor the radiation level of the effluent at about 10-min intervals. Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.

This step completed by: ______________________________ Date_________

14. Stop the cation-anion rinse.	In Building 3042 When the pH of the effluent is less than 7 and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated. Close, in sequence, the following valves: N-25, N-18, N-6, N-7, and W-2. Open valves O.G.3 and O.G.4. This step was completed by: _______________Date:________	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 $\pm$ 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7 and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
15. Replace the spool pieces.	Re-install spool pieces A and B. Replace the flow-through spool piece D with the dummy spool piece. (NOTE: If the "emergency bypass system" was used, close valves N-30 and N-31 before closing W-1, and replace the flow-through spool piece with the dummy spool piece.)	

This step completed by: ______________________________ Date_________

Example 5.3. (Continued)

Objective	Procedure	Remarks
16. Place the demineralizer in service.	In Building 3042 Fill the resin columns by the following valving: open N-2, N-3, N-4, N-5, N-6, N-7, N-8, N-9, and N-18. This will fill the resin columns from the 3004 demineralizer storage tanks. Air in the columns will be vented to the NOG system via the ball float valves. The resin columns will be filled with water when the demineralized water flow as indicated by flow gauge F1-13 located on the pipe tunnel north wall drops to "0." Then close N-18. The resin columns should be full.	If the reactor is operating and excessive reactor primary system water is needed to fill the resin columns, the rate of water makeup from the pool to the reactor system could exceed 60 gpm thereby resulting in a reactor scram. To prevent this occurrence, the resin columns should be filled with demineralized water from Building 3004 prior to placing the demineralizer into service.
	As a precautionary measure, establish voice contact with a reactor primary water make-up observer in the control room. Turn the "automatic control valve" selector switch to position 1 (north); this will close the automatic valve on the south demineralizer and open the one on the north demineralizer. Open N-1 slowly until valve is fully open. Open N-10 in increments until the demineralizer full flow has been established, being careful not to exceed 30 gpm makeup to the reactor primary system should the column not be full of water. This step was completed by: ______________ Date: ______	The "automatic control valve" for the north demineralizer will close when the initial flow from the demineralizer contacts the conductivity-sensing element. (The set point is 900,000 ohm-cm.) When this occurs, the unit may be returned to service by using the "override" feature. This is accomplished by keeping the "start" button depressed on the AY-1 panel. (CAUTION: Do not leave the demineralizer in service by using the "override" feature for an extended period of time. If the unit fails to remain in service after about an hour, without using the override, check the pH and resistivity;

Example 5.3. (Continued)

Objective	Procedure	Remarks
	If both demineralizers are to be placed in service, turn the "selector" switch to the No. 3 (NORTH - SOUTH) position after following the same procedure for filling the south resin columns. This step was completed by: _______________Date:________	if they are not within the specified limits, remove the unit from service and inform the supervisor in charge.)

Example 5.4. Procedural checklist for regenerating the reactor's north anion column

Objective	Procedure	Remarks
1. Prepare for regeneration.		For the efficient operation and utility of the reactor demineralizer, both the columns (cation and anion) are regenerated whenever either column becomes depleted. In general, both columns can be regenerated during one shift.
	Determine the status of the demineralized water supply in Building 3004. Inform the reactor shift supervisor that the north demineralizer will be removed from service for regeneration. Have the Health Physicist survey the cell and prepare a Radiation Work Permit; post the permit at the entrance to the cell. (NOTE: The radiation levels in some of the pipes will vary during the regeneration procedure, e.g., when the regenerant exits from the resin and is routed to the waste system.)	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 40 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow rate indicators for the reactor demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.9 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.7 for a schematic diagram of the regenerant-preparation equipment in Building 3004.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration.

Example 5.4. (Continued)

Objective	Procedure	Remarks
	Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.
	Prepare, and place in service, the reactor's south demineralizer. (See Example 5.6, Objective 18.)	Placing the standby demineralizer in service while the depleted unit is regenerated ensures the continuous demineralization of the reactor primary water.
	Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to the WC-19 waste system (4-8687). This step completed by: ____________Date:__________	Liquid waste material may be routed to either of two retention-type waste systems. These are: (1) the Intermediate Level Waste (ILW) System (this is also referred to as the "hot" drain) and (2) the Process Waste System (also referred to as the "warm" drain). Activity levels of 1000 cpm/ml or above must be routed to the ILW. (WC-19 is part of this system.)
2. Remove the north demineralizer from service.	In Building 3042 Stop the water flow to the north unit by closing the following valves: N-10, N-7, N-6, N-5, N-2, N-1, N-8, N-9, N-3, and N-4. Close the following valves: N-14, N-15, N-16, N-17, W-1, W-2, N-22, N-23, N-24, D-8, D-9, D-10, D-11, D-16, D-17, D-18, D-19, S-22, S-23, S-24,	Since it is recognized that the radiation level of the demineralizer may be considerably higher than normal (e.g., due to a failure of the fuel element cladding), a provision has been made to allow the unit to be regenerated without requiring entry into the cell. The provision is the "emergency bypass

Table 5.4. (Continued)

Objective	Procedure	Remarks
2. (continued)	S-14, S-15, S-16, S-17, W-3, W-4, P-9, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-18, P-19, P-20, P-21, P-22, P-23, P-24, and P-25. This step was completed by: ________________Date:________	system"; it allows access to the two drain systems (Process and ILW) while the dummy spool pieces inside the cell remain in place. The only changes required in the procedures are: (1) replace the dummy spool pieces between valves N-30 and N-31 (outside the cell) with a flow-through spool piece; and (2) open valves N-30 and N-31 instead of replacing the dummy spool piece, D (inside the cell). NOTE: The "emergency bypass system" must not be used without receiving authorization from the Reactor Supervisor.
	Ensure that dummy spool pieces I and J (in the south cell) are installed and dummy spool piece E (in the north cell) is also in place. (NOTE: Dummy spool pieces are color-coded - the bodies are painted blue.) This step was completed by: ________________Date:________	Dummy spool pieces are "no-flow" pipe channels. They are flanged at both ends to facilitate removal and/or installataion. (For normal operation, dummy spool pieces remain installed so that each of the demineralizers is isolated from the waste systems.)
3. Compute the gallons throughput for the run completed.	Multiply the integrator reading by 1.5 and record the data in the ORR logbook. Int.________ x 1.5=________ Gal. through ________________ This step was completed by: ________________Date:________	The difference between this reading and the one recorded at the completion of the previous run will be the gallon throughput.

Example 5.4. (Continued)

Objective	Procedure	Remarks
4. Remove the spool pieces.	Remove spool pieces A and B. Replace the dummy spool piece, D, with the flow-through spool piece provided. This step was completed by: ________________Date:__________	NOTE: Ensure that the spool pieces are removed; this action will prevent regenerant solutions from entering the reactor cooling system. (Spool pieces A and B are in the main flow stream and D is in the waste system.)
	NOTE: If the "emergency bypass sytem" is used, replace the dummy spool piece between valve N-30 and N-31 with a flow-through spool piece; and open valves N-30 and N-31 instead of replacing the dummy spool piece, D.) This alternate step was completed by: ________________Date:__________	CAUTION: While the regenerant solution is being routed to the waste system, valves N-30 and N-31 (and associated piping) will have an extremely high radiation level. This level will be sustained for approximately 15 min.
5. Backwash the anion column using demineralized water.	In Building 3042 Open, in sequence, the following valves: N-26, N-27, W-1, and N-25. Using valve N-21, adjust the backwash flow rate to 37 gpm (as indicated by FE-13); then close valve O.G.3. Maintain this flow rate for 10 min. Time ____________________ Rate ____________________gpm This step was completed by: ________________Date:__________	Demineralized water enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed; and a flow rate of 3 gpm/sq ft of flow area is required to effect this expansion. Since the cation column consists of a tank 4 ft in diameter and 8 ft high, containing 37 cu ft of IRA-401 resin, the 37-gpm flow rate satisfies the requirement.)

Example 5.4. (Continued)

Objective	Procedure	Remarks
6. Stop the backwash.	In Building 3042	
	Close, in sequence, the following valves: N-21, N-27, N-26, and W-1. Time __________ Gal WC-19 __________ This step was completed by: ____________ Date: ________	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.
7. Check the caustic-supply lines and valves for leaks.	In Building 3042	
	Open the following valves: N-22, N-23, N-24, and W-1; partially open N-25. (Approximately 2 1/2 turns)	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by: ____________ Date: ________	NOTE: To open the three-way caustic-supply valve, N-23, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	In Building 3004	
	Close the following valves: West tank (No. 1 unit) 232W, 231W, 230W, 229W, 228W, 267W, 244, 244D, 20W, and 300W.	
	Open valve 300W on the process-water supply lines and fill the caustic-mix tank with water to the half-full marker; then close the valve.	The volume of the caustic-mix tank is approximately 250 gal; the west tank (No. 1 unit) is used for this procedure.

Example 5.4. (Continued)

Objective	Procedure	Remarks
	Open the following valves: 244, 228W, 230W, and 232W.	
	Energize the recycle pump.	The electrical switch for the recycle pump is located on the north side of the mix tank.
	Use valve 244 to adjust the flow rate so that the level of the fluid in the mix tank decreases 1 in./min.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
	In Building 3042	
	Check the following valves and associated piping for leaks: S-22, S-23, and S-24; D-16, D-17, and D-18; P-12, P-13, and P-14; and N-22, N-23, and N-24.	
	If leaks have developed, stop the regeneration and have repairs made as needed. If there are no leaks, proceed with the regeneration.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
	In Building 3004	
	De-energize the recycle pump.	
	Close valves 244, 228W, 232W, and 230 W.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
8. Prepare the regenerant solution (sodium hydroxide, NaOH).	In Building 3004 Open valve 300W and fill the 250-gal caustic-mix tank to the half-full marker with process water.	A total of about 500 gal of 5% caustic solution is required for the regeneration; approximately 20 1/2 gal of 50% sodium hydroxide are used to prepare one mix tank of the 5% caustic solution.

This step completed by: ______________________________ Date__________

Example 5.4. (Continued)

Objective	Procedure	Remarks
8. (continued)		CAUTION: The caustic solution is highly corrosive; all precautions regarding the handling of such chemicals (e.g., the wearing of a rubber apron, rubber gloves, shoe covers, and a face shield) must be followed.
	Energize the exhaust blower over the caustic-mix tank.	The electrical switch for the exhaust blower is located on the west wall, opposite the caustic-mix tank.
	Open the following valves: 239C, 237C, and 236W.	
	Energize the caustic pump. (This will start the flow of caustic from the 750-gal caustic-storage tank to the 17-gal caustic-measuring tank.)	The electrical switch for the caustic pump is located on the north side of the caustic-mix tank.
	Fill the caustic-measuring tank (as indicated by the sight glass); then de-energize the caustic pump.	
	Close valve 236W and open valve 235W. (This will allow the caustic to flow from the measuring tank to the 250-gal mix tank.) After the measuring tank has drained, close valve 235W and open valve 236W.	Valve 236W is the overhead "T"-handle valve.
	Energize the caustic pump and refill the measuring tank to approximately 1/2 full; then, de-energize the pump and close valve 236W.	
	Open valve 235W and again allow the contents of the measuring tank to drain into the mix tank. Close the following valves: 239C, 237C, and 236W.	

Example 5.4. (Continued)

Objective	Procedure	Remarks
8. (continued)	Open valve 300W and fill the caustic-mix tank with process water to within about 4 in. from the top of the tank.	
	Open valve 467W on the steam-supply line to the heating coil in the mix tank. Heat the solution to 120°F.	
	Energize the stirring equipment in the mix tank during the heating operation.	The electrical switch for the stirring equipment is on the side of the motor positioned over the caustic-mix tank.
	De-energize the stirring equipment.	
	Check the specific gravity of the solution to verify that it is within the range of 1.05 to 1.06. If it is not within this range, add more caustic from 750-gal storage tank as needed.	The hydrometer used for this purpose is located on the west work bench; it may be placed directly in the caustic-mix tank.

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
9. Establish regenerant flow to the anion column.	<u>In Building 3004</u>	
	Open the following valves: 228W, 230W, 232W, and 244.	
	Energize the recycle pump.	
	Using valve 244, adjust the flow rate so that the level of the fluid in the mix tank decreases about 1 in./min.	
	When the tank is empty, de-energize the recycle pump.	
	Close valve 228W.	

Time ______________ Rate ______________

This step completed by: ______________________________ Date__________

Example 5.4. (Continued)

Objective	Procedure	Remarks
10. Prepare and send a second solution of caustic through the anion column.	Repeat steps 8 and 9.	
	When the liquid level of the second solution in the mix tank is zero, open valve 300W and allow the tank to fill to about 10 in. with process water. Close valve 300W.	The recycle pump, the caustic-mix tank, and the associated piping to the anion column (which includes the three-way valve) should be rinsed of residual caustic.
	When the level in the mix tank decreases to approximately 2 in., de-energize the recycle pump. Drain remaining water to sump.	
	Rinse the caustic from the measuring tank and associated lines as listed in Example 5.2, "Procedure for rinsing caustic lines and overhead caustic measuring tanks after use."	
	De-energize the exhaust blower.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
11. Stop the regenerant flow.	In Building 3004 Close the following valves: 244, 228W, 230W, and 232W.	

Time ____________________ Gal to WC-19 ____________

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
	In Building 3042 Close the following valves: N-25, N-24, N-23, N-22, and W-1. This step was completed by: ________________Date:________	NOTE: The three-way caustic-addition valve is to be locked in the CLOSED position. (The handle will be in the horizontal position.)

Example 5.4. (Continued)

Objective	Procedure	Remarks
12. Rinse the anion column to ILW (WC-19)	In Building 3042 Open, in sequence, the following valves: N-18, N-6, N-7, W-1, and N-25. Using valve N-25, adjust the flow rate to 30 gpm (as indicated by FE-13). Time ____________ Rate ____________ gpm	This valving arrangement will allow both the cation and anion columns to be rinsed in series. Rinse the column to WC-19 for a minimum of 20 min to rid the effluent of a caustic smell.

This step completed by: ________________________ Date________

Objective	Procedure	Remarks
13. Rinse the anion column to the process drain for 1 h.	In Building 3042 When the activity level of the effluent decreases to 1000 cpm/ml (usually after 20 min of rinse), close valve W-1 and open W-2; this will divert the flow from the ILW drain to the process drain. Time ____________ Rate ____________ gpm Activity __________ cpm/ml Gal to WC-19 ________	Monitor the radiation level of the effluent after 20 min of rinse to WC-19. Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.

This step completed by: ________________________ Date________

Example 5.4. (Continued)

Objective	Procedure	Remarks
14. Stop the rinse to process drain	<u>In Building 3042</u> Terminate the rinse to the process drain after 1 hour of rinsing operation. Close valves W-2, N-25, N-7, N-6, and N-18. Time ______________ Gal to process drain ________	
This step completed by: ____________________________		Date________
15. Start recycle rinse	<u>In Building 3042</u> To place the north demineralizer on recycle rinse: <u>close</u> valves RS, RD, N-18, N-26, N-17, D-13, D-11, W-1, and W-2; <u>open</u> valves RN, N-6, N-7, N-25, and CP-1. Start recycle pump.	
This step completed by: ____________________________		Date________
16. Stop recycle rinse	<u>In Building 3042</u> When the pH of the effluent is less than 7 and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated.	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 $\pm$ 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7 and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is

Example 5.4. (Continued)

Objective	Procedure	Remarks
16. (continued)		of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
	Stop recycle pump. Close RN, N-6, N-7, N-25, and CP-1. pH ____________ Res. ____________ Time ____________	
	This step completed by: ____________ Date ________	
17. Replace the spool pieces.	Reinstall spool pieces A and B. Replace the flow-through spool piece D with the dummy spool piece. NOTE: If the "emergency bypass system" was used, close valves N-30 and N-31 before closing W-1; and replace the flow-through spool piece with the dummy spool piece.	
	This step completed by: ____________ Date ________	
18. Place the demineralizer in service.	In Building 3042 Fill the resin columns by the following valving: open N-2, N-3, N-4, N-5, N-6, N-7, N-8, N-9, and N-18. This will fill the resin columns from the 3004 demineralizer storage tanks. Air in the columns will be vented to the NOG system via the ball float valves. The resin columns will be filled with water when the demineralized water flow as indicated by flow gauge FI-13 located on the pipe tunnel north wall drops to "0." Then close N-18.	If the reactor is operating and excessive reactor primary system water is needed to fill the resin columns, the rate of water makeup from the pool to the reactor system could exceed 60 gpm thereby resulting in a reactor scram. To prevent this occurrence, the resin columns should be filled with demineralized water from Building 3004 prior to placing the demineralizer into service.

Example 5.4. (Continued)

Objective	Procedure	Remarks
18. (continued)	The resin columns should be full. As a precautionary measure establish voice contact with a reactor primary water makeup observer in the control room. Turn the "automatic valve" selector switch to position No. 1 (north); this will close the automatic valve on the south demineralizer and open the one on the north demineralizer. Open N-1 slowly until valve is fully open. Open N-10 in increments until the demineralizer full flow has been established, being careful not to exceed 30-gpm makeup to the reactor primary system should the column not be full of water. This step was completed by: ________________ Date: ________ If both demineralizers are to be placed in service, turn the "selector" switch to the No. 3 (NORTH - SOUTH) position after following the same procedure for filling the south resin columns. This step was completed by: ________________ Date: ________	The "automatic control valve" for the north demineralizer will close when the initial flow from the demineralizer contacts the conductivity-sensing element. (The set point is 900,000 ohm-cm.) When this occurs, the unit may be returned to service by using the "override" feature. This is accomplished by keeping the "start" button depressed on the AY-1 panel. (CAUTION: Do not leave the demineralizer in service by using the "override" feature for an extended period of time. If the unit fails to remain in service after about an hour, without using the override, check the pH and resistivity; if they are not within the specified limits, remove the unit from service and inform the supervisor in charge.)

Example 5.5. Procedural checklist for regenerating the reactor's south cation column

Objective	Procedure	Remarks
1. Prepare for regeneration	Determine the status of the demineralized water supply in Building 3004. Inform the reactor shift supervisor that the south demineralizer will be removed from service for regeneration. Have the Health Physicist survey the cell and prepare a Radiation Work Permit; post the permit at the entrance to the cell. (NOTE: The radiation levels in some of the pipes will vary during the regeneration procedure, e.g., when the regenerant exits from the resin and is routed to the waste system.)	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 50 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow rate indicators for the reactor demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.10 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.11 for a schematic diagram of the regenerant-preparation equipment in Building 3004. Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration. NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.

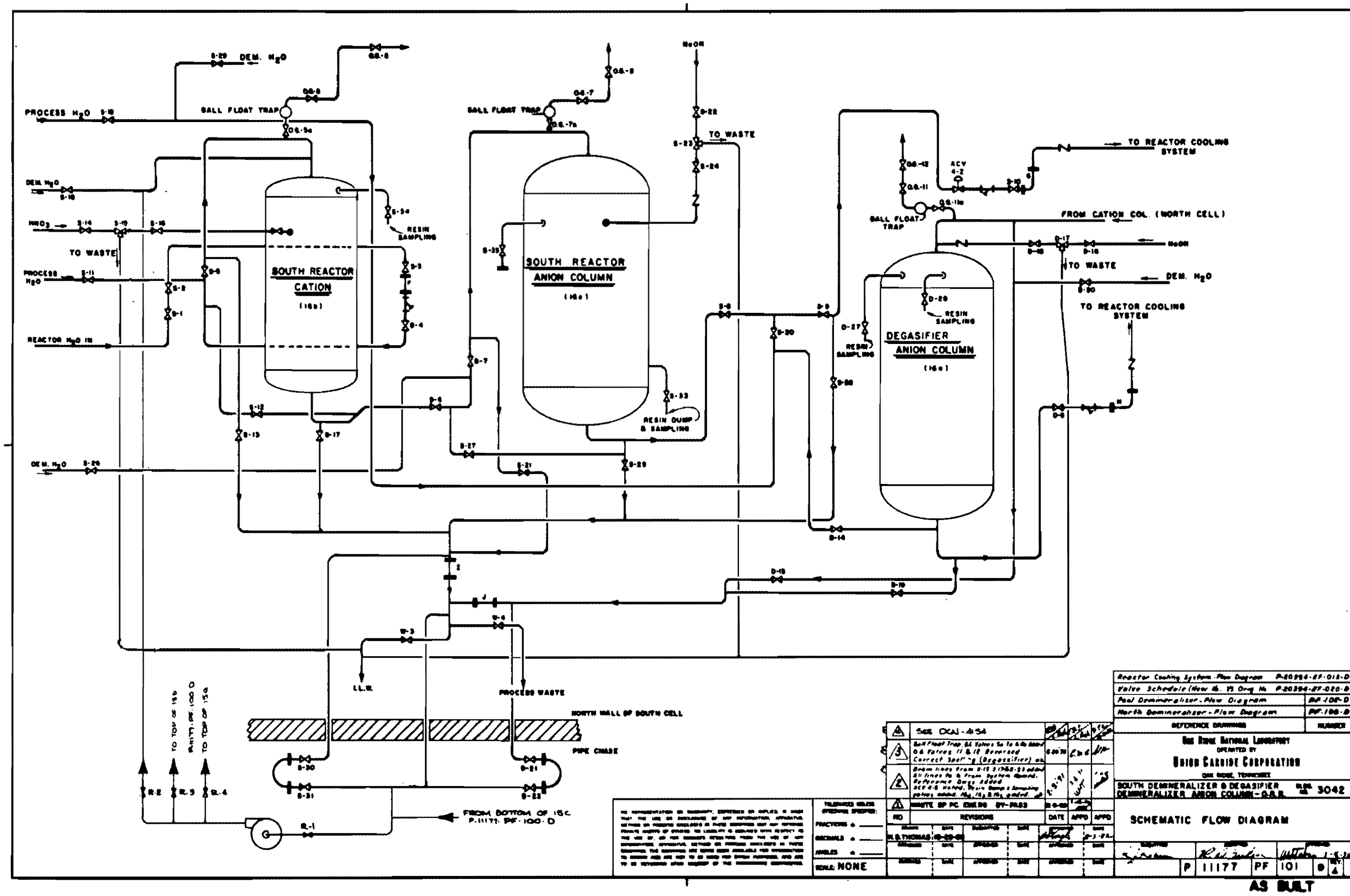

Fig. 5.11 South demineralizer.

Example 5.5. (Continued)

Objective	Procedure	Remarks
1. (continued)	Prepare and place in service, the reactor's north demineralizer. (See Example 5.4, Objective 18.) Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to the WC-19 waste system. This step was completed by: ________________Date:________	Placing the standby demineralizer in service while the depleted unit is regenerated ensures the continuous demineralization of the reactor primary water. Liquid waste material may be routed to either of two retention-type waste systems. These are: (1) the Intermediate Level Waste (ILW) System (this is also referred to as the "hot" drain) and (2) the Process Waste System (also referred to as the "warm" drain). Activity levels of 1000 cpm/ml or above must be routed to the ILW. (WC-19 is part of this system.)

Example 5.5. (Continued)

Objective	Procedure	Remarks
2. Remove the south demineralizer from service.	In Building 3042 Stop the water flow to the south unit by closing the following valves: S-10, S-9, S-8, S-7, S-6, S-5, S-4, S-3, S-2, and S-1. Close the following valves: S-14, S-15, S-16, S-17, W-3, W-4, S-22, S-23, S-24, D-8, D-9, D-10, D-11, D-14, D-15, D-16, D-17, D-18, D-19, N-22, N-24, N-14, N-15; N-16, N-17; W-1, W-2; P-9, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-18, P-19, P-20, P-21, P-22, P-23, P-24, and P-25. Time ________________ This step was completed by: ________________Date:________	Since it is recognized that the radiation level of the demineralizer may be considerably higher than normal (e.g., due to a failure of the fuel element cladding), a provision has been made to allow the unit to be regenerated without requiring entry into the cell. The provision is the "emergency bypass system"; it allows access to the two drain systems (Process and ILW) while the dummy spool pieces inside the cell remain in place. The only changes required in the procedures are: (1) replace the dummy spool pieces between valves S-30 and S-31 (outside the cell) with a flow-through spool piece; and (2) open valves S-30 and S-31 instead of replacing the dummy spool piece, I (inside the cell). NOTE: The "emergency bypass system" must not be used without receiving authorization from the Reactor Supervisor.
	Ensure that dummy spool pieces E and D (in the north cell) are installed and dummy	Dummy spool pieces are "no-flow" pipe channels. They are flanged at both

Example 5.5. (Continued)

Objective	Procedure	Remarks
2. (continued)	spool piece E (in the north cell) is also in place. (NOTE: Dummy spool pieces are color-coded - the bodies are painted blue.) In addition, check that all valves on the emergency bypass system in the pipe tunnel on the north, south, and degasifier demineralizer emergency system are closed: valves N-30 and N-31, S-30 and S-31, D-21, D-22, D-23, and D-24. Also the blank dummy spool pieces must be in place between valves N-30 and N-31, S-30 and S-31, and D-21 and D-22.	ends to facilitate removal and/or installataion. (For normal operation, dummy spool pieces remain installed so that each of the demineralizers is isolated from the waste systems.)
This step was completed by: ____________________		Date: __________
3. Compute the gallons throughput for the run completed.	Multiply the integrator reading by 1.5 and record the data in the ORR logbook. Int.__________ x 1.5 = _____	The difference between this reading and the one recorded at the completion of the previous run will be the gallon throughput.
This step was completed by: ____________________		Date: __________
4. Remove the spool pieces.	Remove spool pieces F and G. Replace the dummy spool piece, I, with the flow-through spool piece provided. This step was completed by: __________________on_________	NOTE: Ensure that the spool pieces are removed; this action will prevent regenerant solutions from entering the reactor cooling system. (Spool pieces F and G are in the main flow stream and I is in the waste system.)

Example 5.5. (Continued)

Objective	Procedure	Remarks
5. Backwash the cation column using process water (or demineralized water).	In Building 3042 Open, in sequence, the following valves: S-11, S-12, W-3, and S-13. Close valve O.G.7. Using valve S-13, adjust the backwash flow rate to 30 gpm (as indicated by FE-12). Maintain this flow rate for 10 min Time __________ Rate __________gpm This step was completed by: __________Date:________	Process water (used in this phase of the procedure) enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed. (The manufacturer, Rohm & Haas Co., recommends a 50% expansion of the resin bed for an efficient backwash; and a flow rate of 6 gpm/sq ft of flow area is required to effect this expansion. Since the cation column consists of a tank 2.5 ft in diameter and 6 ft high, containing 10 cu ft of IR-120 resin, the 30-gpm flow rate satisfies the requirement.)
6. Stop the backwash.	In Building 3042 Close, in sequence, the following valves: S-13, S-12, S-11, and W-3. Time __________ Gal WC-19 __________ This step was completed by: __________Date:________	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.

Example 5.5. (Continued)

Objective	Procedure	Remarks
7. Check the acid-supply lines and valves for leaks.	In Building 3042	
	Open the following valves: S-14, S-15, S-16, and W-3, then open S-17 about 2 1/2 turns.	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by: ________________ Date:________	NOTE: To open the three-way acid-supply valve, S-15, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	In Building 3004	
	Close the following valves: A-3, A-4, A-6, A-10, and A-11.	
	Open valves W-2, A-7, and A-9.	
	Energize the acid pump.	The electrical controls for the acid pump are located on the west wall electrical panel.
	Using valve A-7, adjust the process-water flow rate to 9.0 gpm (as indicated by the rotameter).	

This step completed by: ______________________________ Date_________

Objective	Procedure	Remarks
	In Building 3042	
	Check the following valves and associated piping for leaks: S-14, S-15, S-16, D-8, D-9, D-10, N-14, N-15, N-16, P-9, P-10, and P-11.	
	If leaks have developed, stop the water flow, close W-2, and have the valves and piping repaired as needed. When there are no leaks in the system, proceed with the regeneration.	

This step completed by: ______________________________ Date_________

Example 5.5. (Continued)

Objective	Procedure	Remarks
8. Prepare the regenerant solution (nitric acid, HNO_3).	<u>In Building 3004</u> Complete procedural checklist for preparing acid regenerant solution in mix tank, Building 3004, Example 5.1.	
This step completed by: ______________		Date________
9. Establish regenerant flow to the cation column.	<u>In Building 3004</u> Open the following valves: A-3, A-6, A-7, and A-9	
	Energize the acid pump. Using valve A-7, adjust the regenerant rate to 13 gpm on rotameter for 22 min.	The electrical controls for the acid pump are located on the west wall electrical panel.
	The specific gravity of the solution should now be between 1.03 and 1.06; however, it should be verified.	A sample may be obtained at the "sampling valve," A-8.
	Time ____________ Rate ____________ gpm Sp gr____________	
This step completed by: ______________		Date________
10. Stop the regenerant flow to the cation column.	<u>In Building 3004</u> Close valves A-3, A-6, open W-2 (process water). Continue the process water flow for approximately 5 min to rinse the acid from the acid pump and lines.	

Example 5.5. (Continued)

Objective	Procedure	Remarks
10. (continued)	De-energize the acid pump and close valves W-2, A-7, and A-9. Time ________________ Gal to WC-19 _________	

This step completed by: ______________________________ Date_________

Objective	Procedure	Remarks
	In Building 3042 Close, in sequence, the following valves: S-17, W-3, S-14, S-15, and S-16. This step was completed by: __________________on_________	NOTE: The three-way acid-supply valve, S-15, is to be locked in the CLOSED position. (The handle will be in the horizontal position.)
11. Rinse the cation column (using demineralized water).	In Building 3042 Open, in sequence, the following valves: S-18, W-3, and S-17. Open valves O.G.5 and O.G.6. Using valve S-17, adjust the flow rate to 15 gpm (indicated by FE-12). Rinse for about 15 min; then increase the flow rate to 30 gpm.	This valving arrangement keeps the column filled with water (to minimize channeling) and routes the effluent to the ILW system.
	During the rinsing procedure, obtain a sample of the rinse effluent about every 10 min and determine the pH. When the pH increases to 3.8, stop the rinse.	A sample may be obtained at the "cation exit" sampling valve.

Time on 15 gpm __________________ Time off 15 gpm ___________________

Gal to WC-19 __________________ Time on 30 gpm ___________________

This step completed by: ______________________________ Date_________

Example 5.5. (Continued)

Objective	Procedure	Remarks
12. Stop the cation column rinse.	In Building 3042	
	Close, in sequence, the following valves: S-17, S-18, and W-3.	Closing the valves in this order will avoid pressurizing the waste system and will leave the cation column filled with demineralized water.
	Time ________	
	pH ________	
	gal to WC-19 ________	
This step completed by: ______________________________		Date________
	NOTE: If the south anion resin bed is to be regenerated, omit the remaining steps (Nos. 13, 14, 15, and 16) of this procedure. The next step is the start of the south anion regeneration.	
13. Rinse the cation and anion columns in series.	In Building 3042	
	Open, in sequence, the following valves: S-18, S-6, S-7, W-3, S-25, and O.G.7.	This valving arrangement will allow both the cation and anion columns to be rinsed in series.
	Using valve S-25, adjust the flow rate to 30 gpm (as indicated by FE-13).	
	When the activity level of the effluent decreases to 1000 cpm/ml, close valve W-3 and open W-4; this will divert the flow from the ILW drain to the process drain.	If practical, monitor the radiation level of the effluent at about 10-min intervals. Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.
This step completed by: ______________________________		Date________

Example 5.5. (continued)

Objective	Procedure	Remarks
14. Stop the rinse.	In Building 3042 When the pH of the effluent is less than 7 and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated. Close, in sequence, the following valves: S-25, S-18, S-6, S-7, and W-4. Open valves O.G.7 and O.G.8. This step was completed by: __________________on________	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 ± 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7 and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
15. Replace the sool pieces.	Re-install spool pieces F and G. Replace the flow-through spool piece, I, with the dummy spool piece. NOTE: If the "emergency bypass system" was used, close valves S-30 and S-31 before closing W-3; and replace the flow-through spool piece with the dummy spool piece.	

This step completed by: ____________________________ Date_________

Objective	Procedure	Remarks
16. Place the demineralizer in service.	In Building 3042 Fill the resin columns by the following valving: open S-2, S-3, S-4, S-5, S-6, S-7, S-8, S-9, and S-18. This will fill the resin columns from the 3004 demineralizer storage tanks. Air in the columns will be vented to the NOG system via	If the reactor is operating and excessive reactor primary system water is needed to fill the resin columns, the rate of water makeup from the pool to the reactor system could exceed 60

Example 5.5. (Continued)

Objective	Procedure	Remarks
16. (continued)	the ball float valves. The resin columns will be filled with water when the demineralized water flow as indicated by flow gauge FI-13 located on the pipe tunnel north wall drops to "0". Then close S-18. The resin columns should be full.	gpm thereby resulting in a reactor scram. To prevent this occurrence, the resin columns should be filled with demineralized water from Building 3004 prior to placing the demineralizer into service.
	As a precautionary measure establish voice contact with a reactor primary water make-up observer in the control room. Turn the "automatic control valve" selector switch to position No. 2 (south); this will close the automatic valve on the north demineralizer and open the one on the south demineralizer. Open S-1 slowly until valve is fully open. Open S-10 in increments until the demineralizer full flow has been established, being careful not to exceed 30 gpm makeup to the reactor primary system should the column not be full of water. This step was completed by: ________________ Date: ________ If both demineralizers are to be placed in service, turn the "selector" switch to the No. 3 (NORTH - SOUTH) position after following the same procedure for filling the north resin columns.	The "automatic control valve" for the south demineralizer will close when the initial flow from the demineralizer contacts the conductivity-sensing element. (The set point is 900,000 ohm-cm.) When this occurs, the unit may be returned to service by using the "override" feature. This is accomplished by keeping the "start" button depressed on the AY-1 panel. (CAUTION: Do not leave the demineralizer in service by using the "override" feature for an extended period of time. If the unit fails to remain in service after about an hour, without using the override, check the pH and resistivity; if they are not within the specified limits, remove the unit from service and inform the supervisor in charge.)

This step was completed by:

________________ Date: ________

Example 5.6. Procedural checklist for regenerating the reactor's south anion column

Objective	Procedure	Remarks
1. Prepare for regeneration.		For the efficient operation and utility of the reactor demineralizer, both the columns (cation and anion) are regenerated whenever either column becomes depleted. In general, both columns can be regenerated during one shift.
	Determine the status of the demineralized water supply in Building 3004. Inform the reactor shift supervisor that the south demineralizer will be removed from service for regeneration Have the Health Physicist survey the cell and prepare a Radiation Work Permit; post the permit at the entrance to the cell. (NOTE: The radiation levels in some of the pipes will vary during the regeneration procedure, e.g., when the regenerant exits from the resin and is routed to the waste system.)	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 40 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow rate indicators for the reactor demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode

Example 5.6. (Continued)

Objective	Procedure	Remarks
1. (continued)	Refer to Fig. 5.11 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.7 for a schematic diagram of the regenerant-preparation equipment in Building 3004. Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration. NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.
	Prepare, and place in service, the reactor's north demineralizer. (See Example 5.4, Objective 18.)	Placing the standby demineralizer in service while the depleted unit is regenerated ensures the continuous demineralization of the reactor primary water.
	Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to the WC-19 waste system. This step completed by: ____________Date:________	Liquid waste material may be routed to either of two retention-type waste systems. These are: (1) the Intermediate Level Waste (ILW) System (this is also referred to as the "hot" drain) and (2) the Process Waste System (also referred to as the "warm" drain). Activity levels of 1000 cpm/ml or above must be routed to the ILW. (WC-19 is part of this system.)

Example 5.6. (Continued)

Objective	Procedure	Remarks
2. Remove the south demineralizer from service.	In Building 3042 Stop the water flow to the south unit by closing the following valves: S-10, S-9, S-8, S-7, S-6, S-5, S-4, S-3, S-2, and S-1. Close the following valves: S-14, S-15, S-16, S-17, W-3, W-4, S-22, S-23, S-24, D-8, D-9, D-10, D-11, D-14, D-15, D-16, D-17, D-18, D-19, N-22, N-23, N-24, N-14, N-15, N-16, N-17, W-1, W-2, P-9, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-18, P-19, P-20, P-21, P-22, P-23, and P-25. This step was completed by: ________________Date:_______	Since it is recognized that the radiation level of the demineralizer may be considerably higher than normal (e.g., due to a failure of the fuel element cladding), a provision has been made to allow the unit to be regenerated without requiring entry into the cell. The provision is the "emergency bypass system"; it allows access to the two drain systems (Process and ILW) while the dummy spool pieces inside the cell remain in place. The only changes required in the procedures are: (1) replace the dummy spool pieces between valves S-30 and S-31 (outside the cell) with a flow-through spool piece; and (2) open valves S-30 and S-31 instead of replacing the dummy spool piece, I (inside the cell). NOTE: The "emergency bypass system" must not be used without receiving authorization from the Reactor Supervisor.
	Ensure that dummy spool pieces E and D (in the north cell) are installed and dummy spool piece J (in the south cell) is also in place. (NOTE: Dummy spool pieces are color-coded - the bodies are painted blue.) This step was completed by: ________________Date:_______	Dummy spool pieces are "no-flow" pipe channels. They are flanged at both ends to facilitate removal and/or installataion. (For normal operation, dummy spool pieces remain installed so that each of the demineralizers is isolated from the waste systems.)

Example 5.6. (Continued)

Objective	Procedure	Remarks
3. Compute the gallons throughput for the run completed.	Multiply the integrator reading by 1.5 and record the data in the ORR logbook. Int. ______ x 1.5 = ________ Gal. through ______________ This step was completed by: ______________ Date: _______	The difference between this reading and the one recorded at the completion of the previous run will be the gallon throughput.
4. Remove the spool pieces.	Remove spool pieces F and G. Replace the dummy spool piece, I, with the flow-through spool piece provided. This step was completed by: ______________ Date: _________	NOTE: Ensure that the spool pieces are removed; this action will prevent regenerant solutions from entering the reactor cooling system. (Spool pieces F and G are in the main flow stream and I is in the waste system.)
	NOTE: If the "emergency bypass sytem" is used, replace the dummy spool piece between valve S-30 and S-31 with a flow-through spool piece; and open valves S-30 and S-31 instead of replacing the dummy spool piece, I. This alternate step was completed by: ______________ Date: _________	CAUTION: While the regenerant solution is being routed to the waste system, valves S-30 and S-31 (and associated piping) will have an extremely high radiation level. This level will be sustained for approximately 15 min.

Example 5.6. (Continued)

Objective	Procedure	Remarks
5. Backwash the anion column using demineralized water.	In Building 3042 Open, in sequence, the following valves: S-26, S-27, W-3, S-21. Using valve S-21, adjust the backwash flow rate to 37 gpm (as indicated by FE-13); then close valve O.G.5. Maintain this flow rate for 10 min. Time __________ Rate __________gpm This step was completed by: __________on_____	Demineralized water enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed. (The manufacturer, Rohm & Haas Co., recommends a 50% expansion of the resin bed for an efficient backwash; and a flow rate of 3 gpm/sq ft of flow area is required to effect this expansion. Since the anion column consists of a tank 4 ft in diameter and 8 ft high, containing 37 cu ft of IRA-401 resin, the 37-gpm flow rate satisfies the requirement.)
6. Stop the backwash.	In Building 3042 Close, in sequence, the following valves: S-21, S-26, S-27, and W-3. Time: __________ Gal to WC-19: ______	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.

This step completed by: ____________________ Date________

Example 5.6. (Continued)

Objective	Procedure	Remarks
7. Check the caustic-supply lines and valves for leaks.	In Building 3042	
	Open the following valves: S-22, S-23, S-24, and W-3; partially open S-25.	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by:	NOTE: To open the three-way caustic-supply valve, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	______________ Date:________	
	In Building 3004	
	Close the following valves: West tank (No. 1 unit) 232W, 231W, 230W, 229W, 228W, 267W, 244, 244D, 20W, and 300W.	
	Open valve 300W on the process-water supply lines and fill the caustic-mix tank with water to the half-full marker; then close the valve.	The volume of the caustic-mix tank is approximately 250 gal; the west tank (No. 1 unit) is used for this procedure.
	Open the following valves: 228W, 230W, 232W, and 244.	
	Energize the recycle pump.	The electrical switch for the recycle pump is located on the north side of the mix tank.
	Use valve 244 to adjust the flow rate so that the level of the fluid in the mix tank decreases 1 in./min.	

This step completed by: ______________________________ Date__________

Example 5.6. (Continued)

Objective	Procedure	Remarks
7. (continued)	In Building 3042 Check the following valves and associated piping for leaks: S-22, S-23, and S-24; D-16, D-17, and D-18; P-12, P-13, and P-14; and N-22, N-23, and N-24. If leaks have developed, stop the regeneration and have repairs made as needed. If there are no leaks, proceed with the regeneration.	

This step completed by: ______________________ Date__________

Objective	Procedure	Remarks
	In Building 3004 De-energize the recycle pump. Close valves 244, 228W, 232W, and 230 W.	

This step completed by: ______________________ Date__________

Objective	Procedure	Remarks
8. Prepare the regenerant solution (sodium hydroxide, NaOH).	In Building 3004 Open valve 300W and fill the caustic-mix tank to the half-full marker with process water; then close the valve.	A total of about 500 gal of 5% caustic solution is required for the regeneration; approximately 20 1/2 gal of 50% sodium hydroxide are used to prepare one mix tank of the 5% caustic solution. CAUTION: The caustic solution is highly corrosive; all precautions regarding the handling of such chemicals (e.g., the wearing of a rubber apron, rubber gloves, shoe covers, and a face shield) must be followed.

Example 5.6. (Continued)

Objective	Procedure	Remarks
8. (continued)	Energize the exhaust blower over the caustic-mix tank.	
	Open the following valves: 239C, 237C, and 236W.	
	Energize the caustic pump. (This will start the flow of caustic from the 750-gal caustic-storage tank to the 17-gal caustic-measuring tank.) Fill the caustic-measuring tank (as indicated by the sight glass); then, de-energize the caustic pump.	The electrical switch for the caustic pump is located on the north side of the caustic-mix tank.
	Close valve 236W and open valve 235W. (This will allow the caustic to flow from the measuring tank to the 250-gal mix tank.) After the measuring tank has drained, close valve 235W and open valve 236W.	Valve 236W is the overhead "T"-handle valve.
	Energize the caustic pump and refill the measuring tank to approximately 1/2 full; then de-energize the pump and close valve 236W.	
	Open valve 235W and again allow the contents of the measuring tank to drain into the mix tank.	
	Close the following valves: 239C, 237C, and 236W.	
	Open valve 300W and fill the caustic-mix tank with process water to within about 4 in. from the top of the tank.	
	Open valve 467W on the steam-supply line to the heating coil in the mix tank. Heat the solution to 120°F.	

Example 5.6. (Continued)

Objective	Procedure	Remarks
8. (continued)	Energize the stirring equipment in the mix tank during the heating operation.	The electrical switch for the stirring equipment is on the side of the motor positioned over the casutic-mix tank.
	De-energize the stirring equipment.	
	Check the specific gravity of the solution to verify that it is within the range of 1.05 to 1.06. If it is not within this range, add more caustic from 750-gal storage tank.	The hydrometer used for this purpose is located on the west work bench; it may be placed directly in the caustic-mix tank.
	This step was completed by:	
	_______________ Date: ________	
9. Establish regenerant flow to the anion column.	In Building 3004	
	Open the following valves: 228W, 230W, 232W, and 244.	
	Energize the recycle pump.	
	Time _______________	
	Rate _______________	
	This step was completed by:	
	_______________ Date: ________	
	Using valve 244, adjust the flow rate so that the level of the fluid in the mix tank decreases about 1 in./min.	
	When the tank is empty, de-energize the recycle pump.	
	Close valve 228W.	
	This step was completed by:	
	_______________ Date: ________	

Example 5.6. (Continued)

Objective	Procedure	Remarks
10. Prepare and send a second solution of caustic through the anion column.	Repeat steps 8 and 9.	
	When the liquid level of the second solution in the mix tank is zero, open valve 300W and allow the tank to fill to about 10 in. with process water. Close valve 300W.	The recycle pump, the caustic-mix tank, and the associated piping to the anion column (which includes the three-way valve) should be rinsed of residual caustic.
	When the level in the mix tank decreases to approximately 2 in., de-energize the recycle pump. Drain remaining water to sump.	
	Rinse the caustic from the measuring tank and associated lines as listed in Example 5.2, "Procedure for rinsing caustic lines and overhead caustic measuring tanks after use."	
	De-energize the exhaust blower.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
11. Stop the regenerant flow.	In Building 3004	
	Close the following valves: 244, 228W, 236W, and 232W.	

Time ____________________ Gal to WC-19 ____________

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
	In Building 3042	
	Close the following valves: S-25, S-24, S-23, S-22, and W-3.	NOTE: The three-way caustic-addition valve, S-23, is to be locked in the CLOSED position. (The handle will be in the horizontal position.)

Example 5.6. (Continued)

Objective	Procedure	Remarks
12. Rinse the anion column to ILW (WC-19).	In Building 3042 Open, in sequence, the following valves: S-18, S-6, S-7, W-3, S-25, and O.G.5. Using valve S-25, adjust the flow rate to 30 gpm (as indicated by FE-13). Time ________________ Rate ________________gpm	This valving arrangement will allow both the cation and anion columns to be rinsed in series. Rinse the column to WC-19 for a minimum of 20 min to rid the effluent of a caustic smell.
This step completed by: ______________________________ Date_________		
13. Rinse the anion column to the process drain for 1 h.	In Building 3042 When the activity level of the effluent decreases to 1000 cpm/ml (usually after 20 min of rinse), close valve W-3 and open W-4; this will divert the flow from the ILW drain to the process drain. Time ________________ Rate ________________ gpm Activity _____________cpm/ml Gal to WC-19 _________	Monitor the radiation level of the effluent after 20 min of rinse to WC-19. Do not route water with an activity level in excess of 1000 cpm/ml to the process.
This step completed by: ______________________________ Date_________		

Example 5.6. (Continued)

Objective	Procedure	Remarks
14. Stop the rinse to process drain.	<u>In Building 3042</u> Terminate the rinse to the process drain after 1 hour of rinsing operation. Close valves W-4, S-25, S-7, S-6, and S-18. Time ________________ Gal to process drain ________	
This step completed by: ______________________________ Date__________		
15. Start recycle rinse.	<u>In Building 3042</u> To place the south demineralizer on recycle rinse: <u>close</u> valves RN, RD, S-18, S-26, S-27, S-17, D-19, D-20, W-3, W-4; D-11, N-17, W-1, W-2, N-26, and N-27. <u>Open</u> valves RS, S-6, S-7, S-25, and CP-1. Start recycle pump.	
This step completed by: ______________________________ Date__________		
16. Stop recycle rinse.	<u>In Building 3042</u> When the pH of the effluent is less than 7 and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated.	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 ± 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7 and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is

Example 5.6. (Continued)

Objective	Procedure	Remarks
16. (continued)		of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
	Stop recycle pump. Close valves RS, S-6, S-7, S-25, and CP-1. pH __________ Time __________	Res. __________
This step completed by: __________		Date______
17. Replace the spool pieces.	Reinstall spool pieces F and G. Replace the flow-through spool piece, I, with the dummy spool piece. NOTE: If the "emergency bypass system" was used, close valves S-30 and S-31 before closing W-3; and replace the flow-through spool piece with the dummy spool piece.	
This step completed by: __________		Date______
18. Place the demineralizer in service.	In Building 3042 Fill the resin columns by the following valving: open S-2, S-3, S-4, S-5, S-6, S-7, S-8, S-9, and S-18. This will fill the resin columns from the 3004 demineralizer storage tanks. Air in the columns will be vented to the NOG system via the ball float valves. The resin columns will be filled with water when the demineralized water flow as indicated by flow gauge FI-13 located on the pipe tunnel north wall drops to "0." Then close S-18. The resin columns should be full.	If the reactor is operating and excessive reactor primary system water is needed to fill the resin columns, the rate of water makeup from the pool to the reactor system could exceed 60 gpm thereby resulting in a reactor scram. To prevent this occurrence, the resin columns should be filled with demineralized water water from Building 3004 prior to placing the demineralizer into service.

Example 5.6. (Continued)

Objective	Procedure	Remarks
18. (continued)	As a precautionary measure establish voice contact with a reactor primary water make-up observer in the control room. Turn the "automatic control valve" selector switch to position No. 2 (south); this will close the automatic valve on the north demineralizer and open the one on the south demineralizer. Open S-1 slowly until valve is fully open. Open S-10 in increments until the demineralizer full flow has been established, being careful not to exceed 30 gpm makeup to the reactor primary should the column not be full of water. This step was completed by: ________________ Date:_______ If both demineralizers are to be placed in service, turn the "selector" switch to the No. 3 (NORTH - SOUTH) position following the same procedure for filling the north resin columns. This step was completed by: ________________ Date:_______	The "automatic control valve" for the south demineralizer will close when the initial flow from the demineralizer contacts the conductivity-sensing element. (The set point is 900,000 ohm-cm.) When this occurs, the unit may be returned to service by using the "override" feature. This is accomplished by keeping the "start" button depressed on the AY-1 panel. (CAUTION: Do not leave the demineralizer in service by using the "override" feature for an extended period of time. If the unit fails to remain in service after about an hour, without using the override, check the pH and resistivity; if they are not within the specified limits, remove the unit from service and inform the supervisor in charge.)

Example 5.7. Procedural checklist for regenerating the degasifier's cation column

Objective	Procedure	Remarks
1. Prepare for regeneration.	Determine the status of the demineralized water supply in Building 3004.	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 50 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow rate indicators for the reactor demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.12 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.10 for a schematic diagram of the regenerant-preparation equipment in Building 3004. Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration. NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.

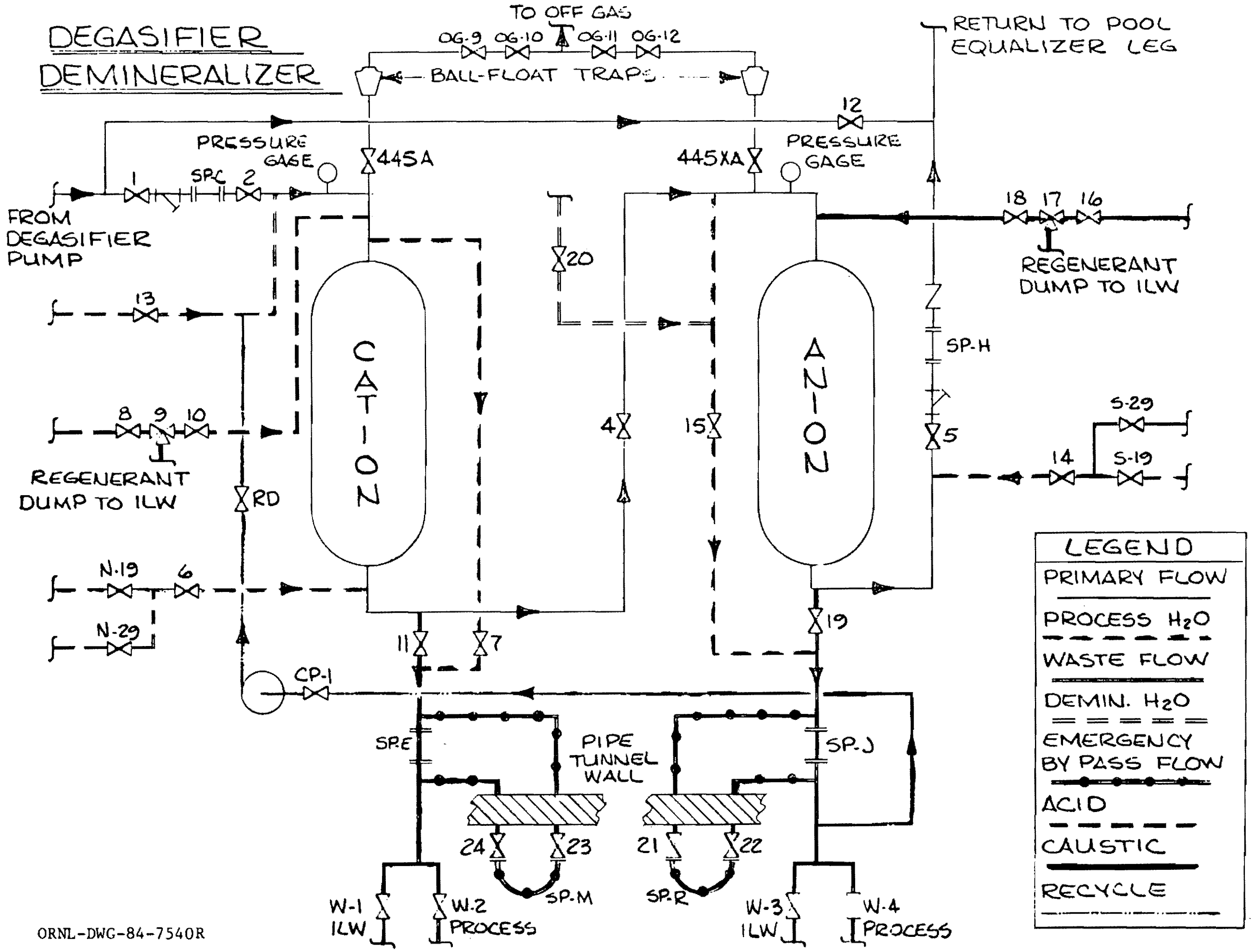

Fig. 5.12. Degasifier demineralizer.

Example 5.7. (Continued)

Objective	Procedure	Remarks
1. (continued)	Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to the WC-19 waste system (4-8687).	

This step was completed by: ________________________ Date: __________

Objective	Procedure	Remarks
2. Remove the degasifier demineralizer from service.	<u>In Building 3042</u>	
	Use valve 4 on the discharge line of the degasifier pump to adjust the flow rate from the degasifier to approximately 15 gpm, as indicated by the rotameter.	Adjusting the flow rate from the pumps to 15 gpm before opening or closing any valves on the demineralizer will prevent the draining or flooding of the degasifier tank.
	Open valve D-12. Close the following valves: D-5, D-4, D-2, and D-1. Adjust the flow rate through the degasifier to approximately 50 gpm.	It should be realized that there are two systems affected by opening valve D-12 and closing valve D-5. If D-5 were closed before opening D-12, the flow from the degasifier would be stopped and the degasifier tank would flood. If D-12 were opened without adjusting the degasifier pump flow rate, the degasifier tank would be pumped empty.

Example 5.7. (Continued)

Objective	Procedure	Remarks
2. (continued)	Close the following valves: N-14, N-15, N-16; N-17; W-1, W-2; N-22, N-23, N-24; D-8, D-9, D-10, D-11, D-16, D-17, D-18, D-19; S-22, S-23, S-24, S-14, S-15, S-16, S-17; W-3, W-4, P-9, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-18, P-19, P-20, P-21, P-22, P-23, P-24, and P-25. Time: ____________________ This step was completed by: ________________Date:________	Since it is recognized that the radiation level of the demineralizer may be considerably higher than normal (e.g., due to a failure of the fuel element cladding), a provision has been made to allow the unit to be regenerated without requiring entry into the cell. The provision is the "emergency bypass system"; it allows access to the two drain systems (process and ILW) while the dummy spool pieces inside the cell remain in place. <u>NOTE: The "emergency bypass system" must not be used without receiving authorization from the Reactor Supervisor</u>.
	Ensure that dummy spool pieces I and D are in place (I is in the south cell and D is in the north cell). (NOTE: Dummy spool pieces are color-coded the bodies are painted blue). In addition, check that all valves on the emergency bypass system in the pipe tunnel on the north, south, and degasifier demineralizer emergency system are closed: valves N-30 and N-31, S-30 and S-31, D-21, D-22, D-23, and D-24. Also, the blank dummy spool pieces must be in place between valves N-30 and N-31, S-30 and S-31, and D-21 and D-22.	Dummy spool pieces are "no-flow" pipe channels. They are flanged at both ends to facilitate removal and/or installataion. (For normal operation, dummy spool pieces remain installed so that each of the demineralizers is isolated from the waste systems.)

This step was completed by: __________________________Date: __________

Example 5.7. (Continued)

Objective	Procedure	Remarks
3. Compute the gallons throughput for the run completed.	Multiply the number of hours the demineralizer was in service by 3000 to compute the throughput gallons; record the data in the ORR logbook. Gal. through _______________	
This step was	completed by: _______________________	Date: _________
4. Remove the spool pieces.	Remove spool piece C; and replace dummy spool piece E with a flow-through spool piece.	These spool pieces are located in the north cell; C is in the inlet line to the cation column, and E is in the waste line from the cation.
	Remove spool piece H and replace dummy spool piece J with a flow-through spool piece.	These spool pieces are located in the south cell. H is in the exit line from the anion, and J is on the waste line from the anion.
	<u>NOTE: If the "emergency bypass sytem" is used, replace the dummy spool piece between valve D-21 and D-22 with a flow-through spool piece; and open valves D-21 and D-22 instead of replacing the dummy spool piece, E.</u>	<u>CAUTION</u>: While the regenerant solution is being routed to the waste system, valves N-30 and N-31 (and associated piping) will have an extremely high radiation level. This level will be sustained for approximately 15 min.

This alternate step was completed by: ____________________ Date: _________

Example 5.7. (Continued)

Objective	Procedure	Remarks
5. Backwash the cation column using process water (or demineralized water).	<u>In Building 3042</u> Open, <u>in sequence</u>, the following valves: N-19, D-6, W-1, and D-7. Close valve O.G.9. Using valve D-7, adjust the backwash flow rate to 40 gpm (as indicated on FE-12 process H_2O). Maintain this flow rate for 10 min.	Process water (used in this phase of the procedure) enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed. (The manufacturer, Rohm & Haas, Co., recommends a 50% expansion of the resin bed for an efficient backwash; and a flow rate of 6 gpm/sq ft of flow area is required to effect this expansion. Since the cation column consists of a tank 3 ft in diameter and 8 ft high, containing 15 cu ft of IR-120 resin, the 40-gal flow rate satisfies the requirement.)

Time ______________________ Rate __________________ gpm

This step was completed by: ____________________ Date: ________

6. Stop the backwash.	<u>In Building 3042</u> Close, <u>in sequence</u>, the following valves: D-7, D-6, W-1, and N-19. Time __________ Gal to WC-19 __________	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.

This step was completed by: ____________________ Date: ________

Example 5.7. (Continued)

Objective	Procedure	Remarks
7. Check the acid-supply lines and valves for leaks.	<u>In Building 3042</u>	
	Open the following valves: D-8, D-9, D-10, and W-1; then, open D-11 approximately 2 turns.	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by: ________________ Date: ________	<u>NOTE</u>: To open the three-way acid-supply valve, D-9, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	<u>In Building 3004</u>	
	To check for leaks, make sure the following valves are closed: A-3, A-4, A-6, A-10, A-11; Open W-2, A-9, and A-7; adjust flow by A-7.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
	<u>In Building 3042</u>	
	Check the following valves and associated piping for leaks: N-14, N-15, N-16; D-8, D-9, D-10; S-14, S-15, S-16; P-9, P-10, and P-11. After leak check is completed, close W-2, A-9, and A-7 in Building 3004.	
	If leaks have developed, stop the regeneration and have the valves and piping repaired as needed. When there are no leaks in the system, proceed with the regeneration.	

This step completed by: ______________________________ Date__________

Example 5.7. (Continued)

Objective	Procedure	Remarks
8. Prepare the regenerant solution (nitric acid, HNO_3).	<u>In Building 3004</u> Complete procedural checklist for preparing acid regenerant solution in mix tank, Building 3004, Example 5.1.	

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
9. Establish regenerant flow to the cation column.	<u>In Building 3004</u> Open the following valves: A-3, A-6, A-7, and A-9.	
	Energize the recycle pump.	The electrical controls for the acid pump are located on the west wall electrical panel.
	Using valve A-7, adjust the acid flow rate to 9.0 gpm for 26 min on rotameter.	
	The specific gravity of the solution should now be between 1.03 and 1.06; however, it should be verified.	A sample may be obtained at the "sampling valve," A-8.

Time ____________________ Rate ______________gpm Sp gr __________

This step was completed by: __________________________Date: __________

Objective	Procedure	Remarks
10. Stop the regenerant flow to the cation column.	<u>In Building 3004</u> Close valves A-3, and A-6; open W-2.	
	Continue the process water flow for approximately 5 min to rinse the acid from the acid pump and lines.	

Example 5.7. (Continued)

Objective	Procedure	Remarks
10. (continued)	De-energize the acid pump and close valves W-2, A-7, and A-9.	

Time ____________ Gal to WC-19 ____________

This step completed by: ____________________ Date________

	<u>In Building 3042</u>	
	Close, <u>in sequence</u>, the following valves: D-8, D-9, D-10, W-1, and D-11.	<u>NOTE</u>: The three-way acid-supply valve, D-9, is to be locked in the CLOSED position. (The handle will be in the horizontal position.)
	This step was completed by: ____________ Date:________	
11. Rinse the cation column (using demineralized water).	<u>In Building 3042</u>	
	Open, <u>in sequence</u>, the following valves: D-13, W-1, D-11, and O.G.9. Use D-11 to adjust the flow rate to 15 gpm. Maintain this rate for 15 min; then increase the flow to 30 gpm.	This valving arrangement keeps the column filled with water (to minimize channeling) and routes the effluent to the ILW system.
	During the rinsing procedure, obtain a sample of the rinse effluent about every 10 min and determine the pH. When the pH increases to 3.8, stop the rinse.	A sample may be obtained at the "cation exit" sampling valve.

Time on 15 gpm ____________ Time off 15 gpm rate____________

Gal to WC-19 ____________ Time on 30 rate ____________

This step was completed by: ____________________Date: ________

Example 5.7. (Continued)

Objective	Procedure	Remarks
12. Stop the cation column rinse.	In Building 3042 Close, in sequence, the following valves: D-11, W-1, and D-13.	 Closing the valves in this order will avoid pressurizing the waste system and will leave the cation column filled with demineralized water.

Time ______________________ Gal to WC-19 ______________________

pH ______________________ Total gal to WC-19 ______________

This step was completed by: ________________________ Date: _________

NOTE: If the degasifier anion resin bed is to be regenerated, omit the remaining steps (Nos. 13, 14, 15, and 16) of this procedure. The next step is the start of the degasifier anion regeneration.

Objective	Procedure	Remarks
13. Rinse the cation and anion columns in series.	In Building 3042 Open, in sequence, the following valves: D-13, D-4, W-3, and D-19.	 This valving arrangement will allow both the cation and anion columns to be rinsed in series.
	Using valve D-19, adjust the flow rate to 30 gpm (as indicated by FE-13).	
	When the activity of the effluent decreases to 1000 cpm/ml, close valve W-3 and open valve W-4; this will divert the flow from the ILW drain to the process drain.	If practical, monitor the radiation level of the effluent at about 10-min intervals. Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.

This step was completed by: ________________________ Date: _________

Example 5.7. (continued)

Objective	Procedure	Remarks
14. Stop the rinse.	In Building 3042 When the pH of the effluent is less than 7 and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated. Close, in sequence, the following valves: D-19, D-4, D-13, and W-4. This step was completed by: ________________Date:_______	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 $\pm$ 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7 and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
15. Replace the spool pieces.	Reinstall spool pieces C and H. Replace the flow-through spool piece with dummy spool piece, E. Replace the flow-through spool piece with dummy spool piece, J.	

This step completed by: ______________________________ Date_________

NOTE: If the "emergency bypass system" was used, close valves D-23 and D-24 before closing W-1; and replace the flow-through spool piece with the dummy spool piece.

This alternate step completed by: ____________________Date:_________

Example 5.7. (continued)

Objective	Procedure	Remarks
16. Place the demineralizer in service.	In Building 3042	
	Fill the resin columns by the following valving: open D-2, D-4, and D-13. This will fill the resin columns from the 3004 demineralizer storage tanks. Air in the columns will be vented to the NOG system via the ball float valves. The resin columns will be filled with water when the demineralized water flow as indicated by flow gauge FI-13 located on the pipe tunnel north wall drops to "0." Then close D-13. The resin columns should be full.	If the reactor is operating and excessive reactor primary system water is needed to fill the resin columns, the rate of water makeup from the pool to the reactor system could exceed 60 gpm thereby resulting in a reactor scram. To prevent this occurrence, the resin columns should be filled with demineralized water from Building 3004 prior to placing the demineralizer into service.
	As a precautionary measure establish voice contact with a reactor primary water makeup observer in the control room. Using valve 4 (at the degasifier pump), adjust the degasifier flow rate to 20 gpm (as indicated by the rotameter). Open D-1 slowly until valve is fully open. Open D-5 in increments until the demineralizer full flow has been established, being careful not to exceed 30-gpm makeup to the reactor primary system should the column not be full of water.	CAUTION: There is no automatic action of any control valve to remove the degasifier demineralizer from service if the quality of the effluent is poor; consequently, the degasifier demineralizer should not be placed in service until the pH is 7 and the resistivity is $\geq$800,000 ohm-cm.
	Close valve D-12 (slowly) and then check the flow through the rotameter; adjust the flow rate to 50 gpm.	NOTE: Any changes in the mode of D-12 must be made slowly. The valve movement should be such that 5 min are required to either open or close the valve. Opening the valve in this manner will allow the automatic level-control valve on the degasifier system to control the liquid level of the degasifier tank.
	This step was completed by: ________________ Date:________	

Example 5.8. Procedural checklist for regenerating the degasifier's anion column

Objective	Procedure	Remarks
1. Prepare for regeneration.		For the efficient operation and utility of the reactor demineralizer, both the columns (cation and anion) are regenerated whenever either column becomes depleted. In general, both columns can be regenerated during one shift.
	Determine the status of the demineralized water supply in Building 3004.	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 40 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be place in service. (The flow rate indicators for the reactor demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.12 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.7 for a schematic diagram of the regenerant-preparation equipment in Building 3004.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration.

Example 5.8. (Continued)

Objective	Procedure	Remarks
1. (continued)	Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.
	Check the operation of the automatic control valve for the unit (north or south demineralizer) that is in service by turning the three-position "selector" switch to the "IN STANDBY UNIT" position. Observe the flow meter to verify that the flow decreases to zero. If the flow rate is not reduced to zero by the action of the automatic control valve, stop the regeneration and have the valve repaired.	The air-operated automatic control valves, ACV-4A1 and ACV-4A2, can be closed either manually (i.e., by placing the "selector" switch in the position to select the alternate demineralizer) or automatically (i.e., when the water exiting from the column decreases in purity to 900,000 ohm-cm). NOTE: Do not regenerate any of the reactor demineralizers without verifying the reliability of the automatic control valves.
	After checking the automatic control valve, return the "selector" switch to the "IN SERVICE UNIT" position. This action will re-establish flow through the south demineralizer.	
	Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to the WC-19 waste system.	

This step was completed by: ______________________ Date: _________

Example 5.8. (Continued)

Objective	Procedure	Remarks
2. Remove the degasifier demineralizer from service.	In Building 3042 Use valve 4 on the discharge line of the degasifier pump to adjust the flow rate from the degasifier to approximately 15 gpm, as indicated by the rotameter.	Adjusting the flow rate from the pumps to 15 gpm before opening or closing any valves on the demineralizer will prevent the draining or flooding of the degasifier tank.
This step was completed by: ____________ Date: ______		
	Open valve D-12. Close the following valves: D-5, D-4, D-2, and D-1. Adjust the flow rate through the degasifier to approximately 50 gpm.	It should be realized that there are two systems affected by opening valve D-12 and closing valve D-5. If D-5 were closed before opening D-12, the flow from the degasifier would be stopped and the degasifier tank would flood. If D-12 were opened without adjusting the degasifier pump flow rate, the degasifier tank would be pumped empty.
	Close the following valves: N-14, N-15, N-16, N-17, W-1, W-2; N-22, N-23, N-24; D-8, D-9, D-10, D-11, D-16, D-17, D-18, D-19; S-22, S-23, S-24, S-14, S-15, S-16, S-17; W-3, W-4, P-9, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-18, P-19, P-20, P-21, P-22, P-23, P-24, and P-25. Time: ____________ This step was completed by: ____________ Date: ______	Since it is recognized that the radiation level of the demineralizer may be considerably higher than normal (e.g., due to a failure of the fuel element cladding), a provision has been made to allow the unit to be regenerated without requiring entry into the cell. The provision is the "emergency bypass system"; it allows access to the two drain systems (process and ILW) while

Example 5.8. (Continued)

Objective	Procedure	Remarks
2. (continued)		the dummy spool pieces inside the cell remain in place. (NOTE: The "emergency bypass system" must not be used without receiving authorization from the Reactor Supervisor.)
	Ensure that dummy spool pieces I and D are in place (I is in the south cell and D is in the north cell). (NOTE: Dummy spool pieces are color-coded; the bodies are painted blue). This step was completed by: ________________Date:________	Dummy spool pieces are "no-flow" pipe channels. They are flanged at both ends to facilitate removal and/or installation. (For normal operation, dummy spool pieces remain installed so that each of the demineralizers is isolated from the waste systems.)
3. Compute the gallons throughput for the run completed.	Multiply the number of hours the demineralizer was in service by 3000 to compute the throughput gallons; record the data in the ORR logbook. Gal through ________________	
This step was completed by: __________________________ Date: __________		
4. Remove the spool pieces.	Remove spool piece C; and replace dummy spool piece E with a flow-through spool piece.	These spool pieces are located in the north cell. C is in the inlet line to the cation column, and E is in the waste line from the cation.
	Remove spool piece H; and replace dummy spool piece J with a flow-through spool piece.	These spool pieces are located in the south cell. H is in the exit line from the anion, and J is on the waste line from the anion.

Example 5.8. (Continued)

Objective	Procedure	Remarks
4. (continued)	NOTE: If the "emergency bypass sytem" is used, replace the dummy spool piece between valve D-21 and D-22 with a flow-through spool piece; and open valves D-21 and D-22 instead of replacing the dummy spool piece, E. This alternate step was completed by: ________________ Date: __________	CAUTION: While the regenerant solution is being routed to the waste system, valves N-30 and N-31 (and associated piping) will have an extremely high radiation level. This level will be sustained for approximately 15 min.
5. Backwash the anion column using demineralized water.	In Building 3042 Open the following valves: W-3, D-14, S-29, and D-15. Using valve D-15, adjust the flow rate to 21 gpm (as indicated by FE-13).	Demineralized water enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed for an efficient backwash; and a flow rate of 3 gpm/sq ft of flow area is required to effect this expansion.
	Maintain this flow rate for 10 min. Time ________________ Rate ________________ gpm	Since the anion column consists of a tank 3 ft in diameter and 8 ft high, containing 21 cu ft of IONAC-540 resin, the 21-gpm flow rate satisfies this requirement.

This step was completed by: ________________________ Date: __________

Example 5.8. (Continued)

Objective	Procedure	Remarks
6. Stop the backwash.	In Building 3042	
	Close, in sequence, the following valves: D-15, D-14, S-29, and W-3. Time ____________ Gal to WC-19 ___________	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.
This step was completed by: ______________________ Date: ________		
7. Check the caustic-supply lines and valves for leaks.	In Building 3042	
	Open the following valves: D-16, D-17, D-18, and W-3; open D-19 approximately 2 1/2 turns.	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by: ________________ Date:______	NOTE: To open the three-way caustic-supply valve, D-17, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	In Building 3004	
	Close the following valves: 228W, 229W, 230W, 231W, 232W, 244, 244D, and 20W. Open valve 300W on the process-water supply lines and fill the caustic-mix tank with water to the half-full marker; then close the valve.	The volume of the caustic-mix tank is approximately 250 gal; the west tank (No. 1 unit) is used for this procedure.

Example 5.8. (Continued)

Objective	Procedure	Remarks
7. (continued)	Open the following valves: 228W, 230W, 232W, and 244.	
	Energize the recycle pump.	The electrical switch for the recycle pump is located on the north side of the mix tank.
	Use valve 244 to adjust the flow rate so that the level of the fluid in the mix tank decreases 1 in./min.	

This step completed by: ______________________________ Date__________

	<u>In Building 3042</u>	
	Check the following valves and associated piping for leaks: S-22, S-23, and S-24; D-16, D-17, and D-18; P-12, P-13, and P-14; and N-22, N-23, and N-24.	
	If leaks have developed, stop the regeneration and have repairs made as needed. If there are no leaks, proceed with the regeneration.	

This step completed by: ______________________________ Date__________

	<u>In Building 3004</u>	
	De-energize the recycle pump.	
	Close valves 244, 228W, 232W, and 230 W.	

This step completed by: ______________________________ Date__________

Example 5.8. (Continued)

Objective	Procedure	Remarks
8. Prepare the regenerant solution (sodium hydroxide, NaOH).	In Building 3004 Open valve 300W and fill the 250-gal caustic-mix tank to the half-full marker with process water.	A total of about 250 gal of 5% caustic solution is required for the regeneration; approximately 20 1/2 gal of 50% sodium hydroxide are used to prepare one mix tank of the 5% caustic solution. CAUTION: The caustic solution is highly corrosive; all precautions regarding the handling of such chemicals (e.g., the wearing of a rubber apron, rubber gloves, shoe covers, and a face shield) must be followed.
	Energize the exhaust blower over the caustic-mix tank.	The electrical switch for the exhaust blower is located on the west wall, opposite the caustic-mix tank.
	Open the following valves: 239C, 237C, and 236W.	
	Energize the caustic pump. (This will start the flow of caustic from the 750-gal caustic-storage tank to the 17-gal caustic-measuring tank.)	The electrical switch for the caustic pump is located on the north side of the caustic-mix tank.
	Fill the caustic-measuring tank (as indicated by the sight glass); then de-energize the caustic pump.	
	Close valve 236W and open valve 235W. (This will allow the caustic to flow from the measuring tank to the 250-gal mix tank.) After the measuring tank has drained, close valve 235W and open valve 236W.	Valve 236W is the overhead "T"-handle valve.

Example 5.8. (Continued)

Objective	Procedure	Remarks
8. (continued)	Energize the caustic pump and refill the measuring tank to approximately 1/2 full; then de-energize the pump and close valve 236W.	
	Open valve 235W and again allow the contents of the measuring tank to drain into the mix tank.	
	Close the following valves: 239C, 237C, and 236W.	
	Open valve 300W and fill the caustic-mix tank with process water to within about 4 in. from the top of the tank.	
	Open valve 467W on the steam-supply line to the heating coil in the mix tank. Heat the solution to 120°F.	
	Energize the stirring equipment in the mix tank during the heating operation.	The electrical switch for the stirring equipment is on the side of the motor positioned over the casutic-mix tank.
	De-energize the stirring equipment.	
	Check the specific gravity of the solution to verify that it is within the range of 1.05 to 1.06. If it is not within this range, add more caustic from the 750-gal storage tank.	The hydrometer used for this purpose is located on the west work bench; it may be placed directly in the caustic-mix tank.

This step completed by: ______________________ Date__________

Objective	Procedure	Remarks
9. Establish regenerant flow to the anion column.	<u>In Building 3004</u>	
	Open the following valves: 228W, 230W, 232W, and 244.	
	Energize the recycle pump.	

Example 5.8. (Continued)

Objective	Procedure	Remarks
9. (continued)	Using valve 244, adjust the flow rate so that the level of the fluid in the mix tank decreases about 1 in./min.	
Time ________________	Rate ________________	in./min
	When the level of the fluid in the mix tank is empty, open valve 300W and allow the tank to fill to about 10 in. with process water for rinsing purposes.	The recycle pump, the caustic-mix tank, and the associated piping to the anion column (which includes the three-way valve) should be rinsed of residual caustic.
	When the level in the mix tank decreases to approximately 2 in., de-energize the recycle pump. Drain remaining water to sump.	
	Rinse the caustic from the measuring tank and associated lines as listed in Example 5.2, "Procedure for rinsing caustic lines and overhead caustic measuring tanks after use."	
	Close valve 228W.	
This step was completed by: ________________		Date: ________
10. Stop the regenerant flow.	In Building 3004 Close the following valves: 244, 228W, 236W, and 232W.	
Time ________________		Gal. to WC-19 ________
This step completed by: ________________		Date ________
	In Building 3042 Close the following valves: D-16, D-17, D-18, D-19, and W-3. This step was completed by: ________________ Date: ________	NOTE: The three-way caustic-addition valve is to be locked in the CLOSED position. (The handle will be in the horizontal position.)

Example 5.8. (Continued)

Objective	Procedure	Remarks
11. Rinse the anion column to ILW (WC-19).	In Building 3042 Open, in sequence, the following valves: D-13, D-4, W-3, and D-19. Using valve D-19, adjust the flow rate to 30 gpm (as indicated by FE-13). Maintain this rate for 20 min. Time ____________ Rate ____________gpm	This valving arrangement will allow both the cation and anion columns to be rinsed in series. Rinse the column to WC-19 for a minimum of 20 min to rid the effluent of a caustic smell.

This step completed by: ____________________ Date________

Objective	Procedure	Remarks
12. Rinse the anion column to the process drain for 1 h.	In Building 3042 When the activity level of the effluent decreases to 1000 cpm/ml (usually after 20 min of rinse), close valve W-3 and open W-4; this will divert the flow from the ILW drain to the process drain.	If practical, monitor the radiation level of the effluent at about 10-min intervals. Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.

Time ____________ Rate ____________ gpm

Activity __________cpm/ml Gal to WC-19 ________

This step completed by: ____________________ Date________

Objective	Procedure	Remarks
13. Stop the rinse to process drain.	In Building 3042 Terminate the rinse to the process drain after 1 hour of rinsing operation. Close valves W-4, D-19, D-4, and D-13.	

Time ____________ Gal to process drain __________

This step completed by: ____________________ Date________

Example 5.8. (Continued)

Objective	Procedure	Remarks
14. Start recycle rinse.	In Building 3042 To place the degasifier demineralizer on recycle rinse: close valves RS and RN; open valves D-19, CP-1, RD, and D-4. Start recycle pump.	

This step completed by: ______________________ Date__________

Objective	Procedure	Remarks
15. Stop recycle rinse.	In Building 3042 When the pH of the effluent is less than 7 and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated.	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 ± 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7 and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
	Stop recycle pump. Close valves: D-19, CP-1, RD, and D-4. Time: ______________	

pH______________________ Res. ______________________

This step completed by: ______________________ Date__________

Example 5.8. (Continued)

Objective	Procedure	Remarks
16. Replace the spool pieces.	Reinstall spool pieces C and H. Replace the flow-through spool piece with dummy spool piece, E. Replace the flow-through spool piece with dummy spool piece, J. NOTE: If the "emergency bypass system" was used, close valves D-23 and D-24 before closing W-1; and replace the flow-through spool piece with the dummy spool piece.	
This step was	completed by: ______________________	Date: __________
17. Place the demineralizer in service.	In Building 3042 Fill the resin columns by the following valving: open D-2, D-4, and D-13. This will fill the resin columns from the 3004 demineralizer storage tanks. Air in the columns will be vented to the NOG system via the ball float valves. The resin columns will be filled with water when the demineralized water flow as indicated by flow gauge FI-13 located on the pipe tunnel north wall drops to "0." Then close D-13. The resin columns should be full.	If the reactor is operating and excessive reactor primary system water is needed to fill the resin columns, the rate of water makeup from the pool to reactor system could exceed 60 gpm thereby resulting in a reactor scram. To prevent this occurrence, the resin columns should be filled with demineralized water from Building 3004 prior to placing the demineralizer into service.
	As a precautionary measure establish voice contact with a reactor primary water makeup observer in the control room. Using valve 4 (at the degasifier pump), adjust the degasifier flow rate to 20 gpm (as indicated by the rotameter).	CAUTION: There is no automatic action of any control valve to remove the degasifier demineralizer from service if the quality of the effluent is poor; consequently, the degasifier demineralizer should not be placed in service until the pH is 7 and the resistivity is $\geq$800,000 ohm-cm.

Example 5.8. (Continued)

Objective	Procedure	Remarks
17. Continued	Open D-1 slowly until valve is fully open. Open D-5 in increments until the demineralizer full flow has been established, being careful not to exceed 30-gpm makeup to the reactor primary system should the column not be full of water. Close valve D-12 (slowly) and then check the flow through the rotameter; adjust the flow rate to 50 gpm.	NOTE: Any changes in the mode of D-12 must be made slowly. The valve movement should be such that 5 min are required to either open or close the valve. Opening the valve in this manner will allow the automatic level-control valve on the degasifier system to control the liquid level of the degasifier tank.

This step was completed by:______________________________ Date:__________

5.2.6. Bypass Degasifier

Reference

Dwgs. D-30382, D-30383, D-30384, D-30385, and RC 2-21-1C

1. Introduction

The ORR bypass degasifier, Fig. 5.13, is a unit designed to remove entrapped gases from the water used in the reactor or pool primary cooling systems. The use of this unit aids in reducing the entrapped gases in the water system thereby reducing the probability of air radioactivity in the reactor building. The degasifier unit is located in the basement, east of the north reactor anion column enclosure. It is housed in a cubicle with 8-in. concrete block shielding.

2. Operation

Water from the reactor system via line 301 or from the pool system via line 203 is available as the supply for the degasifier. This stream of water passes through an automatic control valve (ACV) into the top of the degasifier. The water is sprayed into the tank and collects as a liquid at the bottom where it supplies a centrifugal pump. The pump discharges to one of the following: the reactor system via line 114 (the exit line from the reactor demineralizers); the reactor system via the degasifier demineralizer; the reactor system via line 233 (the line to the equalizer leg); the pool cooling system via line 201 (the suction of the pool cooling pumps); or the demineralizers via the inlet line to the demineralizers. The function of the ACV mentioned above is to maintain the water in the tank at a level which will prevent cavitation of the pumps.

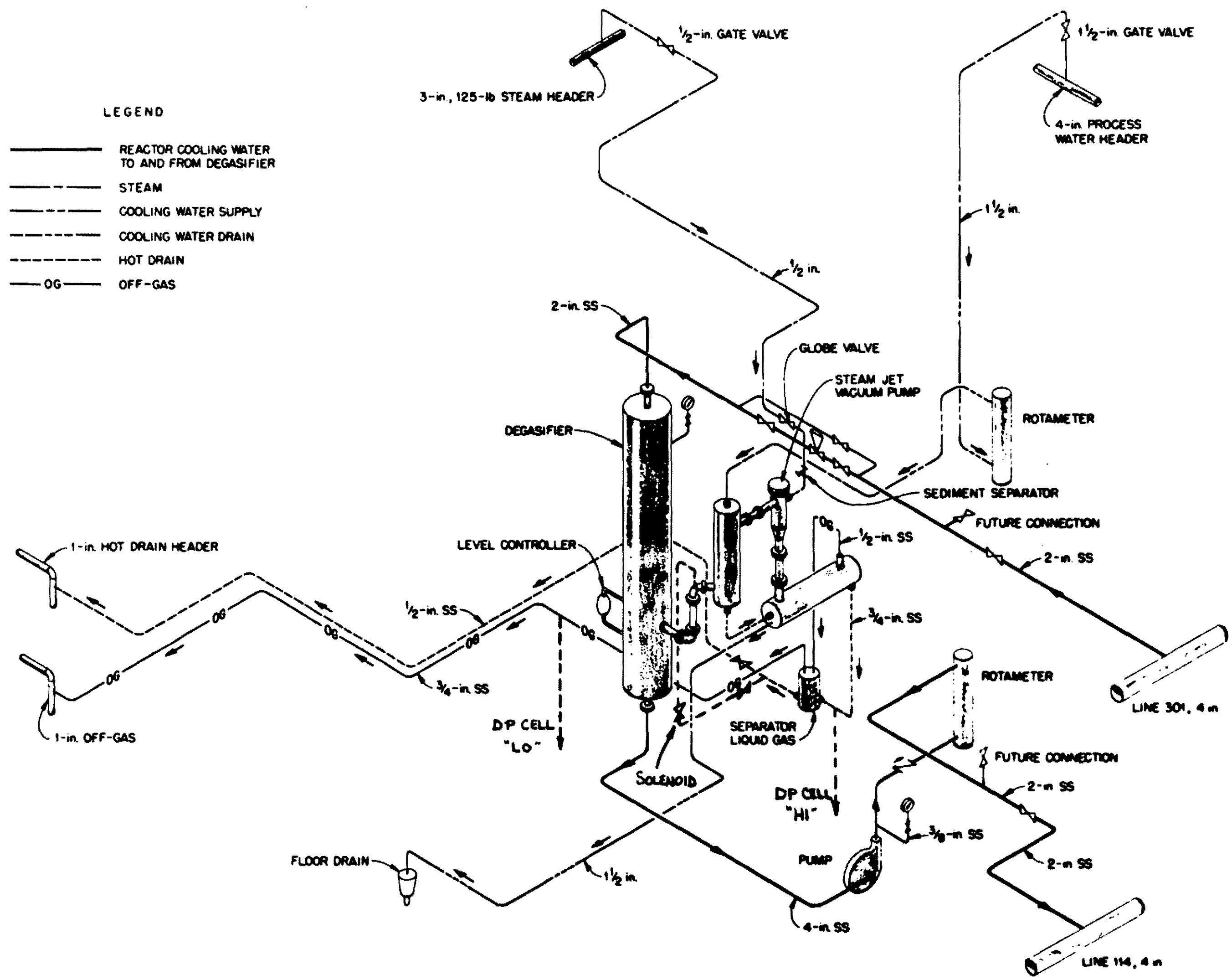

Fig. 5.13. ORR degasifier flow diagram.

In order to remove any liberated gases, the degasifier tank is evacuated continuously by a steam jet to produce a negative pressure equal to 26 in. of mercury. Located between the jet and degasifier tank is a condenser used to condense any water vapor which the jet removes from the tank while removing the previously entrapped gases. This condensed vapor is returned to the degasifier tank via the same line supplying the condenser since the pipe line is large enough in diameter to allow simultaneous flow in both directions.

The exhaust from the steam jet vacuum pump, which now contains the gases removed from the water, is fed through another condenser to condense the steam vapor. The steam condensate and the free gases enter a fluid-gas separator via separate lines. The final separation of liquid and gas is made here with the gas being removed by a line connected to the building off-gas system. The fluid, since it might contain traces of radioactivity, is returned to the degasifier tank and, if desired, the fluid can be piped to the ILW drain which services the second and third floors and is in the pipe chase. The condensers mentioned above are cooled by plant process water.

3. Placing the degasifier in service

The following operations, necessary to place the degasifier in service, are given with the assumption that the degasifier is empty and that all of its valves are completely closed. If the equipment is in a condition other than that stated above, some degree of caution should be exercised when making changes.

To place the unit in service, the following preliminary steps should be completed:

a. Check that the bypass valve around the ACV is closed (valve No. 1).

b. Check that the valves immediately above and below the ACV are fully closed (valves Nos. 2 and 3).

c. Check that the valve between the check valve and the rotameter on the exit side of the centrifugal pump is fully closed (valve No. 4).

d. Check that there is an air supply to the controller. The gauge on the north reactor anion column cell wall should indicate approximately 20 psig.

4. <u>Reactor system</u>

a. Via line No. 114

(1) Make sure that the degasifier supply and return valves from the pool cooling system are closed. These valves are No. 9, inside the north facility pump cell, and No. 10, near line 201 in the east end of the pipe tunnel.

(2) Make sure that both the degasifier supply valve from the hydraulic tubes and the return valve to the demineralizers are closed. These valves are HTC-DR, overhead in the east end of the pipe tunnel, and No. 11, on the north wall of the north facility pump cell.

(3) Open the valve on line 301 completely (valve No. 5). This valve is located inside the north facility pump cell. If the south facility pump is in service, it is necessary to open valve 301-A to obtain flow to the degasifier.

(4) Make sure that the degasifier exit valve to the equalizer leg is closed. This is valve No. D-12, overhead at the east end of the pipe tunnel. Determine that the degasifier exit valve to the degasifier demineralizer is closed. This is valve No. D-1, located in the north demineralizer cell near the north cation column.

(5) Open the valve on line 114 completely (valve No. 6). This valve is located near the pipe chase wall on the south side of the pipe tunnel, north of the centerline of line 114.

(6) Open valve No. 2, above the ACV.

(7) Open the valve below the ACV slowly (valve No. 3). This will allow the water to enter the degasifier tank. As the tank fills, the level will rise in the sight glass on the west side of the tank. When the level in the sight glass is at or near the top of the glass, the ACV should close. If it does not close, close all valves and report the malfunction to the Reactor Supervisor or the shift supervisor. If the ACV closes, open the valve below the ACV completely (valve No. 3).

(8) Open the valve between the check valve and the rotameter on the exit side of the pump one complete turn (valve No. 4).

(9) Start and stop the pump a few times to ensure the absence of air in the pump. Turn on the pump. The control switch for the pump is located on the wall behind the degasifier unit.

(10) Adjust the valve mentioned in step "8" above until a 8low of 40 gpm is established.

(11) Turn on the process water (valve No. 7) and adjust the flow to 20% of maximum flow. The valve and rotameter for this purpose are located outside the degasifier cubicle on the cubicle wall.

(12) Turn on the steam to the steam jet (valve No. 8) about one quarter of a turn, using the long steel "tee" handle hanging near the ACV. After a vacuum of 26 in. of mercury is indicated on the tank pressure gauge, slowly reduce the steam flow to that point where a further reduction in steam flow would result in a loss of vacuum.

b. Via the equalizer leg

(1) Determine that valves Nos. 6, 9, 10, 11, and HTC-DR are closed.

(2) Determine that valve No. D-1 in the north demineralizer cell is closed.

(3) Open valve No. D-12, located overhead in the east end of the pipe tunnel, and valve No. 5.

(4) Proceed with step "(6)" under "Reactor system" above.

c. Via degasifier demineralizer to equalizer leg

(1) Determine that valves Nos. 6, 9, 10, 11, D-12, and HTC-DR are closed.

(2) Open valves Nos. D-1 and C113 in the north demineralizer cell.

(3) Open valves Nos. C112, C114, and C233, in the pipe tunnel, and valve No. 5.

(4) Proceed with step "(6)" under "Reactor system" above.

The degasifier is now in service. Before leaving the area, however, be sure that the pump flow rate is still 40 gpm.

5. Pool system

a. Make sure that the degasifier valves from the reactor bypass system are closed. These valves are No. 5, inside the north facility pump cell, and No. 6, near line 114.

b. Determine that the degasifier exit valve to the equalizer leg is closed. This valve is No. D-12, overhead at the east end of the pipe tunnel. Determine that valve No. D-1 in the north demineralizer cell is closed.

c. Determine that the degasifier supply from the hydraulic tubes and return to the demineralizers are closed. These valves are HTC-DR, overhead in the east end of the pipe tunnel, and No. 11, on the north wall of the north facility pump cell.

d. Completely open valve No. 9, located inside the north facility pump cell.

e. Completely open valve No. 10, near line 201 in the pipe tunnel.

f. Proceed with step "(6)" under "Reactor System" above.

6. Hydraulic tube - demineralizer system (Currently the hydraulic tube is not in service.)

   a. Make sure that the degasifier supply and return valves from the pool cooling system are closed. These valves are No. 9, inside the north facility pump cell, and No. 10, near line 201 in the east end of the pipe tunnel.

   b. Close valve No. 6, located near line No. 114 at the east end of the pipe tunnel.

   c. Close valve No. D-12, located overhead at the east end of the pipe tunnel. Close the degasifier exit valve to the Degasifier Demineralizer." This is valve No. D-1, located in the north demineralizer cell near the north cation column.

   d. Completely open HTC-DR, overhead in the east end of the pipe tunnel.

   e. Completely open No. 11, on the north wall fo the north facility cell.

   f. Open the valve on line 301 (valve No. 5). This valve is located inside the north facility pump cell. If the south pump is in service, it is also necessary to open valve No. 301A to obtain flow to the degasifier.

7. Proceed with step "(6)" under "Reactor system" above.

As can be seen from the procedures, the following flow through the degasifier may exit as follows.

from	to
(1) Reactor system	(1) Reactor system, line No. 114
(2) Pool system	(2) Pool system
(3) Hydraulic tube No. 2 (presently not in use)	(3) Demineralizers, north and south
a. From pool	(4) Reactor system, equalizer leg-line No. 233
b. From reactor	(5) Reactor system via degasifier demineralizer

Care must be exercised while valving. For example, do not place the unit in service from the pool system to the reactor system, since this would flow reactor water from the reactor to the pool system through the equalizer legs. Here are the valving arrangements: 1-1, 1-3, 2-2, 3A-2, 3B-1, and 3B-1. When switching the degasifier to systems involving the pool, valving should be done as quickly as possible to avoid transfer of excess water between systems.

7. Removing the Degasifier from Service

The degasifier is taken out of service by a step-by-step reversal of the above procedures.

5.2.7. Large Facility Water System

References

Dwgs. D-24644 and C-24645

1. Introduction

Reactor system cooling water, supplied from the facility cooling system, Fig. 5.14, is used to cool the north and south facilities. The pebble bed of the large plug, the annulus of the plug, and the volume of the dished head and oval facility in the reactor vessel are normally filled with this water which circulates and removes the heat.

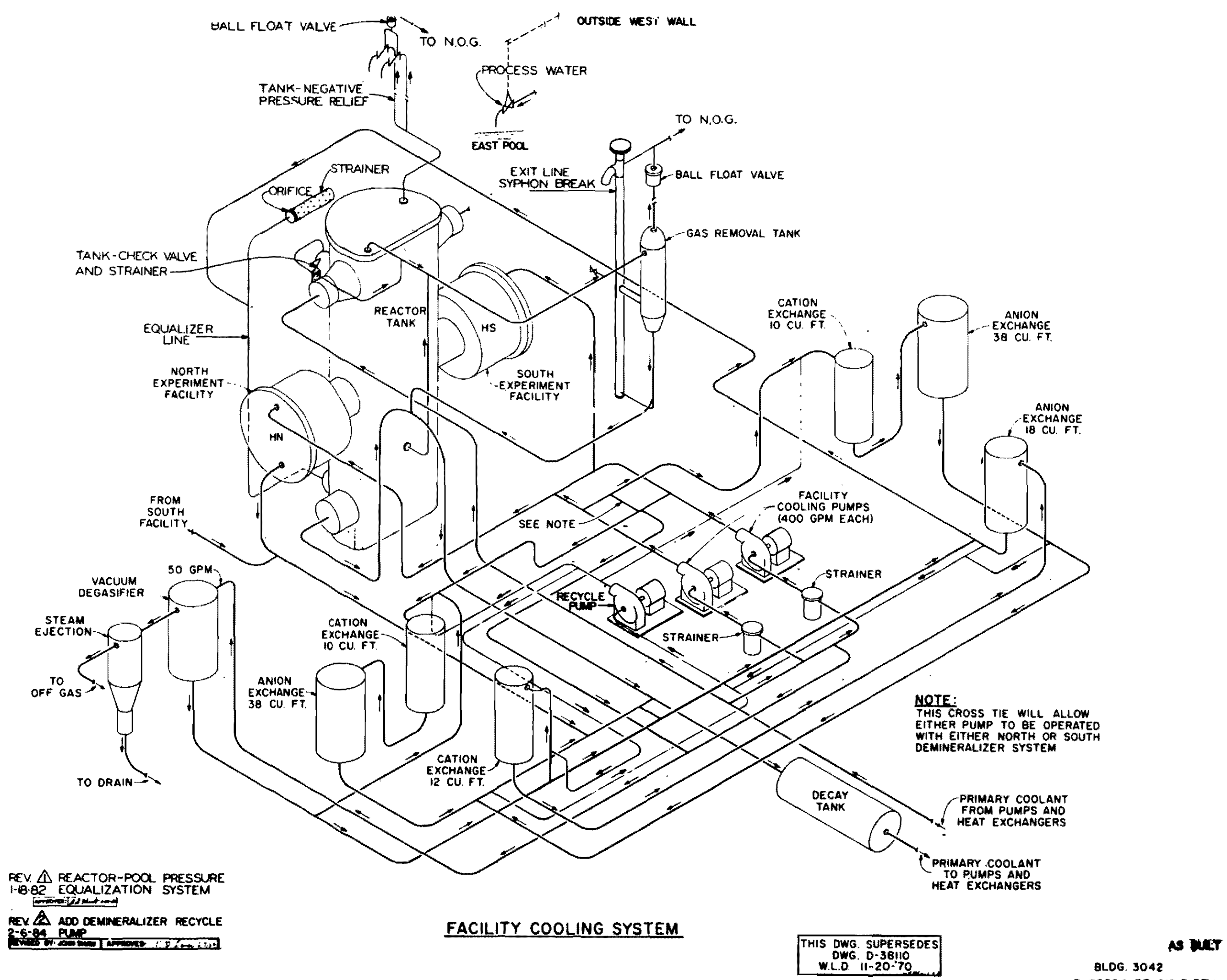

Fig. 5.14. Facility cooling system and reactor primary demineralizer flow system.

Since there are similar units on opposite sides of the reactor vessel, extreme caution must be exercised when obstructing the normal flow. Design engineers have placed a maximum differential pressure on the facilities of 15 psi; this should never be exceeded. The piping to the facilities has been rearranged to simplify draining and minimize the chance of error.

Serious radiation incidents can occur as a result of errors during draining since the reactor pool water is usually at grating level when the facilities are drained. It is possible to lower the water level in the reactor tank during an erroneous draining procedure, resulting in an extremely high radiation level in the reactor pool.

Procedures for filling and draining, below, should be followed in the order given.

A checklist for this procedure, Example 5.9, is to be completed for each draining and filling operation. The completed list, properly signed, is to be submitted to the Reactor Supervisor by the shift supervisor.

2. Draining the facilities

   a. The following steps must be completed when draining the north or south facility, or both facilities.

      (1) Lock out and tag the main reactor cooling pumps. These pumps must not run during the draining operation or while only one facility is drained because of high differential pressure.

      (2) If the reactor pool water is at grating level, station a Health Physics surveyor or an appropriate alarming monitron over the reactor tank.

      (3) If the reactor pool is full (to overflow lip)

         (a) Remove the reactor demineralizer from service.

ORR NORTH AND SOUTH FACILITIES

DATE	TIME	SUPERVISOR

Facility to be drained: ☐ North ☐ South ☐ Both

☐ Main pump test blocks pulled
☐ Pump switches tagged

☐ Cut off facility cooling pump and valve shut

☐ H. P. or monitron above tank
☐ Operator at poolside

DRAIN NORTH FACILITY	DRAIN SOUTH FACILITY ANNULUS
☐ Fill valves S-730 and S-750 closed	☐ Fill valve N-1 closed
☐ Fill valve N-1 closed	☐ Fill valves S-730 and S-750 closed
☐ Grinnel valve 303-A closed	☐ Grinnel valve 303-A closed
☐ North vent valve open	☐ South vent valve open
☐ Drain valve N-2 open	☐ Annulus drain valves S-739 and S-740 open
☐ Drain valve N-3 open	☐ Plug drain valves S-759 and S-760 closed, locked
☐ Restart facility pump for demineralizer	☐ Restart facility pump for demineralizer
OPERATOR	OPERATOR
SUPERVISOR	SUPERVISOR

FILLING THE FACILITIES

☐ Drain valves N-2 and N-3 closed
☐ Drain valves S-739, S-740, S-759 and S-760 closed and locked
☐ Grinnel valve 303-A open
☐ Fill valve N-1 open
☐ Fill valves S-730 and S-750 open

☐ Valve facility pump open and restart pump
☐ Adjust south facility flow per MSR
☐ Close vent valves
South facility flow ____________ gpm
North facility flow ____________ gpm

OPERATOR

SUPERVISOR

UCN-2342
(3 8-83)

Example 5.9.

(b) Station an operator at poolside to observe the water level. A warning should be given if the level is lowered during this operation.

(4) Complete the checklist of this section.

b. For draining the south facility, proceed in the order given below:

(1) Complete parts a(1), a(2), and a(3) above.

(2) Close the inlet valve, No. N-1, to the north facility. This will prevent a syphon action between the facilities which drains the reactor tank.

(3) Close the inlet valves, Nos. S-730 and S-750, to the south facility.

(4) Close valve No. 303-A, a Grinnel valve, located in the basement area at the extreme east end of the demineralizer gallery. It has a remote-control handle at this point. The actual location of the valve is in the pipe chase. Failure to close this valve will allow the reactor tank to drain.

(5) A vent valve for each facility is located on the third level on the inside wall of the reactor pool approximately 2 ft below the normal water level. Open the vent valve on the south side when the pool level is lowered.

(6) The drain valves for the south facility plug are located on the basement ceiling and are Nos. S-759 and S-760. Check to see that these valves are closed and locked. Open annulus drain valves Nos. S-739 and S-740 located on the ceiling of the basement.

(7) Complete the checklist for this section.

c. For draining the north facility, proceed in the order given below:

(1) Complete parts a(1), a(2), and a(3) above.

(2) Close the inlet valve to the south facility, No. S-1. This will prevent a syphon action between the facilities which will drain the reactor tank.

(3) Close the inlet valve to the north facility, No. N-1.

(4) Close valve No. 303-A, a Grinnel valve, located in the basement at the extreme east end of the demineralizer gallery. It has a remote-control handle at this point. The actual location of the valve is in the pipe chase. Failure to close this valve will allow the reactor tank to drain.

(5) A vent valve for each facility is located on the third level on the inside wall of the reactor pool approximately two feet below the normal water level. Open the vent valve on the south side when the pool level is lowered.

(6) The drain valves for the north facility plug are located in the basement directly under the facility but at the basement ceiling elevation. These two valves, Nos. N-2 and N-3, should be opened to the warm drain.

d. To drain both facilities:

(1) Complete sections a, b, and c above.

(2) Complete all applicable sections of the checklist.

3. Filling the Facilities

a. Close drain valves Nos. N-2 and N-3 on the north facility.

b. Close drain valves No. S-739, S-740, S-759, and S-760 on the south facility.

c. Open valve No. 303-A, located in basement, which is the only exit valve on the facilities.

d. Open the inlet valves to the facilities - on the north side, first level, valve No. N-1; on the south side, first level, valve Nos. S-730 and S-750.

e. Start the facility cooling pump if it is not already running.

f. By checking the vent valves at the third level, it can be determined when the facilities are filled. As soon as the air has bled off, close the "Hoke" vent valves.

g. Flow through each unit can be observed via a square-root gauge located on the wall at each facility.

h. Complete the checklist for this section.

5.2.8. The Bypass Filters

It is desirable to continually pass a portion of the reactor system water through a filter. Two 100-gpm filters, located north of the ORR pump house, have been provided for this purpose. To put the filters into service perform the following valving operations.

1. Open valves No. 115B and No. 115C.
2. Open valves No. 115A and No. 115C on the east filter column and/or valves No. 116B and 116C on the west filter column.
3. Close valves No. 109A and No. 503A.
4. Vent air from columns.

5.2.9. Gas Removal System

The ORR gas removal system consists of several ball-float traps which are located above, and connected to, parts of the water system where gases would naturally collect. These ball-float traps, normally full of water, contain valves which open automatically when gas is collected. The exit lines are connected to the building off-gas system.

Figure 5.4, Gas removal system of ORR, shows the ball-float trap and associated piping for gas removal from the reactor tank and the north exit water line. A similar installation exists for the south exit line.

The ball-float trap is located in a recess in the pool parapet. The gas-removal tank is located in the reactor pool below the grating level and near the north wall of the pool. Any entrapped gases would move, as shown by the arrows, from the reactor tank or the exit line to the gas-removal tank and up to the ball-float trap. Final movement would be to the off-gas system.

The reactor pool equalizer leg, also shown in Fig. 5.4, is not directly related to gas removal; but, rather, it allows for expansion or contraction of water in the otherwise totally enclosed reactor cooling loop. The equalizer leg also can be used to provide emergency cooling flow.

Additional ball-float trap installations throughout the reactor water system are:

1. above the bellows-type expansion joint in line 101, reactor water exit located in the expansion pit (sump No. 4) near the bottom of the steps to the pump-house area,
2. above the 10,000-gal decay tank located south of the pump house,
3. one above each column of the reactor and degasifier demineralizers (total of 8),
4. one above each column of the pool demineralizers (total of 2), and
5. one which serves the upper reactor tank check-valve assembly (syphon-break system) located in the southeast corner of the reactor pool.

5.2.10. The Syphon-Break System

1. Introduction

Since certain types of pipe ruptures have the potential to uncover the core shortly after a rupture occurs, the ORR has a syphon-break system to deal with major pipe ruptures. The reactor primary cooling system contains a piping arrangement depicted in

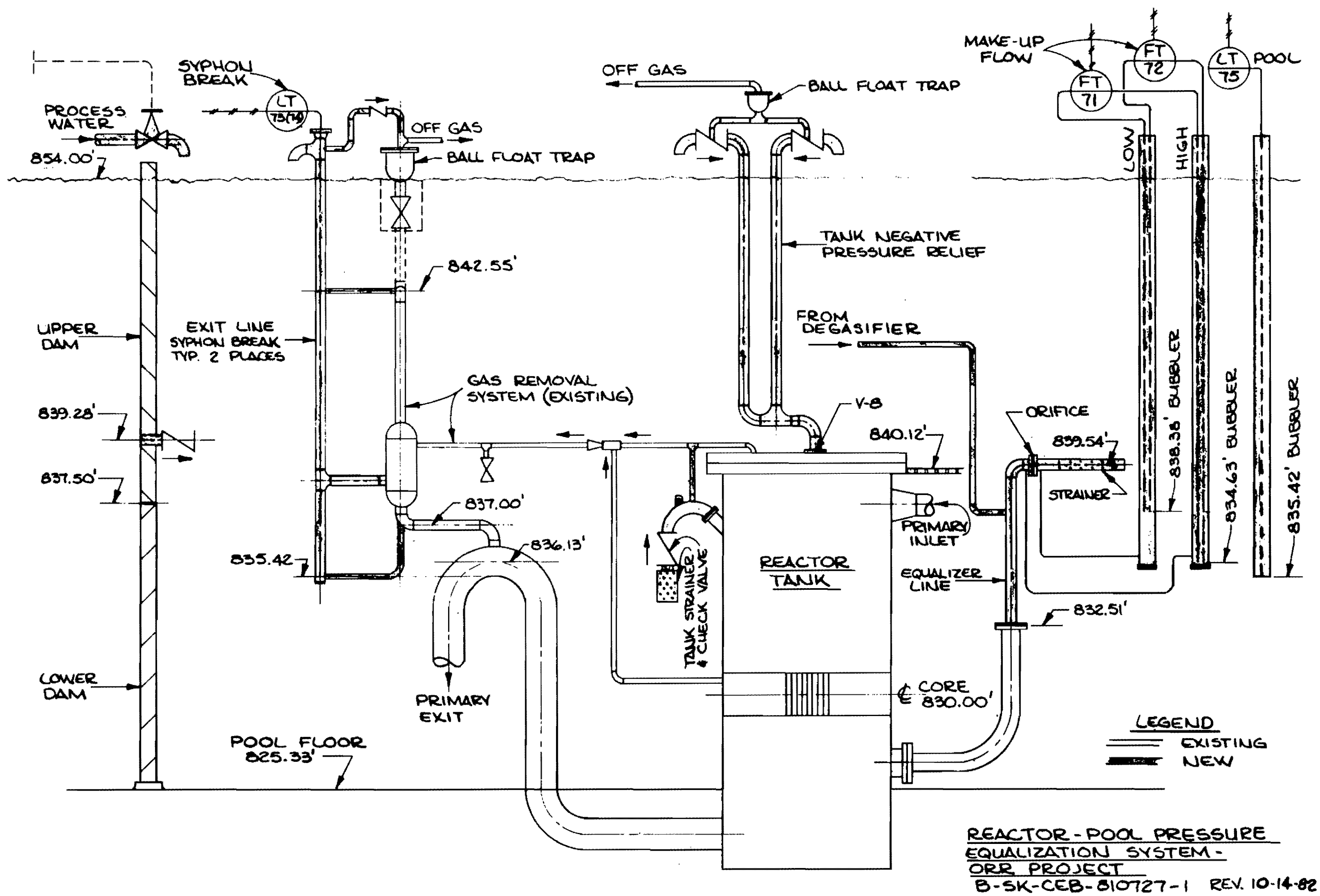

Fig. 5.15. ORR syphon-break system.

Fig. 5.15 which will minimize the consequences of major pipe ruptures. This section will give a brief explanation of the major components of the system.

2. System modifications

a. Standpipe

A 3-in. diam aluminum standpipe is connected to each of the two existing gas-removal tanks. The purpose of these standpipes is to allow a large volume of air to enter the tops of the primary piping inverted U-bends in the event of a rupture, thus precluding the formation of a reactor-tank-draining syphon.

The top of the standpipe (open end) terminates in a "T" and 90° elbow configuration; any water that might splash out of the standpipe is thus redirected to enter the pool. The standpipe is also kept under a constant off-gas sweep to scavange any radioactive gases that might evolve. After it connects with the gas-removal tank, the standpipe continues downward and terminates at an elevation corresponding to the bottom section of the inverted U-bend. One-inch tubing then runs from the bottom of the standpipe to the 3-in. piping that connects the gas-removal tank with the top of the inverted U-bend. The purpose of this configuration is to allow measurement of the standpipe's level from completely full to about 6 in. above the top of the inverted U-bend. A bubbler system is used to measure each standpipe's level.

b. Equalizer line

The equalizer line is located on the east side of the reactor vessel and connects with the primary system at the lower reactor tank manhole flange. The equalization line strainer is located just below the pool grating level.

Immediately downstream of the equalizer line's strainer, yet upstream of the degasifier line connection, a 2-in. diam orifice plate is installed. The differential pressure across this orifice plate is a function of makeup rate through the equalizer line and, thus, is used to generate indication, alarm, and automatic control function.

c. Slant-tube check valves

A 4-in. swing check valve is installed on each 45° slant tube (total of two). The purpose of these check valves is to dump pool water directly on top of the core in the event the reactor tank is depressurized. Two check valves were used rather than a single one for redundancy and reliability.

Each check valve contains a pivot shaft through the valve body with an attached lever arm and weight assembly. The lever arm and weight were adjusted so that the check valve will lift when a 1 psi differential pressure is applied across it. A strainer is bolted on each check valve's suction to screen out foreign matter. A gas-removal connection was made to the uppermost point in the slant-tube check valve assembly to remove any air trapped by draining and refilling the reactor tank.

d. Upper reactor tank check valves

This piping prevents the formation of a vacuum in the upper reactor tank. If allowed to form, such a vacuum would draw air from the inverted U-bend standpipes up through the core, possibly unseating core elements. In addition, a vacuum in the reactor tank could cause core boiling or damage to the tank itself. In order to preclude such effects, two 3-in. swing check valves are installed on the reactor tank top.

Specifically, a 4-in.-diam aluminum pipe is attached to experiment flange V-8 in the reactor tank top. This 4-in. pipe is run to the southeast corner of the pool, where it joins two 3-in.-diam aluminum risers. These risers extend upwards out of the pool, and then turn horizontal. Check valves are installed at the tops of each riser. A 90° elbow is installed on the suction side of each check valve so that any back leakage will be redirected to the pool. Also, the uppermost portion of the piping is vented to the off-gas system via a ball-float trap so that any air trapped by draining and refilling the reactor tank will be removed. The check valves are designed to lift when the upper reactor tank pressure drops to a vacuum of 1 psi.

e. Instrumentation and controls

Instrumentation is provided for control-room indication and for automatic control purposes. Pneumatic bubbler systems are used throughout to avoid locating instruments in the pool; rather, all of the ΔP cells are mounted on one panel located on the north pool balcony with dip legs that run into the pool. The system is designed so that a loss of pneumatic control air will scram the reactor and transfer the main cooling pumps to the pony motors.

f. Makeup rate

Makeup rate is determined by measuring the differential pressure across the equalizer line orifice. Two 1-3/4 in. standpipes are connected to the upstream and downstream sides of the orifice via 5/8-in. tubing; thus, the difference in the level between these two standpipes is proportional to the differential pressure across the orifice. Two 3/8-in. dip legs extend down into each standpipe and are connected to the ΔP cell and bubbler panel. This provides two channels of makeup flow rate indication. The makeup flow rate ΔP cells' outputs are pneumatically transmitted to the control room where a recorder displays makeup rate. In addition, pressure switches are also connected to the output. These switches provide an alarm at 30 gpm, a scram at 60 gpm, and an automatic transfer of the main pumps to the pony motors at 75 gpm.

g. Standpipe and pool level

One 3/8-in. dip leg extends down each of the inverted U-bend standpipes, and is connected to the ΔP cell and bubbler panel. In addition, a 3/8-in. dip leg extends down the northeast wall of the reactor pool to measure pool level. The outputs of these level ΔP cells are pneumatically transmitted to the control room where they are displayed on two 2-pen recorders, i.e., north standpipe level and pool level are shown on one recorder and south standpipe level and pool level are shown on the other recorder. The difference between pool level and inverted U-bend standpipe level can thus be easily evaluated. (This difference is roughly proportional to makeup rate.)

5.3. Reactor Secondary Cooling System

References

Dwgs. D-44118, D-37843, D-37865, D-37866, D-37961, D-37963, D-38723, D-39834, D-43643, and D-39833

5.3.1. Introduction

The reactor secondary system uses process water as the heat transfer medium. The secondary cooling water flows from the cooling tower basin, which normally contains approximately 70,000 gal of cool water, to the secondary circulating pumps. The discharge from the pumps runs to a common 14-in. line in the secondary pump house and travels west to the outside and underground. From this point, the line turns southwest to the heat exchanger pit, rises out of the ground and into the north top opening of the east end of the four shell-and-tube heat exchangers. The water makes two passes on the tube side and out the south top opening of the east end of the exchangers, Fig. 5.5. The pipe parallels the inlet line to the heat exchangers and proceeds toward the secondary pump house. Just outside the pump house, the line turns north, parallel to the cooling tower.

Part of the water can bypass the tower and proceed to the pump suction, depending on the cooling demand; the remainder flows through the two risers to the top of the tower. As the warm water falls through the cooling tower, the cooling tower fans draw air past it, evaporating some of the water and cooling the remainder. The cool water is then retained in the cooling tower basin which serves as a reservoir for the system. the basin water level is kept constant by a ball-float level-control valve which adds process water to make up evaporation and other losses.

5.3.2. Draining the Reactor Secondary System

The reactor secondary system is drained for cleaning and/or inspection as required.

1. Draining the cooling loop
   a. The reactor must be shut down and the secondary circulation stopped.
   b. Close block valve 450A on the process-water make-up line.
   c. Open the drain valve, located underground at the southwest corner of the tower.
   d. When the tower basin is drained, close the drain valve.
2. Draining the heat exchangers

   Drainage is accomplished by removing two pipe plugs in each heat exchanger after closing off the inlet and exit valves on each heat exchanger if the remainder of the loop is not to be drained. If the entire system is to be drained, it is not necessary to close these valves.

5.3.3. Filling the Reactor Secondary System

Before the loop can be placed in operation, the tower basin must be filled to operating level with process water. This is accomplished as follows:

1. Inform the steam-plant operator that the tower basin will be filled, requiring approximately 70,000 gal of process water.
2. Slowly open block valve 450A, which is located underground at the southwest corner of the tower. This allows process water to flow through the automatic float valve, 450B, into the tower basin. Valve 450A should remain open after the basin is filled.
3. If the process-water header pressure can be further reduced without affecting other areas, valve 451A, located in the process-water line above ground near valve 450A, can be slowly opened. The basin level must be observed closely while valve 451A is open, and the valve must be closed when the water level nears the operating point.

5.3.4. Placing the System in Operation

After the water in the tower basin has reached the operating level (determined and automatically controlled by the float valve on the process-water make-up line), the entire secondary loop should be readied for automatic operation. The following items should be checked for proper status:

1. Tower fans
    a. Circuit breakers in "on" position
    b. "Forward" mode of operation selected
    c. Toggle switches in "auto" position
2. Heat exchangers
    a. Secondary inlet valves 801A, 802A, 803A, and 804A open
    b. Secondary exit valves 811A, 812A, 813A, and 814A open
3. Tower

    Block valves 815A and 816A, at the top of the tower on the water risers, open
4. Control system

    Set points established and system in "auto"
5. Circulating pumps
    a. Inlet block valves 817B, 818B, and 819B open
    b. Exit block valves 817C, 818C, and 819C open
    c. Cooling water turned on to each pump gland
    d. Air bled off the top of each impeller housing
    e. Air bled off the bypass line at the west end
    f. Circuit breakers in "on" position

The secondary loop can now be placed in operation, when required, by turning the circulating pumps on from the pump house. The "pump on" light in the center of the switch in the control room should come on.

When the pumps are started, the following items should be checked immediately:

1. Recheck the cooling water to the pump glands. Check the glands for excessive temperature.
2. Equalize the flow in the north and south risers by adjusting valves 815A and 816A at the top of the tower. Observe the flow rate in each riser on the flow meters in the pump house. A visual check of the flow can be made at the top of the tower in the event the flow meters are inoperative.
3. Check the fans and the tower structure for excessive vibration.
4. Observe that the fan mode lights in the control room indicate the actual "high," low," or "off" status.

5.3.5. Tower Operations

The two cooling-tower fans, located at the top of the tower on the east side, pull air through the west side of the tower, across the falling streams of water, and exhaust it out the top of the tower with a high velocity. The large volume of air partly evaporates and cools the warm water falling through the tower. Due to the location of the heavy fans high on the tower in a warm, humid air stream, the fan components are the units most likely to give trouble. Since continuous, dependable fan operation is essential, these units should always be checked carefully.

The fans can be operated in the forward direction (i.e., where air is pulled in from the west side of the tower and blown out the top) at high and low speeds in either "manual" or "automatic" mode. A small toggle switch for each fan is located between the breakers and labeled "auto," "off," and "manual" in its three positions.

1. <u>Operating the fans in the forward direction in "manual"</u>
   a. Place the toggle switch of the desired fan in the "manual" position.
   b. The "stop" light, located on the reversing box adjacent to the breaker, should come on after about 2 min. If this light does not come on, check the main breaker.
   c. Press the "forward" button on the reversing box.
   d. The "low" and "high" speed buttons are now operative, and the desired speed can be selected.
2. <u>Operating the fans in the forward direction in "automatic"</u>
   a. Place the toggle switch of the desired fan in the "automatic" position.
   b. The "stop" light, located on the reversing box adjacent to the breaker, should be on. If this light is not on, check the main breaker.
   c. Press the "forward" button on the reversing box.
   d. The fan will now operate automatically at either low or high speed as required by the control system.
3. <u>Operating the fans in the "reverse" direction</u>

The fans are sometimes operated in the "reverse" direction in order to de-ice the cooling tower. In this mode, air is pulled in at the top of the tower, warmed by contact with the water, and then blown out the west side of the tower, melting any ice which may have formed on the louvers. Since the tower efficiency is much lower than normal, the continual presence of an operator is required when the fans are operated in this mode.

Reverse only one fan at a time, leaving the other to handle normal cooling requirements. Reversing both fans simultaneously has been known to shut the reactor down due to loss of cooling.

Do the following to the controls of the fan to be reversed:

a. Place the fan to be reversed in manual. This will eliminate off/on and high-speed operation from the automatic controls.

b. Push the "stop" button on the reversing box. After some 2 min, the "stop" light will come back on.

c. Push the reverse button.

d. Push the low-speed button.

Observe the ice after about 10 min. When ice has melted, continue as follows:

e. Push "stop" button on reversing box. After some 2 min, the "stop" light will come back on.

f. Push forward button.

g. Push low-speed button.

h. Follow above steps to reverse the other fan.

i. Operate fan control switches in low-speed manual until basin water temperature decreases to approximately 75°F and fan speed indicator controller is demanding at least fan speeds of low-off or low-low before switching back to automatic mode.

4. Cooling tower preventive maintenance

The cooling tower and secondary circulation system were designed to operate continuously, 24 h per day. However, dependable operation demands that there be a systematic schedule of inspection, lubrication, maintenance, and ultimate replacement of all the components. To facilitate this systematic check, an inspection form, provided by the tower manufacturer, is completed during the quarterly shutdowns. This inspection form is Example 5.10.

ORR COOLING TOWER INSPECTION

OWNER	DATE INSPECTED
PLANT	INSPECTED BY
LOCATION	TOWER MANUFACTURER
INSTALLED 19 / MODEL NO.	WATER TREATMENT USED

CONDITION: 1-GOOD; 2-REPAIR; 3-REPLACE	1	2	3	CONDITION: 1-GOOD; 2-REPAIR; 3-REPLACE	1	2	3
END WALL CASING				WATER DISTRIBUTION			
LOUVERS				UNIFORM			
STAIRWAY				NOT UNIFORM			
HANDRAILS				STRUCTURAL MEMBERS			
WALKWAYS				COLLECTING BASIN			
DISTRIBUTION SYSTEM				CONCRETE			
STEEL PIPE				SUMP			
CAST-IRON PIPE				SCREENS			
FLOW VALVE				OVERFLOW			
DISTRIBUTION BASIN				FAN			
NEEDS CLEANING				BLADES			
FAN DECK FLOOR				TIP CLEARANCE			
FAN DECK FLOOR SUPPORTS				BLADE PITCH			
FAN CYLINDERS				VIBRATION NO VIBRATION			
WOOD				GEAREDUCER			
STEEL				QUIET NOISY			
FAN BEAMS AND CONNECTING FRAMING				OIL LEVEL			
MOTOR AND GEAREDUCER MOUNTS				OIL VENT			
DOORS				BACK LASH			
PARTITIONS				PINION SHAFT PLAY			
ELIMINATORS				FAN SHAFT END PLAY			
FILL				DRIVE SHAFT			
				MOTOR			
				BLOWDOWN LINES			

GENERAL COMMENTS AND REPAIR

UCN-5595
(3 3-64)

Example 5.10.

5. Routine Checks

The following checks should be made at the indicated frequency:

a. Check once each shift when the tower is in operation:

   (1) Unusual noise or vibration of the mechanical equipment

   (2) Indication of the motor overheating or bearing trouble

   (3) Proper water level in the tower basin

   (4) Proper water distribution and break-up in the tower-fill area

   (5) Operation of the circulating pumps

   (6) Suction screens, for clogging

   (7) Indication of oil leakage on the motors, pumps, and gear reducers

b. The quarterly inspection is made with special emphasis on the following checks:

   WARNING: Be sure that the main switch is locked out before entering the fan cylinder.

   (1) Check the speed-reducer lubricant for evidence of sludge or condensation. If the lubricant is contaminated, flush and refill the speed reducer.

   (2) Check the drive-shaft alignment and coupling condition. Align the drive shaft, if necessary, and replace worn or damaged couplings.

   (3) Check the condition of the fan blades and hub. Be sure the attaching bolts and cap screws are in good condition.

   (4) Check and tighten, as required, the bolts holding the mechanical equipment to the tower framing.

   (5) Clean the water-distribution system as required.

c. Every six months:

(1) Drain, flush, and refill the speed reducer with oil.

(2) Check the condition of the tower structural members, end wall casing, louvers, stairway, distribution system, fill, and drift eliminators. Replace or repair any damaged members. Tighten the structural-member bolting if necessary. Test the structural wood for indication of fungus attack by probing or testing with a hammer for soft spots. Infected members should be replaced.

5.3.6. Chemical Conditioning of Tower Water

1. Objectives

Water-conditioning procedures and chemical additions are employed to accomplish a number of objectives. Some of these are:

a. To maintain a protective film on metal components, a continuous phosphonate feed is used. It is desirable for the pH to be held between 7.3 and 7.8 for this treatment to be most effective.

b. To control microbiological growths, periodic additions of biocide minimize the deterioration of the redwood lumber in the cooling tower.

c. The close control of the total solids in the system is essential for the chemical treatment to be successful at a minimum cost. If the total solids content is permitted to rise too high, there is some risk of solids depositing on the heat-transfer surfaces. On the other hand, too low a total solids content indicates excessive blowdown and excessive costs for treatment chemicals and water.

2. Phosphate treatment

The phosphate treatment should be started as soon as the tower basin is filled and circulation is established. The continuous injection into the system is accomplished by a small pump, pumping from a 55-gal drum of treatment chemicals to the basin.

a. Set pump speed control knob on 30 and the stroke length knob on 38. At these settings the pump discharge rate should be approximately 15 ml/min. To keep the phosphate concentration at approximately 100 ppm, the pump discharge rate can be increased or decreased by the speed control knob on the south side of the pump.
b. Analyze for phosphate content twice each shift and make required adjustments to maintain the desired phosphate level.

3. Biocide treatment

The periodic injections of biocide to control microbiological growths should be performed as follows.

a. After the tower basin is filled and water circulation is started, add 3 gal of biocide to the sump.
b. Close the No. 1 blowdown valve and leave closed for 4 h.
c. During operation, treat the tower basin with 7 gal of sodium hypochlorite on Tuesday and 3 gal of biocide on Friday of each week. Close the blowdown valve for 4 h after each treatment. NOTE: Do not close the corrosion test holder valve on the reactor tower south riser during the treatments.

4. Total solids control

The water blowdown to control total-solids content should be started not more than 24 h after the heat load has been placed on the tower. The blowdown rate is set as follows.

a. Sample the water and analyze it for conductivity. See section on conductivity analysis with a Nalcometer, page 5-146. Control between 900 and 1000 micromhos.

b. If the micromho reading is greater than 1000, start the blowdown water flow in the following manner.

   (1) Open blowdown valve No. 1 located on the 2-in. blowdown line on the west side of the tower basin approximately one-half way open. This is a manually operated valve used for coarse control.

   (2) Turn on the power to the total solids controller which supplies power to two solenoid valves, one in the north riser 1-in. blowdown line and one in the south riser 1-in. blowdown line. These two solenoid valves provide automatic control for fine control within the control limits.

c. The blowdown rate will be approximately 40 gpm at equilibrium to maintain the desired ratio.

d. Under normal operating conditions, the conductivity of the tower water will be determined once each shift and the coarse blowdown rate adjusted accordingly.

5. <u>pH control</u>

Since the solids in the process water fed to the basin are being concentrated because of the high evaporation rate, the pH of the system tends to rise, primarily due to the increased concentration of $CaCO_3$. A high pH is very deleterious to the wood in the cooling tower, so sulfuric acid is fed into the system to lower the pH. However, this acid addition must be controlled very carefully, since an excessive amount of acid would be harmful to the metallic components of the system. A pH of 7.3 to 7.8 is desirable for normal operation. Control of the pH is normally effected through an automatic-control system as described below. Manual operation may become necessary at times and a constant watch must be maintained to ensure that the controls are operating properly. It is the purpose of this procedure to describe the control system and to outline the daily operational procedure.

The pH-control system at the reactor cooling tower consists of:

a. the 900-gal capacity storage tank for concentrated H_2SO_4,

b. two variable-stroke metering pumps,

c. a constant-flow pH monitor,

d. a local pH-indicating modifier,

e. a control room pH recorder with high and low alarms, and

f. a control room controller with an "auto-manual" switch and a pumping-rate indicator.

When the system is in automatic, a signal from the probes is transmitted through appropriate wiring to the local indicating modifier, AM-7. The output of the local indicating modifier is a 0-10 millivolt electrical signal to the control room recorder, AR-7. Microswitches in AR-7 give an alarm if the pH drops below 7.3 or rises above 7.8. Recorder AR-7 also contains a control slidewire which covers 20% of the range of AR-7. Voltage which varies with the pH recorded is "picked off" this slidewire as a signal to controller AC-7. The output signal (0-5 milliamps) from controller AC-7 is transmitted to an electrical-pneumatic converter in the secondary pump house. This signal is indicated in the control room (AC-7) and in the secondary pump house (AI-7). The converter's pneumatic output (3-15 psi) supplies a "coniflo" positioner at the metering pump selected for service. The "coniflo" positioner determines the pumping rate by varying the length of stroke of the pump. The milliamp signal to the electrical-pneumatic converter is controlled by the operator when in the manual mode through use of the "current adjust" knob on the face of the controller in the control room.

6. Placing the system in service

NOTE: The acid-metering pump selected for service (the selector switch is located on the No. 2 acid-metering-pump breaker box at the pump house) will automatically start when one of the reactor secondary pumps is running and the secondary bypass valve is less than 90% open. These conditions prevent the pumping of acid into the tower basin when there is no flow over the tower. It is evident, then, that the acid-addition system should be readied for service before the secondary system is started. If it is not practical to ready the acid system, the disconnects for the acid-metering pumps should be opened before starting the secondary system.

a. Open the inlet and exit valves at the metering pump.
b. Close the breaker for the selected metering pump.
c. Open the inlet valves to the pH probe and rotate the cleaner blade of the strainer.
d. Place the system in AUTOMATIC or MANUAL mode, as deemed necessary, by use of the switch in the control room.
e. After secondary flow has been established over the tower for a period of 15 to 20 min, begin the sampling procedure as outlined below.

7. Sampling procedure

To ensure proper operation of the automatic control or to provide a basis for adjustment, if in MANUAL, it is normally necessary to sample the secondary stream at 4-h intervals. More frequent checks are necessary when the condition of the reactor system is undergoing rapid changes.

a. Collect a sample of the secondary water from the sampling station provided in the secondary pump house. Secondary water should flow through this line continuously; if not, then start a flow and allow sufficient time for the sample line to be cleared of stagnant water before sampling.

b. Measure the pH of the sample using the portable pH meter provided at the secondary pump house. Be assured that the meter is operating properly, using a buffer to check if necessary.

c. Adjust the acid flow to obtain a pH of 7.3 to 7.8 if in MANUAL.

d. If in AUTOMATIC, compare the reading obtained with the portable instrument with the indicated pH at the local panelboard. The two should agree within reasonable limits (difference of 0.2 pH units).

e. Rotate the "tee" handle on the filter several times to clean the plates in the filter.

f. Check that the flow across the probes is about 0.2 gpm.

8. Removing the system from service

a. No action is necessary for short-term shutdowns.

b. For shutdowns lasting several days, or during which experimental or maintenance work will be done at the secondary system, the following steps are necessary.

(1) Open the breakers supplying the metering pumps. Tag with a properly completed "DO NOT OPERATE" tag.

(2) Close the inlet and exit valves at the metering pumps.

5.3.7. Chemical Hazards

As described in this section, Microbiotreat DK520, ENDCOR 4630, and sulfuric acid are presently used to treat the reactor and pool secondary-water systems for various reasons. These chemicals are potentially hazardous if they are not handled properly. Brief descriptions of the purposes, the toxicology, and the disaster hazard for each chemical along with recommended safe operating practices are given below.

1. Microbiotreat DK520

   a. Purpose. The use of Microbiotreat DK520 in the treatment of cooling-tower water controls slime and microbiological and actually kills microorganisms. It also has nonoxidizing characteristics for the prevention of wood rot in the cooling towers. This biocide is a liquid preparation which contains the following active ingredients.

      Poly[oxyethylene(dimethyliminio)ethylene (dimethyliminio)ethylene-dichloride]

   b. Harmful effects. Causes eye damage and skin irritation. Harmful if swallowed or inhaled over a prolonged period. In case of skin contact, wash with plenty of soap and water. For eyes, flush with water 15 min and get prompt medical attention. If swallowed, drink promptly a large quantity of milk, egg white, gelatin solution, or if these are not available, drink large quantities of water. Avoid alcohol. Get prompt medical attention.

2. ENDCOR 4630

   a. Purpose. This blend of organic sequestrants and anti-foulants is used to control mineral and organic fouling. It contains corrosion inhibitors which provide protection to all system metals. ENDCOR 4630 contains the following ingredients:

      (1) HEDP - Hydroxyethylidene diphosphonic acid

      (2) EDTMPA - Ethylenediaminetetramethylene diphosphonic acid

      (3) PMA - Polymethacrylate

      (4) MBT - Mercaptobenzothiazole

      (5) Na_3PO_4 - Trisodium phosphate

      WARNING. Alkaline solution not to be taken internally. Use gloves and protective clothing when handling. If solution gets on skin, wash with plenty of water. If eyes are affected, flush with water and get medical attention.

3. Sulfuric acid

a. Purpose. The solids in the process water fed to the basin are being concentrated because of the high evaporation rate. This tends to raise the pH primarily due to the increased concentration of calcium carbonate. A high pH is undesirable for two reasons: (1) it is deleterious to the wood in the tower, and (2) it is not conducive to good control of corrosion and biological growth. The pH of the water, therefore, is controlled in the range of 7.3 to 7.8 by the addition of sulfuric acid.

b. Toxicology. In concentrated form, sulfuric acid acts as a powerful caustic to the skin, destroying the epidermis and penetrating to the underlying tissue. This causes great pain, and, if much of the skin is involved, it is accompanied by shock, collapse, and symptoms similar to those seen in severe burns. The fumes cause coughing and irritation of the mucous membrane of the eyes and upper respiratory tract.

c. Disaster hazard. Dangerous; when heated it emits highly toxic fumes.

d. Countermeasures. In all cases of contact in any form, immediately give prolonged applications of running water to wash the material from the body. If the eyes are involved, they should be irrigated immediately with copious quantities of water for at least 15 min. If swallowed, do not induce vomiting. If the patient is conscious, have him wash out his mouth with water and drink as much water as possible (milk is preferable but not as readily available).

4. Safe operating practices

a. Transporting. When loading, transporting, or unloading toxic or corrosive materials, handle the containers carefully to avoid possible damage and subsequent leakage. Protective clothing should also be worn. If a leaky container is discovered, report it immediately to the shift supervisor.

Normally, flushing the spilled chamical with water to a process floor drain will be the corrective action.

b. Storage. The metal drums containing Microbiotreat DK520 should be stored where the temperature is above 32°F (0°C). ENDCOR 4630 should be stored where the temperature is above 2°F.

c. Routine handling

(1) When transferring acid from the truck to the storage tank, protective equipment must be used. This includes wearing rubber gloves, a rubber apron, and a face shield. Rubber gloves and a face shield are used when handling Microbiotreat DK520 at either tower.

(2) When changing from almost empty to full drums of ENDCOR 4630, use rubber gloves and face shield.

(3) Whenever these chemicals come in contact with the skin, wash the affected areas immediately. Showers are available at both towers. If the eyes are involved, wash immediately with the water hoses available at each tower for at least 15 min. If assistance is required, communication is readily available, and at least two individuals on each shift have completed a course in first aid training. All injuries are to be reported to Medical as soon as possible (4-7431).

(4) Personal hygiene is also of primary importance; after handling these chemicals, one should always wash his hands before eating, smoking, or drinking. Reiterating, these chemicals are not dangerous when handled properly. As with most things, they are hazardous when elementary safety practices are ignored.

5.3.8. Procedures for Operating Chemical Testing Instruments

1. L & N pH Meter

Determination of the pH is made on a number of water samples. In all cases, reasonable precautions should be taken to get a representative sample. That is, clean sample containers should be used and they should be rinsed with the sample water. The sample lines should be thoroughly purged, and an adequate sample should be obtained.

After a proper sample has been obtained, the pH meter should be checked. Normally, the meters are left plugged into a 110 V ac supply with the electrodes in water.

a. If the meter is not plugged in, take the following steps.
   (1) Set the mode switch to "start."
   (2) Plug the power cord in the 110 V ac socket.
   (3) Wait 5 min for the meter to warm up.
b. Standardize the meter as follows:
   (1) Place the mode switch in "neut" position.
   (2) Rinse the electrodes with buffer solution and wipe them clean with tissue.
   (3) Immerse the electrodes in buffer solution and place the mode switch in the proper pH range.
   (4) Set the "temp-°C" dial to the temperature of the buffer solution.
   (5) Adjust the "standardization" control until the meter needle indicates the exact buffer pH.
   (6) Place the mode switch in "neut" and move the dial pointer to mark the needle position.
c. After the meter has been properly standardized, a series of pH measurements can be performed as follows:
   (1) Place the mode switch in "neut" and adjust the "standard ization" control, if required, so the needle rests at the dial-pointer position.
   (2) Rinse the electrodes with sample solution and wipe them clean with tissue paper.
   (3) Immerse the electrodes in the solution to be tested.

(4) Place the mode switch in the proper range and read the indicated pH on the meter.

(5) After the measurements are complete, rinse the electrodes with water and leave them immersed in water.

WARNING: Never leave the electrodes immersed in ENDCOR 4630 solution.

2. ENDCOR 4630 phosphate analysis

The secondary water systems are treated with a phosphate solution to retard corrosion. The water must be analyzed for its phosphate content so that the proper level can be maintained. Dearborn 370 Test Kit is used for this analysis, and the proper procedure is as follows.

a. Fill the sample tube to 25 ml scribe mark with water to be tested.

b. Add 10 drops of sodium thiosulfate and swirl to mix. Allow to react 30 s.

c. Add one dipper xylenol orange indicator and swirl to mix. The solution should now be a violet color.

d. Add one drop hydrochloric acid and swirl to mix. Check pH using phydrion paper. Continue dropwise addition of hydrochloric acid and pH checking until the proper pH (2.0-3.0) is reached. The proper pH adjustment at this point is essential. After proper pH is obtained, the solution should be a yellow color. See note following item "h" for proper use of pH paper.

e. Add 10 drops of Interference Suppressor. Mix. Avoid contact with skin or eyes.

f. Add thorium nitrate dropwise, mixing constantly. Count the number of drops needed to change the color from yellow to the first permanent violet color which persists for 30 s. Always hold the dropper bottle in a vertical position. If held at another angle, the drop size may vary.

g. Repeat the procedure on a sample of make-up water without treatment to determine the blank. If a titration is in excess of 15 drops, the sample must be diluted to get a titration value of less than 15 drops.

h. Results

(A-B) x F = ppm Dearborn treatment

A = drops thorium nitrate used in sample

B = drops thorium nitrate used in blank

F = factor - furnished by Dearborn representative

FACTOR = 18

NOTE: Tear off 4-in. strip of pH paper. Dip only the tip of the strip into the sample and compare to the color chart. Tear off the spent tip of the paper and use a fresh end for each comparison. Do not drop paper into sample. The paper is not instantaneously reversible. More important, the dye will leach out and contribute troublesome color background during the chelation end point. The optimum pH for the chelation titration is 2.5.

3. Total-solids analysis with a Nalcometer

For the proper operation of the cooling-tower system, it is necessary to control the total solids dissolved in the secondary water. The total-solids analysis is routinely performed with the Nalcometer as follows:

a. Fill the Nalcometer cup located on top of the instrument with the solution to be tested.

b. Meter scale reads from 0 to 10 micromhos with a range setting of 1 to 1000.

c. Set range setting until meter reads on scale when meter actuate button is depressed.

d. Read meter scale and multiply reading by range setting to obtain total-solids.

5.3.9. Description of Tower Components

To aid in properly inspecting the cooling tower, the various components, their purposes, and the method of operation will be briefly discussed. These items should be familiar to everyone inspecting the secondary system.

1. Speed reducer

The speed reducer is the heart of the tower. It receives power from the high-speed motor, reduces the speed, and increases the torque to drive the fan blades. It is subject to extreme service wear and warrants careful attention and maintenance.

The power-input shaft is held in place within the pinion cage by a set of roller bearings. The output shaft, or fan shaft, is perpendicular to the input shaft and is also held in place by roller bearings. Spiral bevel and helical gears within the reducer change the direction and reduce the speed of the power applied.

Wear develops first in the shaft bearings, both pinion and axle, resulting in loose shafts. Wear can also develop between the gears, resulting in excessive backlash.

As a preliminary check on the condition of the speed reducer, do the following.

a. Try to move the pinion shaft up and down or sideways (indicating pinion bearing wear).

b. Try to move a fan blade up and down (indicating fan-shaft bearing wear).

c. Hold the fan still and rock the drive shaft back and forth (indicating backlash).

If excessive movement is noted at any point, have the drive shaft disconnected and see if the pinion shaft can be moved in and out of the pinion cage. The pinion shaft bearings are set to slightly preload the roller bearings; therefore, any movement of the pinion shaft indicates wear of the roller bearings. If movement is detected, the bearings should be removed for inspection and replaced if damaged or severely worn.

The bearings on the fan shaft can be checked for wear by moving a fan blade up and down and observing the movement of the fan shaft with reference to the top of the speed-reducer casting. Relative movement of this shaft should be slight. Any excessive movement indicates that the speed reducer should be opened and the shaft bearings inspected.

Excessive gear wear can be determined by the degree of backlash or movement of one of the shafts with the other shaft locked. Too much backlash indicates wear of the gear teeth and bearings. These should be inspected and replaced if necessary.

The speed reducer must operate as a unit. Excessive wear or vibration at any one point may impose loads on other parts which lead to their failure. Therefore, the entire unit should be inspected frequently and kept well-adjusted.

Due to the severe atmospheric conditions encountered at the top of a cooling tower, it is easy for moisture to contaminate the gear-reducer lubricant. Any time this oil becomes contaminated, it must be drained, the case flushed out, and the proper lubricant replaced. Two types of contamination can be present, sludge and water condensation.

To check for condensation, heat a metal plate to between 300° and 350°F and place a few drops of gear-reducer oil on it. If the oil boils and foams, it indicates the presence of water. If it merely spreads out and smokes, there is no water present.

To check for sludge, examine the filter cartridge by unscrewing the cap screw and removing the filter-case cap. Inspect the outside of the filter cartridge. If the filter is not dirty, reassemble and refill the system with oil. If it is dirty, the cartridge must be replaced. If the cartridge is exceptionally dirty, inspect the inside of the gear reducer for sludge.

If either sludge or moisture is found in the lubricant, it must be drained, the case flushed out with flushing oil, and refilled with clean oil.

2. Drive shafts

The drive shaft connects the motor, located out of the hot, humid air streams, to the gear reducer in the center of the fan cylinder. It has flexible joints at both the motor end and the speed-reducer end; yet, it is still the major source of vibration in the mechanical equipment. Excessive vibration is cause for shutting the fan down and realigning or balancing the drive shaft.

In the event that the drive-shaft guards are removed for maintenance, they must be reinstalled before the tower is put back into service. Failure of the drive shaft, unprotected by the drive-shaft guards, can result in excessive damage to the fan and speed reducer.

3. Fan assembly

The fan assembly consists of a steel hub, turned by the fan shaft, with the blades attached in radial sockets. Normally, the fan does not require much maintenance, but any unusual noise or vibration is cause for shutting the unit down for inspection. The entire assembly should be closely checked bimonthly to determine that all parts are in good condition and that all assembly bolts are tight. The blades should also be inspected for cracks at the blade attachment and at points where fatigue might be concentrated.

The cooling-tower fans have been balanced. If it is necessary to replace or repair any part of the fan assembly, the balance must be checked when it is first put back into operation. An unbalanced fan assembly will result in vibration and abnormal loads being imposed on the other units of the fan drive.

4. Reactor secondary tower fan vibration switches

Vibration switches are located over the fan motor couplings on top of the tower. If the fan shuts down, pilot lights on the fan panels in the tower pump house will indicate if failure is due to vibration switches or fan overloads. The same push button used to reset the overloads will also reset the vibration switches. If the fan continues to kick out, loosen the set-point lock screw on the vibration switch and turn the set-point control knob 90° clockwise. Start the fan and observe for any excessive vibration. If the vibration is normal, investigate cause of trouble in the vibration switches. When the vibration switch set-point control knob is turned as far clockwise as it will turn, it should allow the fan to operate but will not offer any protection for excessive vibration.

5. Tower lumber

The wetted wooden portions of the cooling tower are redwood, which resists deterioration. However, it is still subject to attack by chemical agents and fungi. The water chemical treatment is designed to minimize this wood deterioration but cannot eliminate it completely.

Chemical attack on tower lumber is a form of deterioration in which oxidizing agents and alkalies attack lignin and also remove materials naturally present which are toxic to wood-destroying organisms. Oxidizing agents such as chlorine can cause very serious damage. Evidence of chemical attack (delignification) can probably be found during the earliest stages of attack in the most heavily wetted and washed portions of the tower wood.

Fungus attack is the decomposition of wood by microorganisms. These microorganisms utilize wood as food. They are everpresent in decaying wood in the forests, and their spores are easily blown by the wind into the cooling tower.

Fungus attack can be classed as white rot, brown rot, and soft rot. White rot decomposes all components of the wood lignin and cellulose. Look for a spongy, stringy condition of the wood and also pockets of white or yellow fibrous material. Brown rot decomposes the cellulose, leaving the lignin more or less unaffected. The wood is reduced to a brown mass which powders easily in the fingers. Both white and brown rots usually leave the surface intact and it is necessary to probe beneath the surface of the wood to detect their presence. These fungi are usually found in the nonflooded zones of the tower.

Soft rot usually takes place in the flooded zones. Attack starts on the surface and progresses inward. It is identified by loosening of surface fibers, eroded surface, and loss of strength. Surface checks across the grain are frequently visible after the wood has dried.

Samples of fill and drift eliminator both should be broken and the interior examined for a darkening in color. The manner in which the wood breaks should be noted - infected woods tend to break straight across the grain with little or no splintering.

6. <u>Tower hardware</u>

All metal parts in the cooling tower are subject to severe corrosive conditions. Special attention should be given to surface protection. Structural bolts must be kept reasonably tight and in good condition. In the event of failure through corrosion or other causes, bolts, nuts, and other hardware must be replaced as required. All structural steel must have a good protective coating (paint) at all times.

5.3.10. Heat Exchangers, Maintenance

At regular intervals, as determined by the Reactor Supervisor, the interior and exterior of all tubes should be examined and cleaned if necessary. Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes, with consequent overheating of these tubes as compared to surrounding tubes, resulting in severe expansion strains and leaking tube joints. Also, a light sludge or scale coating on the tube greatly reduces its effectiveness. A marked reduction in performance usually indicates cleaning is necessary if the unit has been checked for air or vapor binding and such binding is not the cause. Since the difficulty of cleaning increases rapidly as the scale thickens or deposit increases, the intervals between cleanings should not be excessive.

To clean or inspect the insides of the tubes, remove the channel cover and bonnet. Do not remove the channel. CAUTION: Do not loosen heads until assured that all pressure is off the equipment and the unit is drained.

To locate either leaking joints between tubes and tube sheet or a split tube, it is necessary to remove the channel cover and bonnet and apply hydraulic pressure in the shell. The point where the water escapes indicates the defective tube or joint. Use only cold water for hydrostatic test. Hot water will expand the tubes more than the shell, resulting in excessive strain and probable damage.

Scale removal from the tubes may be accomplished either by use of suitable, commercially available, cleaning compounds or by merely circulating high velocity water. Qualified experts from other divisions within the Laboratory may be called upon to check the nature of the deposits to be removed, furnish proper acid solutions containing inhibitors, and provide equipment and personnel for a complete cleaning job. If the above methods are ineffective, hard scale may be removed by mechanical means. CAUTION: Do not attempt to clean tubes by blowing steam through individual tubes.

Gaskets and gasket surfaces should be thoroughly cleaned and should be free of scratches and other defects. Gaskets should be properly positioned before attempting to retighten bolts. It is recommended that when a heat exchanger is dismantled for any cause, it be reassembled with new gaskets. This will tend to prevent further leaks and/or damage to the gasket seating surfaces of the heat exchanger. Composition gaskets become dried out and brittle so that they do not always provide an effective seal when reused. Metal or metal-jacketed gaskets, when compressed initially, flow to match their contact surfaces. In so doing, they are work-hardened and, if reused, they may provide an imperfect seal or result in deformation and damage to the gasket contact surfaces of the exchanger.

5.4. Reactor Water, Temperature Control System

5.4.1. Description of the System

The cooling system for the Oak Ridge Research Reactor has been expanded to allow continuous operation of the reactor at its present maximum power level of 30 MW. A two-section Marley cooling tower has been installed with a four-unit Crane water-to-water heat exchanger to isolate the reactor loop from the tower loop. Figure 5.16 shows the basic flow diagram of the system for which temperature control is required.

The new system replaced eight Trane water-to-air heat exchangers used for the former 20-MW operation.

The reactor or primary loop is a closed loop of demineralized water recirculated through the reactor and the heat exchanger at a rate of 18,000 gpm. The secondary loop is semi-closed with the water recirculated through the heat exchangers at a rate of 10,500 gpm. The cooling tower is rated at 30.78 MW at design conditions of 10,500-gpm water flow rate, 104°F inlet temperature, and a 78°F ambient wet-bulb temperature.

5.4.2. Objectives of the System

The objectives for the temperature-control system are as follows:

1. To maintain steady-state (constant reactor power level) control of the reactor inlet temperature to within ±0.25°F.
   a. It is important to minimize the fatiguing of the reactor structure which results from stresses produced by temperature cycling.
   b. The most accurate method of determining reactor power is to compute it from reactor cooling water flow and the temperature rise across the reactor. Since there is a transport delay across the reactor, if the inlet temperature is

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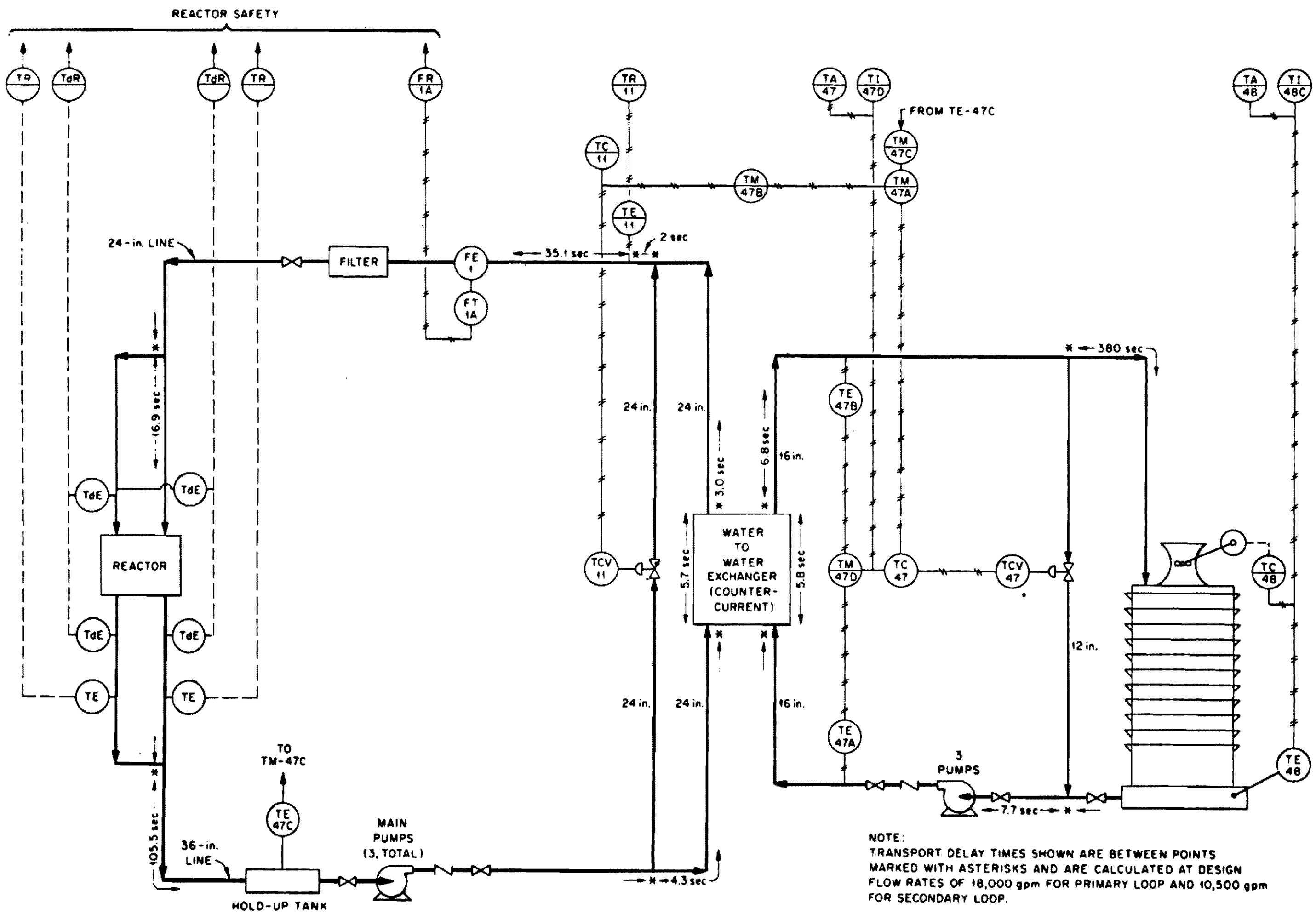

Fig. 5.16. Basic cooling water flow diagram.

changing, the measurement of the temperature differential and consequently the calculated power is incorrect. The differential temperature is only 11 to 12°F at the 30-MW power level; therefore an error in the differential temperature measurement of 0.5°F will result in a 4% error in calculated power.

2. To provide a system of sufficiently fast response that the reactor operation will not be inhibited by the temperature control system.
   a. When the reactor is unexpectedly shut down by abnormal conditions, xenon poisoning makes it mandatory to return to power within a short time or else suffer a delay for a change of reactor fuel. The cooling system must, therefore, be capable of control with a reactor power cycle from the 30-MW power level to essentially zero power and, thence, rapidly back to the 30-MW power level.
   b. Good transient response reduces the danger of overheating the reactor fuel and reactor structure on rapid power increases. The operating conditions at 30 MW are such that very little or no temperature overshoot is permissible.
   c. A fast response system is required to prevent recirculation of temperature transients around the primary cooling loop. The long loop time and low natural damping enhances the problem as has been exhibited in the past.
3. To provide a design such that the failure of control valves within the water loops will not result in an abrupt loss of cooling to the reactor. This dictates the use of "fail-closed" bypass valves rather than a series of throttling valves in the cooling loops. Thus, the most probable valve failure will not stop cooling water flow and will allow maximum cooling.

5.4.3. System Design Problems

The design of the temperature-control system presented three fundamental problems.

1. Slow thermal response of the tower

The first problem was to adapt the sluggish thermal response characteristics of the cooling tower to the extremely fast response of the reactor. The basin of the cooling tower contains some 60,000 gal of water which, if totally circulated, gives a transport time of about 380 s for the water to travel from inlet to outlet of the tower. The reactor, on the other hand, is capable of an exponential power increase from 0.3 MW (N_L) to 30 MW (N_F) in 90 s under servo control. This is an exponential rise; the rate of which approaches 1.5 MW/s between the 20- and 30-MW levels. Obviously, the temperature of the tower basin cannot be made to respond fast enough to cope with fast reactor power changes.

2. Synchronization

Problem number two was to synchronize the required rapid changes in cooling capacity with the changes in reactor power level after an appropriate delay. The primary water loop is essentially a long heat-conveyor system. Heat losses in the piping are relatively small compared to the total heat to be removed. The long length of the loop compared to the diameter of the piping prevents any appreciable mixing of the water and equalization of the temperature around the loop. The heat-conveyor loop is thus loaded at the reactor end and unloaded at the heat exchanger end. From Fig. 5.16, it is shown that:

a. The loading time is short - the water transport time through the heat exchanger is approximately 5.7 s; and

b. The transport time from the reactor to the heat exchanger, by comparison, is long, approximately 117.3 s. This long transport lag system with short load and unload times is conducive to recirculating temperature transients. Rapid changes in reactor power induce transients in the loop. The transients must be sensed before reaching the heat exchanger and, after proper delay time, the rate of heat removal at the heat exchanger must be altered such that exactly the right amount of heat is removed at exactly the right time. This prevents the transients from recirculating.

3. Large control range

The final problem was to provide a large dynamic range of control of cooling capcity. On a hot summer day, the full cooling capacity of the tower is barely sufficient to handle the 30 MW of heat generated by the reactor. On a cold winter day, however, the full tower capacity may be as high as 70 MW. Since the reactor will operate at power levels as low as a few megawatts at times, the required dynamic control range is large.

If constant temperature must be maintained during a setback (1% of power) period of up to 30 min, the required dynamic control range would be 250 to 1. A good single stage control system would normally have a dynamic range of 10 to 1.

5.4.4. Mode of Control

The varied control problems outlined made it impossible to obtain the required degree of temperature control with a single simple control system. By employing several simple control systems, however, with proper interconnection such that the over-all control is the sum of the control afforded by each, the design objectives were reached. Three systems are used: (1) tower control system - controlling the temperature of the cooling-tower basin, (2) secondary control system - controlling the mean temperature of the secondary side of the heat exchanger, and (3) primary control system - controlling the temperature of the water returning to the reactor.

The ultimate objective is the $\pm 0.25°F$ control of the primary water passing through the reactor. The three systems, in the order listed, lead progressively toward this end; i.e., control of the tower-basin temperature allows the secondary temperature to be regulated, and control of the secondary allows close control of the primary temperature. In this way, fast response and a fine degree of control are attained. Figure 5.17 shows these three control systems on a basic flow diagram.

All three of these control systems are designed around simple temperature control. The primary control system has a fixed setpoint designed to maintain a constant cooling-water temperature determined by the desired power level of the reactor. The constant temperature is accomplished by adjusting, by means of a bypass valve, the amount of cooling water flowing through the primary-to-secondary heat exchanger. At the other end of the cooling system, the tower basin is also designed to operate at a constant temperature. The basin may be regarded as an infinite heat sink from which the primary system may draw varying amounts of cooling capacity as the situation demands. Its temperature is maintained slightly below the level required for dissipation of full reactor power, and thus cooling capacity is immediately available. In between is the primary-intermediate link. It provides for transference of the cooling potential from the basin to the primary loop. In effecting the transfer, the temperature set point of the secondary is made to vary in response to conditions from two

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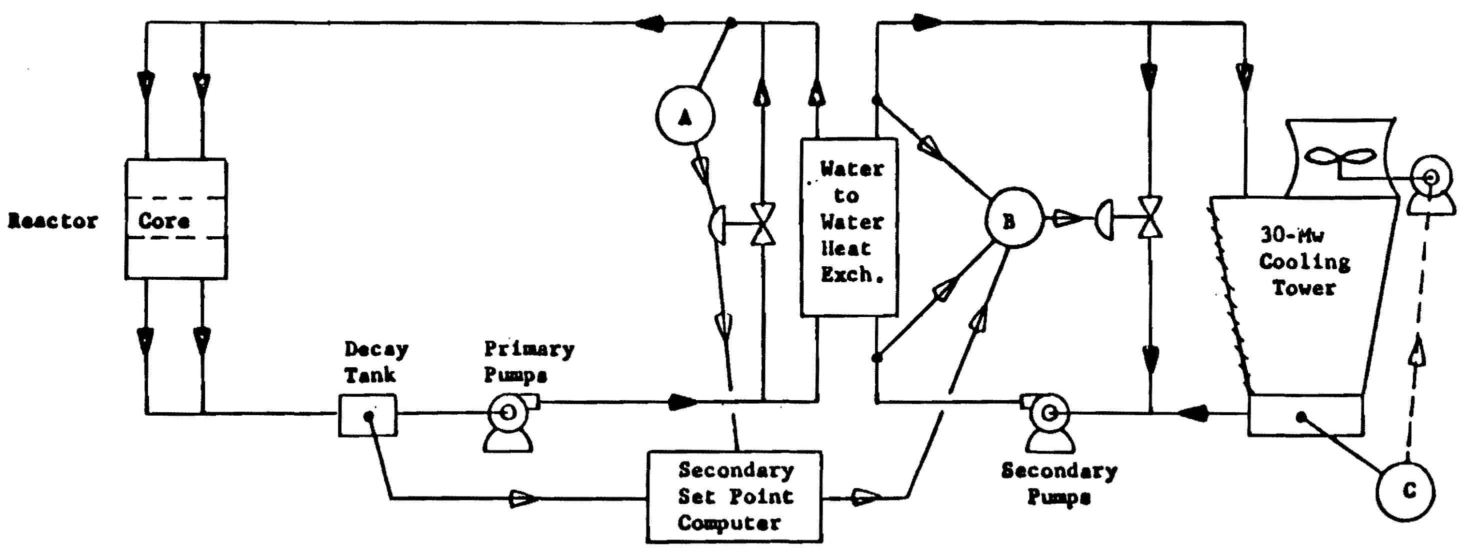

Fig. 5.17. Basic flow diagram with temperature control loops.

sources: (1) fluctuations in the reactor power level - providing more cooling water from the basin if the power goes above the desired level and less if it goes below and (2) adjustments already made in the primary system.

When a fluctuation occurs in the power level, the primary control system responds immediately, opening or closing the primary bypass valve to meet the new demand. The secondary system then continues to alter its set point until no correction is necessary by the primary system. This allows the primary bypass valve to return to its equilibrium position, approximately 50% open, again ready for optimum response, in either direction, to further sudden fluctuations in power level. Summation of the two conditions determining the secondary control set point is made by a simple pneumatic analog computer. The computer output is used to regulate a bypass valve on the secondary side of the heat exchanger, giving a secondary control action similar to that in the primary.

Thus by the interconnection of three control systems, the conditions for rapid and optimum control response are provided in the primary control system. The system adapts the slow response of the tower basin to the fast responses of the reactor and is able to damp out transients. Each of the three systems will next be considered in detail.

5.4.5. Tower Control System (Elementary Inst. Flow Diagram Q-1594-28)

The cooling tower provides a link between the cooling system and the atmosphere. Heat absorbed by the cooling system from the reactor is transferred to the atmosphere when water from the secondary cooling loop is made to cascade down through the tower against a forced upward draft of air. The flow of air is maintained in the two-cell tower by a two-speed fan in each cell. Each fan can be operated independently, thus providing five steps of control for the two cells considered as a unit, i.e., off-off, low-off, low-low, high-low, and high-high.

The heat dissipating capacity of the cooling tower is a function of several parameters. An approximate formula derived from data furnished by the Marley Company is as follows:

$$MW = \%FW\ (0.35T_i - 0.69T_{wb} + 34.4)(\%S_f) + (0.72T_i - 0.18T_{wb} - 47.06)$$

where

MW = heat dissipation in megawatts (rated at 30.78),

$\%FW$ = % of rated water flow over the tower (rated at 10,500 gpm),

T_i = inlet water temperature to the tower in °F (rated at 104°),

T_{wb} = ambient air wet-bulb temperature in °F (rated at 78°), and

$\%S_f$ = % full fan speed (both fans on high).

This formula is correct when the parameters are at or near rated values for the tower. How nearly correct it is when the parameters differ widely from rated values is not known. The formula, therefore, should not be used for evaluation of tower performance but it is useful in understanding tower operation. Figure 5.18 shows curves of the expected cooling capacity as derived from this formula. From these curves, it is shown that at full-rated water flow, 104°F inlet water temperature, and an ambient wet-bulb temperature of 78°F, the tower cooling capacity may be varied from 13 to 30 MW by varying the fan speed. With ambient wet-bulb temperature lowered to 55°F, the range is 18 to 50 MW via fan speed, and with the ambient wet-bulb temperature further lowered to 32°F, the range is 22 to 70 MW via fan speed.

The tower control system maintains the temperature of the cooling tower basin at a relatively constant temperature. This utilizes the slow natural response of the tower basin to advantage. Controlling the basin to a relatively constant temperature at a value slightly below the temperature which is required by the heat exchanger inlet for dissipation of full reactor power has several advantages.

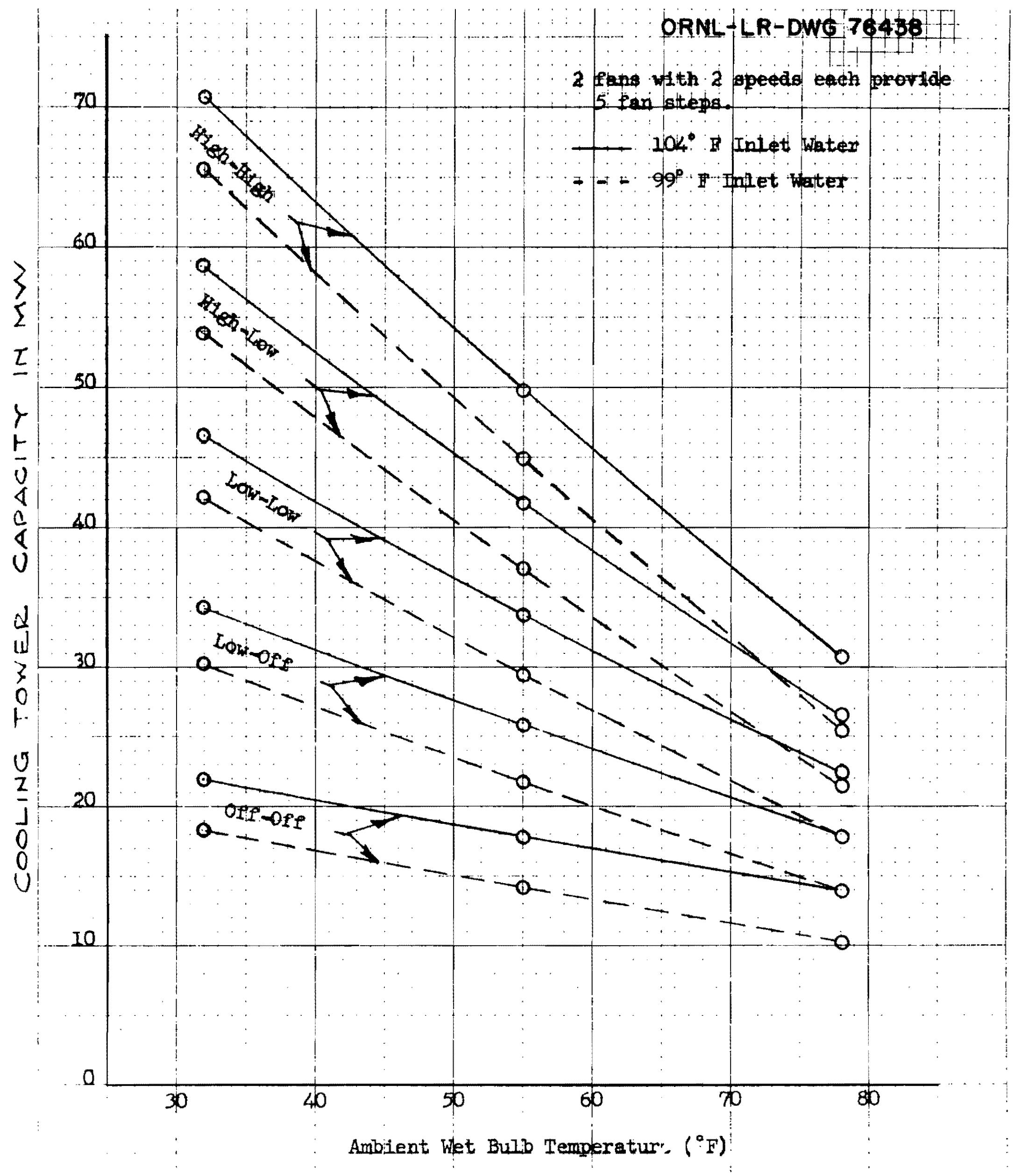

Fig. 5.18. Cooling tower capacity at full rate water flow.

1. It reduces the dynamic control range of the secondary and primary control loops, making the tower appear to the secondary control loop as essentially an infinite-capacity heat sink.
2. It prevents transient air temperatures from feeding back into and upsetting the over-all control.
3. It provides a stored cooling capacity allowing rapid increases in reactor power.

A block diagram of the tower cooling loop is given in Fig. 5.19. A gas-filled bulb (TE48) attached to a pneumatic temperature transmitter (TT48) is used to measure the basin temperature. A conventional pneumatic controller (TC48) with proportional control action only is used to compare the measured temperature to the set point and provide an output pressure signal accordingly. This output pressure, in turn, operates four pressure switches (TX48A, TX48B, TX48C, and TX48D) which, in turn, operate the two fans to provide the five-step control as described above.

5.4.6. Secondary Control System

The secondary control system may be considered as consisting of two parts: (1) a conventional temperature control system and (2) the pneumatic analog setpoint computer.

The control system receives its set point from the computer.

1. Conventional control

Figure 5.20 shows the conventional temperature control system. The mean temperature of the secondary side of the heat exchanger is controlled in such a way that the proper amount of cooling at the right time is supplied to the primary system. Transients are thereby damped out and the primary is maintained in its optimum control range.

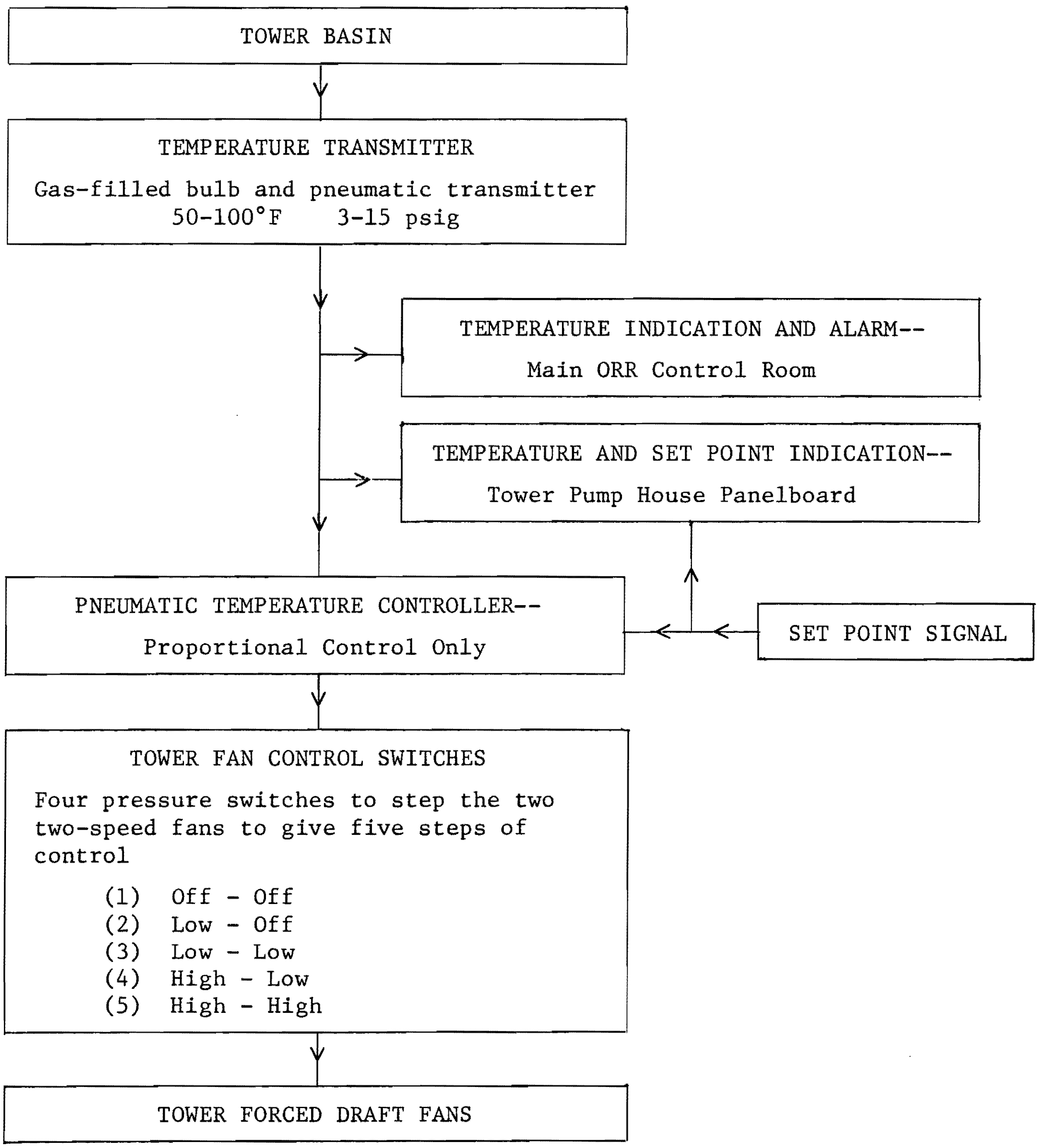

Fig. 5.19. Tower control system block diagram.

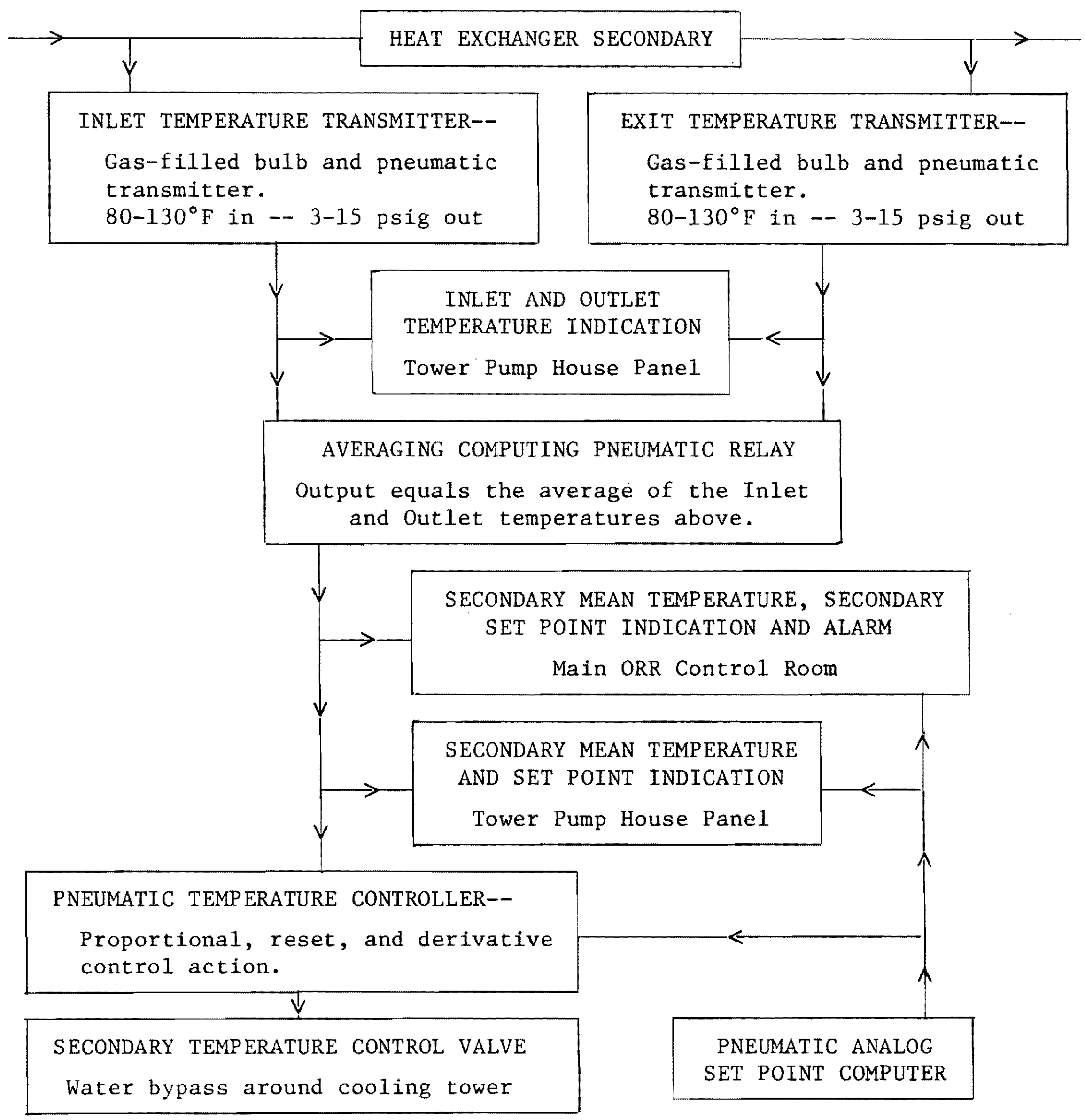

Fig. 5.20. Secondary control system block diagram.

Since it is impractical to measure temperatures within the heat exchanger, gas-filled bulbs and pneumatic temperature transmitters (TE47A, TE47B, TT47A, and TT47B) on the inlet and outlet water lines are used to provide a mean reading. A simple computing relay (TM47D) has an output which is the average of the two readings. This is considered as the mean secondary temperature which is to be controlled. A conventional pneumatic controller (TC47) then compares this mean temperature to a set point provided by the set point computer and provides an output control signal to operate the secondary control valve. The valve bypasses outlet water back to the pumps instead of over the cooling tower. By thus controlling the degree of bypassing, the mean temperature of the secondary system is controlled.

2. Set point computer

Figure 5.21 shows the analog computer used for obtaining the set point for the secondary control system. As mentioned, the set point is determined by two conditions: (1) fluctuations in the reactor power and (2) adjustments made to meet this in the primary system. The computer system may be conveniently approached by tracing the signals from each of these sources.

3. Reactor power

The temperature of the cooling water leaving the reactor is taken as an indication of reactor power level. The outlet temperature is measured by a gas-filled bulb (TE47C) and a 3- to 15-psig signal corresponding to a 100-150°F temperature range is transmitted by a pneumatic transmitter (TT47C). A pneumatic computing relay (TM47C) is designed to take this 100-150°F temperature signal, C, compare it with a desired temperature, and produce an output signal,

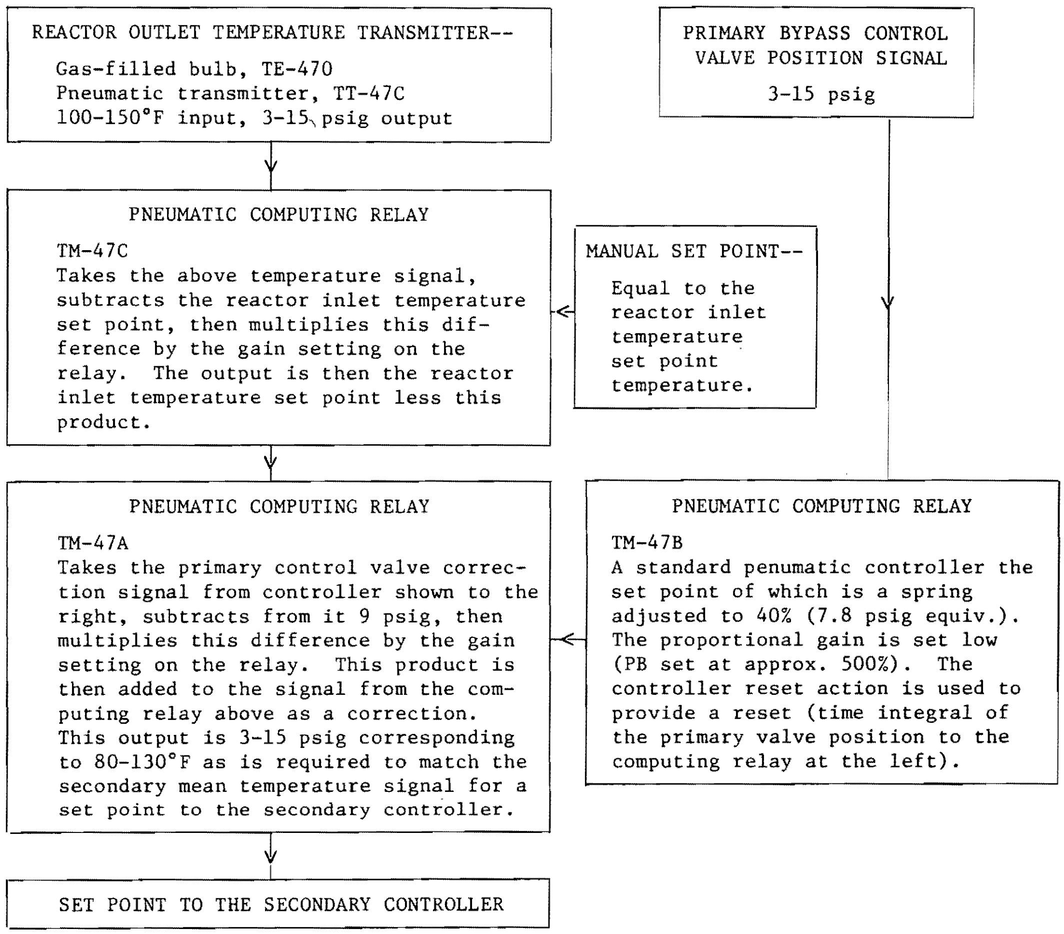

Fig. 5.21. Secondary control system set point block diagram.

P, corresponding to the corrective action required by the secondary system. In accomplishing this, C is compared to two set points, A and B, and the computer output may be represented as:

$$P = B + \frac{1}{PB}(A-C)$$

Under normal operating conditions, both A and B are set for 117 to 120°F. The temperature of the inlet cooling water varies over this range, and, at a reactor power level of zero, the outlet corresponds to the inlet. Consequently, when the outlet cooling water is, for example, 120°F, or equal to the inlet temperature, the signal, C, is equal to A and the term (A-C)/PB is zero. The output of the computer, P, is then equal to B, which is the zero power temperature, and no change is called for from this source in the secondary cooling loop. If the reactor power rises, C increases, and the term (A-C)/PB assumes a negative value. The output, P, then drops below the set-point temperature, B, and provides a signal to the secondary cooling system calling for more cooling capacity. If the reactor power drops, the reverse is true. P increases, and the secondary is asked to provide less cooling.

4. Conditions of primary system

When a change in cooling-water temperature occurs in the primary cooling system, the primary bypass valve responds immediately to provide a corresponding change in cooling capacity. Temperature fluctuations are sensed by temperature elements (TE11A) or (TE11B) and proportional signals are transmitted by TT11A and TT11B to the valve controller (TCV11). These signals, which determine the valve position, are also picked up by an isolator-booster (TM11B) and fed into the computer system.

The optimum operating condition for the primary valve has been determined as 40% open, which condition is produced by an 8-psi signal from TT11A or TT11B. Consequently, when an 8-psi signal is received, the primary system is at equilibrium, and no corrective action is necessary in the secondary. Equating this 8-psi signal to equilibrium conditions is accomplished by an 8-lb spring in the pneumatic computing relay TM47B. An 8-psi signal to the valve is received at "A" by TM47B and is exactly balanced by the 8-lb spring. As the primary valve opens and closes to meet fluctuations around the temperature set point, the output of TM47B will correspondingly swing positive and negative. The relay is adjusted to give a 9-psi output for equilibrium conditions. It may thus make a 6-psi swing in both the positive and negative directions in accordance with the 3 to 15-psi range of the instrument.

Still another pneumatic computing relay, TM47A, sums up the two conditions determining the secondary cooling loop set point. Since the signal from the primary bypass valve swings around 9 psi, a 9-lb spring is provided in TM47A to balance this offset and give a zero signal to the secondary from the primary valve when it is in its optimum condition.

5.4.7. Primary Control System

As mentioned previously, the temperature of the cooling water in the primary control system is determined by a conventional temperature control system. At 30-MW operation, TE11A senses the reactor inlet temperature at a point on the downstream side of the converging flows from the heat exchangers and the bypass line. The signal from TE11A is converted into a 3 to 15-psi output by TT11A which is fed through an isolator-booster relay (TM11A) to a recorder (TR11) in the control room and to a controller (TC11) whose output actuates the primary bypass valve TCV11.

5.4.8. Reactor Differential and Outlet Temperature System

Since cooling water temperature parallels the reactor power level and reflects temperatures within the core, measurements of the parameter are used to indicate the limits of safe operation for the reactor. Two types of temperature measurement, differential and outlet, are connected in the reactor safety system, giving alarm, setback, reverse, or scram if either exceeds safe limits.

Cooling water enters the reactor tank through two parallel lines (north and south) from the bottom, is brought up and circulated down over the core, and then leaves the reactor through continuation of the north and south parallel lines at the bottom (Ref. Q-1594-28). Both inlet and outlet lines, consequently, are located in close proximity directly beneath the reactor core in the reactor's "pipe chase," and all differential and outlet temperature elements are conveniently located there.

1. Differential temperature system

The difference between the temperature of cooling water entering the reactor and that leaving is a direct indication of the heat or power being produced in the reactor core. The general working formula for reactor thermal power is:

$$MW = 1.448 \times gpm \times \Delta T \times 10^{-4} \quad ,$$

where MW is reactor power in megawatts, gpm is cooling water flow in gpm and ΔT is the temperature differential across the reactor in °F.

At normal 30-MW operation, the temperature of water entering the reactor is in the neighborhood of 120°F and the corresponding temperature of water leaving would be 131.6°F. This gives a temperature differential of 11.6°F. If this differential rises above prescribed limits, it is an indication that a safe reactor power level is being exceeded. A ΔT reading greater than 13.0°F calls for an alarm, 13.5°F calls for a setback and reverse, and 15.5°F for a scram.

Since cooling water passes over the core from two parallel lines, it is likely that changes in core loading will cause one line to absorb more heat than the other. For this reason, two sets of readings are used to determine ΔT, one from the north leg and one from the south leg. The average is used as an indication of the over-all ΔT parameter and gives the proper control action. Safety action is taken if either channel gives an abnormal indication. The two channels are labeled Td1A and Td1B. The arrangement of components in the Td1A series is outlined in the following paragraph. The arrangement is exactly duplicated in the Td1B channel.

Since water entering the reactor is at the same temperature in both legs, the inlet temperature elements (TdE1A1 and TdE1A2) for both ΔT measurements are located, for convenience of access, in the south leg. On the outlet side, TdE1A3 is in the south leg and TdE1A4 is in the north leg. All are thermohm or resistance-type temperature elements which change their resistance values in direct proportions to their temperature. In a bridge-type connection, the sum of the voltage drops produced across the two inlet-line resistors is subtracted from the sum of voltages produced across the two outlet-line resistors. This difference is proportional to the average ΔT for the two cooling lines and is recorded by a Leeds and Northrup recorder (TdR1A) in the control room. Microswitches on the recorder give the alarm, setback, reverse, and scram actions at the proper levels.

2. Outlet temperature system

If plate temperatures within the reactor core exceed 270°F, there is danger of boiling in the reactor. With allowance for a proper safety factor, it has been determined that the cooling water outlet temperature should be maintained below 135°F in order to maintain safe core temperatures. Outlet temperature is measured by two thermohm elements (TE43 and TE44) and recorded in the control room by Leeds and Northrup recorders TR43 and TR44. Operating temperature at 30 MW is in the range 129 to 131.6°F. Microswitches in the recorders give an alarm at 134°F, setback and reverse at 135°F, and scram at 140°F.

Thermocouples TE2A, TE2D, and TE2G supply readings of inlet and outlet water temperatures to a multipoint Brown recorder in the control room for readout purposes only.

5.5. Reactor Water, Other Controls

5.5.1. Reactor Flow Measuring System

Flow in the ORR cooling loop is measured by a conventional flow-measuring system and readings from this system are used as the basis for manually operating three 6000-gpm pumps at the main pump house (Building 3085). Under shutdown conditions, a 1000-gpm shutdown pump is automatically started when flow drops below 1600 gpm and provides water for afterheat cooling during normal reactor shutdowns. Thus, the flow-measuring system may be thought of as being composed of two almost identical channels, one for measuring full operational flow in the range of 17,000-20,000 gpm and one for measuring shutdown flow in the range of 0-2000 gpm.

The first line of defense for afterheat removal from the core during power outage is by the dc pony-motor system which drives the main pumps at a reduced rate. Since they drive the main pumps to produce a "shutdown" flow rate, the instrumentation associated with that condition is applicable. Details of their operation are included in Section 7.3.1.

1. Full flow system

   A Foxboro 13A differential-pressure cell (FT1A) measures the pressure drop across a venturi located in the 24-in. return line under the porch of the main pump house (Building 3085) and transmits a 3- to 15-psig signal which is proportional to flow. The range of the instrument is 0-250 in. of water. The signal is fed to a flow indicator (FI1A) in the main pump house (Building 3085) and to a recorder (FR1A) in the ORR control room. Switch FX1A1 is set to give an alarm and setback at a flow of <17,000 gpm, and two switches (FX1A3 and FX1A4) are set to de-energize at a flow of less than 14,000 gpm to give a scram.

2. Shutdown flow system

A Foxboro 15A ΔP cell (FT1B) measures the pressure drop across the same venturi and transmits a 3- to 15-psig signal over approximately a 0 to 2000-gpm range. The range of the instrument is 0-5 in. of water. When at least two of the dc pony motors are operating, the flow will be approximately 2000 gpm. Should the flow drop below 1600 gpm, switch FX1B-3B starts the shutdown cooling pump which maintains a flow of approximately 1200 gpm. In the event that the flow should decrease to 1000 gpm, switch FX1B-1 would actuate giving the "Lo" shutdown coolant alarm (FA1B) in the ORR control room.

In addition to these two principal flow measuring channels, there is one other flow measuring channel in the primary cooling loop. A Foxboro 13A ΔP cell (FE14 and FT14) detects the pressure drop across an orifice meter and transmits a 3- to 15-psig signal proportional to flow through the primary loop's two filters. The flow is read on indicators FI14A in the main pump house (Building 3085) and FI14B in the ORR control room. No direct flow measurement has been provided for the bypass line of the heat exchangers. A calculated value may be obtained through use of the flow constant of the valve and pressure and flow parameters measured elsewhere in the cooling loop. A plotted valve flow as well as valve ΔP, heat exchanger flow, upstream pressure and total flow against valve opening has been calculated and is shown in Fig. 5.22.

No direct flow measurement is provided for total flow under all conditions in the secondary side of the cooling loop as the parameter is not essential to reactor operation. Two orifice meters are located in the north and south inlet lines to the cooling tower. Two Foxboro 13A ΔP cells measure drops across the two meters and transmit

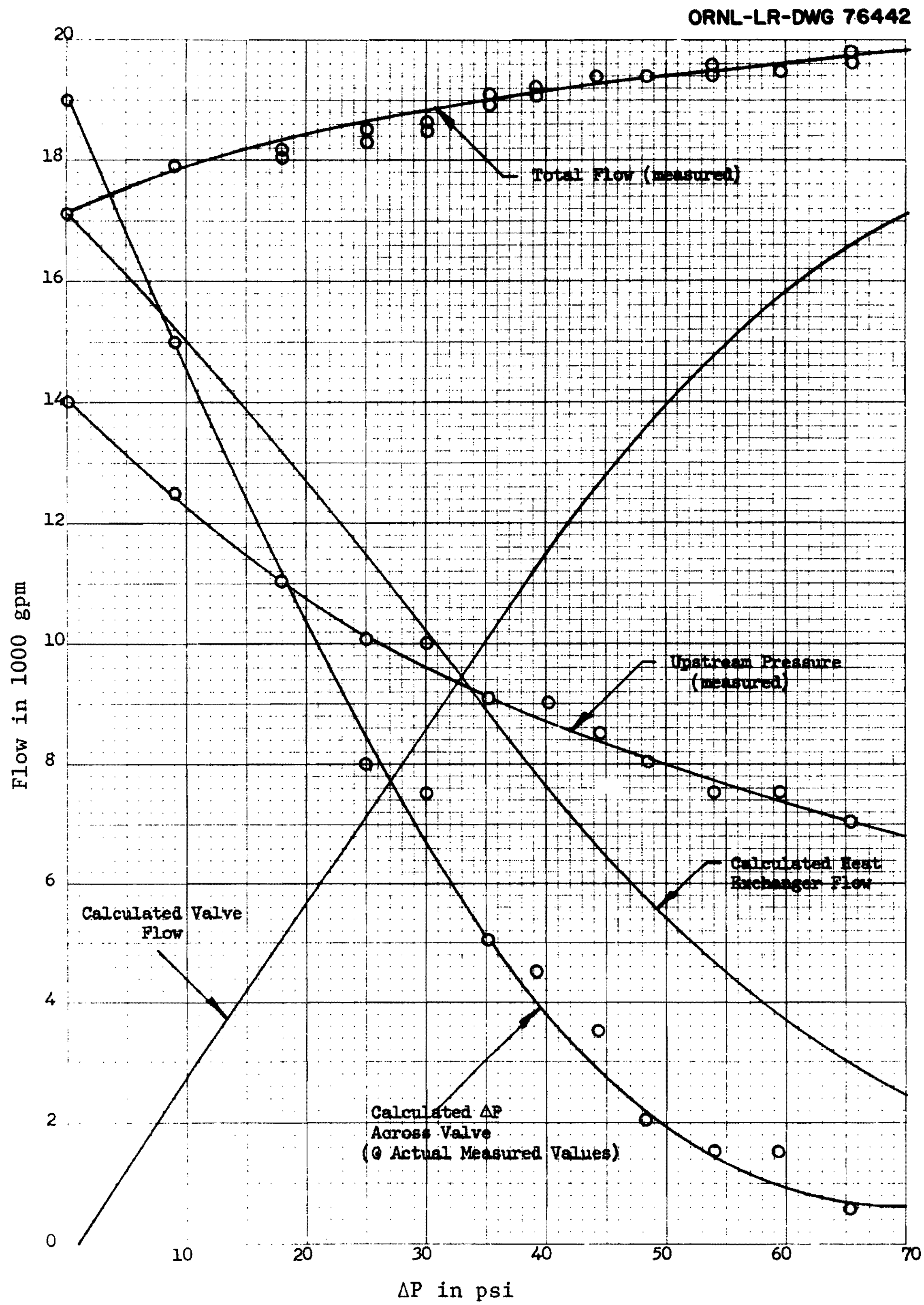

Fig. 5.22. Cooling water flow curves.

proportional 3- to 15-psig signals to flow indicators FI19A and FI19B in the cooling tower pump house. For the condition when the secondary bypass valve is closed and total flow is routed over the cooling tower, the sum of the two meter readings gives total flow in the secondary. The two meter readings also make it possible to achieve the desired balance between flows in the two lines and are necessary also in evaluating the performance of the cooling tower.

5.5.2. Cooling Tower pH Control System

In order to maintain the proper pH level for chemical corrosion and algae inhibitors in the secondary loop cooling water, a system for automatic control of the secondary pH is included in the reactor control system. A Leeds and Northrup industrial element takes a 0.2-gpm sample from the pump discharge line. The sample is fed through a Leeds and Northrup pH flow block mounted on the northeast wall of the cooling tower pump house above the sink. The sample is discharged into a floor drain via the sink. Electrical leads are run from the flow block to panelboard 2A in the cooling tower pump house and into a Leeds and Northrup indicator-modifier (AM7) which supplies an electrical signal to a control room recorder (AR-7). Microswitches (AA-7) in AR-7 give an alarm if the pH drops below 7.3 or rises above 7.8.

The automatic system calls for a controller (AC-7) to supply a signal to a pulser-feeder type pump with a variable stroke which will vary the flow of acid to the secondary system.

5.6. Reactor Pool Cooling

References

Dwgs. D-22318-R-2, D-22319-R-2, D-19425, D-15959, D-22320, D-22321-R-3. "Auxiliary Pumps for the ORR Process Water System," Sanders and Watts, ORNL 55-8-183

5.6.1. Pool Water System

The heat that is transferred to the pool surrounding the reactor tank, Fig. 5.2, both by conduction through the tank wall and by gamma absorption, has been found to be approximately 0.7 megawatt. The purpose of the pool coolant loop, which has a flow rate of approximately 550 gpm based on a ΔT of 8.5°F, is to transfer this heat via a shell-and-tube heat exchanger to a secondary loop where the heat will be dissipated through an induced-draft cooling tower.

The water leaves the pool through a 6-in. line, No. 201, and passes through valve No. 201a and strainer No. 201b prior to entry into the pump. The pump, a 900-gpm unit, forces the water through check valve No. 202a where the flow may split, part of it passing through valve No. 202b, filter unit No. 202c, and valve No. 202d; the remaining portion may bypass the filter through line No. 234 which is regulated by valve No. 234a. At the point of convergence, line No. 202 carries the flow through valve No. 202e to the single-pass heat exchanger. Leaving the heat exchanger through line No. 203, the water passes through valve No. 203a and line No. 203 on its return to the reactor pool.

To establish normal flow through this loop, the following procedure should be followed

1. Open valves:
   201a, at the inlet side of the strainer,
   202d, on the south side of the filter unit,

202e and 203a, the inlet and outlet to the heat exchanger,

234a and 202b, the valve in the filter unit bypass and the valve north of the filter unit, respectively.

2. Open the filter unit vent valve.

3. Start the pump.

4. Close the filter unit vent valve after air has been vented.

With the filter unit in service and valve No. 234a fully open, a flow of 550 gpm will be attained. Normally, the flow with valves fully open will be approximately 150 gpm through the filter, with a total flow of approximately 550 gpm.

There are gutters, located along the top of both the north and south pool walls, into which water is always overflowing from the pool. From the gutters, it goes to a 400-gal reservoir tank near the basement ceiling at the west end. Water flows from this tank to the suction leg of a 100-gpm pump, located on the floor, which provides water to the pool demineralizer. After leaving the demineralizer, the water returns to any or all of the pools. The level in the reservoir tank is automatically controlled, admitting water from Building 3004 when the level falls in the tank.

It has been previously stated that the reactor tank cannot be drained down to the level of the core. Likewise, the reactor pool has no inlet or outlet located below the level of the top of the core. Consequently, it cannot be drained below that level. However, both of the other pools have inlets and outlets in their floors. Thus, if the gate separating the reactor pool from the other pools is not in place, the reactor pool can be drained to within 3 ft of the bottom.

5.6.2. The Pool Demineralizers

The radioactivity in the ORR pool water would build up to an appreciable level if a method were not provided to remove the radioactive ions. The neutron flux in the pool just outside the reactor tank wall is of the order of 10^{14} neutrons cm^{-2} s^{-1}, and produces radioactive ^{24}Na, ^{16}N, and other unstable nuclides; so, a pool bypass demineralizer is used to remove a portion of these nuclides.

In the present operation of the demineralizer, water overflow from the pool is collected in a 400-gal overflow reservoir which serves as the supply for the pump in the demineralizer system. The pump passes the water through both a cation resin bed and an anion resin bed, then returns it to the pool. The cation unit, 48 in. in diameter and 72 in. high, contains 30 cu ft of IR-120 cation resin or a similar resin. The anion unit, 48 in. in diameter and 72 in. high, contains 35 cu ft of IRA-401 anion resin or a similar resin. The system, using both the cation and anion columns at all times, has a flow rate of 100 gpm with the discharge of the system re-entering the pool through the fill lines.

1. Normal flow pattern (Refer to Fig. 5.23 for valve locations.)
   a. From the overflow tank, through line P-1 to the pump, through line 214, and through a number of valves, the flow is routed to the top of the cation column. Valves which affect the path of flow and their positions for normal flow are as follows:

      P-1, open, line 213 overflow to pump
      P-2, open completely, on outlet line from pump
      P-3, open to obtain desired flow
      Inlet sampling valve, closed
      P-4, open completely, on inlet line to cation column

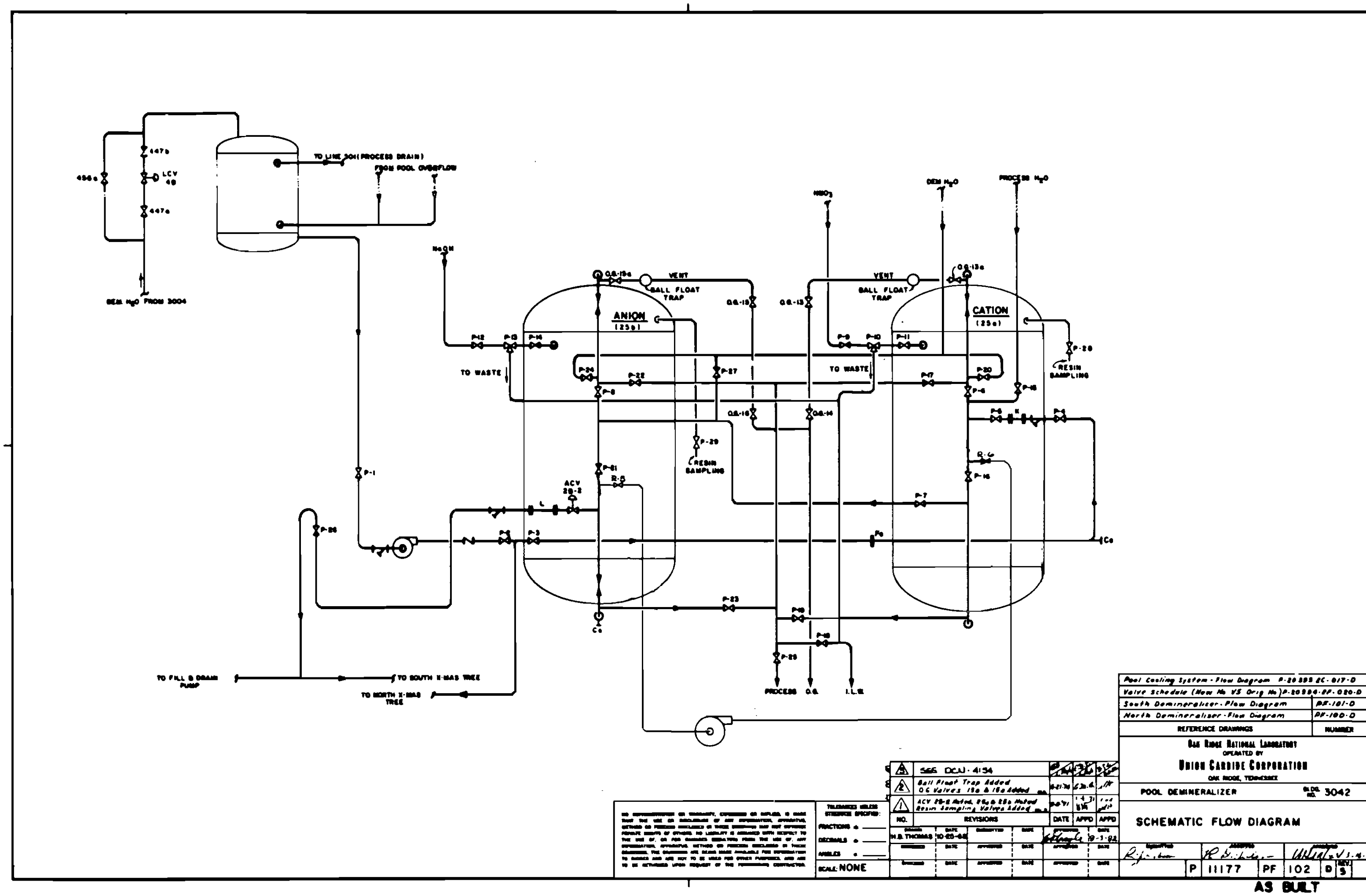

Fig. 5.23. Pool demineralizer.

P-5, open completely, on inlet line to cation

P-15, closed, a process water supply line

P-16, closed, routes flow to bottom of unit

P-6, open, to route flow to top of unit

P-17, closed, to route flow to drain

P-20, closed, a demineralized water supply line

O.G.13, open, vent to off-gas

O.G.14, open, vent to off-gas

P-9, closed, acid addition line

P-10, 3-way valve in the locked position

P-11, closed, acid addition line

b. From the cation unit to the top of the anion unit, line 215 carries the flow. The valves which affect the route and their positions for normal flow are as follows:

P-19, closed, to drain

P-7, open, routes flow from cation to anion column

Both cation sampling valves, closed

P-27, closed, demineralized water supply

P-21, closed, routes flow to bottom of unit

P-8, open, on inlet line to anion column

P-22, closed, to drain

P-24, closed, demineralized water supply

O.G.15, open, vent to off-gas

O.G.16, open, vent to off-gas

P-12, closed, caustic addition

P-13, 3-way valve in the locked position

P-14, closed, caustic addition

P-23, closed, to drain

c. From the anion column, the flow returns to the pools via lines 216 and 205. The flow through the demineralizers is controlled by an air-operated control valve in 216, which in turn is controlled by the resistance of the water. The valving arrangement is as follows:

P-23, closed, to drain
Sampling valve, closed
ACV-3B, open, actuated by Solu-Bridge probe
P-8, open, on inlet line to anion column
208a, east pool, open if desired
205c, center pool, open if desired
207a, west pool, open if desired

Valve P-3 is used to adjust the flow to approximately 70 gpm. If the level falls too low in the 400-gal tank, a level-control valve opens in line 447, admitting make-up water to the system. If the level in the 400-gal reservoir should rise too high, the overflow goes through line 501 to the process drain system.

2. Through-flow of pool demineralizer:

For special usage, a "thru-flow" circuit of the demineralizers is necessary whereby water from other sources can be passed through the demineralizers for purification. In this special flow circuit, the demineralizer pump and reservoir tank are isolated, and the "fill-drain" pump is used as a source of water movement.

To establish a "thru-flow" circuit in the pool demineralizers from sources outside of the normal demineralizer flow path, the following procedure is used:

a. The following valves should be <u>closed</u>:

All sampling valves
P-15, plant process water
P-16, a bypass of the cation unit
P-20, demineralizer water
O.G.13, vent of off-gas
P-17, bypass to drain
P-19, cation unit to drain
P-27, demineralized water
P-21, bypass anion unit
P-22, bypass to drain
P-24, demineralized water
O.G.15, vent to off-gas
P-12, caustic addition
P-23, anion unit to drain line
P-9, acid addition

b. The following valves should be <u>open</u>:

P-3, control valve
P-4, inlet to filter
P-5, exit of filter
P-6, on inlet line to cation column
P-7, on line from cation to anion column
P-8, on inlet line to anion column
ACV-3B, discharge line of anion unit

3. <u>Recirculating the reactor pool through the pool demineralizer</u>: In the event of gross contamination in the reactor pool, it may be desirable to recirculate the reactor pool water through the pool demineralizer for major clean-up work. This operation can

be performed by using lines of the primary cooling loop as the inlet and exit of the reactor pool. The procedure for this operation is as follows:

a. The regular demineralizer pump will not be used and should be isolated by closing valves P-2 and P-1.

b. Valves 205c and 207a, located on the fill lines to the center and west pools, should be closed.

c. The following valves, normally closed, should be checked to make sure they are closed:

    502a, drain to process drain - located in the north bank
    228a, near suction of fill-drain pump
    217a, in the north bank of valves
    204b, on line 204 - 4 in. to storage tanks
    227b, in this arrangement will be the throttling valve
    219b, on line 219 - 4 in. in south bank of valves
    205b, on the line discharge side of the south bank of valves
    205c, on the line fill leg of the center pool
    207a, on the line fill leg of the west pool
    143a, on the line to the reactor system
    204a, drain line of the center pool
    206a, drain line of the west pool

d. Make the valving arrangement as in step 2 above, for "thru-flow" demineralizer flow but keep the pump isolated.

e. The following valves should be opened:

    209a, in the north bank of valves
    218a, in the suction leg of the fill-drain pump
    P-26, in the north bank of valves
    208a, in the south bank of valves

f. Start the fill-drain pump and adjust the flow (not greater than 100 gpm) with valve 227b on line 214.

g. Upon completion, restore all valves to their normal positions.

4. Recirculating the center pool water through the pool demineralizer: To ready the flow circuit for recirculating the center-pool water through the pool demineralizer, the following changes are necessary.

   a. Stop the main demineralizer pump and isolate from the demineralizers by closing valve P-2 located on the discharge side of the demineralizer pump.

   b. Arrange the demineralizer for "thru-flow" as outlined in step 2 above.

   c. Close the following valves:

      209a, on line 209 - 4 in. in the north bank of valves, connects line 201 to line 204
      502a, on line 502 - 4 in. in the north bank of valves
      228a, on line 228 - 3 in. in the north bank of valves
      204b, on line 204 - 4 in. in the north bank of valves
      205b, on line 205 - 4 in. in the south bank of valves
      217a, on line 217 - 4 in. in the north bank of valves
      208a, on line 208 - 4 in. in the south bank of valves
      143a, on line 143 - 4 in. in the south bank of valves
      219b, on line 219 - 4 in. in the south bank of valves
      206a, on line 206 - 2 in. drain line from the west pool
      207a, on line 207 - 4 in. in the south bank of valves, and is the fill line to the west pool

   d. The following valves should be open:

      204a, on line 204 - 2 in. in the north bank of valves
      218a, on line 218 - 4 in. which is the suction leg of the fill-drain pump

227b, on line 227 - 3 in. inlet to the demineralizer in the north bank of valves, used for throttling the flow

P-26, on line 216 - 4 in. in the north bank of valves

205c, on line 205 - 4 in. fill line to center pool in south bank of valves

e. The fill-drain pump should be started against a closed valve, 227b. This valve is then opened to obtain the desired flow of not greater than 100 gpm.

f. Flow is indicated by FE-7.

5. Recirculating water from the west pool through the demineralizer: Any time the pool radiation is above normal or the water becomes bad, the following method is used for cleaning and decontaminating the water.

a. Close the following valves:

204a, on the 2-in. drain line from the center pool

205c, on the 4-in. fill line to the center pool

209a, on the 4-in. drain line from the reactor pool

208a, on the fill line to the reactor pool

219b, on the 4-in. line from the storage tanks to the drain-fill pump

143a, on the 4-in. line from the main pool fill line to the 24-in. inlet line to the reactor

205b, on the 4-in. line from the discharge side of the drain-fill pump

217a, on the 4-in. line from the discharge side of the drain-fill pump to the main drain line

502a, on the 4-in. line to the process drain

228a, on the 3-in. line from the demineralizer

P-2, on the discharge line from the demineralizer pump

Since the drain-fill pump is being used, this will isolate the demineralizer pump.

b. Open valve 218a on the 4-in. line from the main drain line to the drain-fill pump.

c. Close valve 204b on the main drain line.

d. Open the following valves:

206a on the 2-in. drain line from the west pool

207a on the inlet line to the west pool

P-26 on the 3-in. line from the demineralizer to the main fill line

e. Start the drain-fill pump and control the flow at 100 gpm with valve 227b on the 3-in. line to the demineralizers.

5.6.3. Regeneration Procedures

The units are regenerated in place using facilities which are located in the basement of Building 3042 and in Building 3004. As in the case of the other demineralizers used by Operations personnel, all regenerants are mixed in Building 3004 and pumped to the ORR basement via permanent piping which connects the two areas. Since the pool demineralizer system consists of only one complete unit, at times it is necessary to operate the reactor without the pool demineralizer system in operation when one or both of the resin columns are undergoing regeneration.

The techniques used in the regeneration of units of this system are typical of any single-unit bed. The particular procedures applicable to these resin columns are given in Examples 5.11 and 5.12.

They are of a "checklist type" and identified as procedural checklists for regenerating the pool's cation and anion columns. When a resin column becomes unable to sufficiently remove radioactive ions from the pool water system, it should be removed from service and regenerated. An individual copy of the procedure to be completed and initialed by the responsible party as the regeneration progresses will be furnished for each regeneration.

Example 5.11. Procedural checklist for regenerating the pool's cation column

Objective	Procedure	Remarks
1. Prepare for regeneration.	Determine the status of the demineralized water supply in Building 3004. Inform the reactor shift supervisor that the pool demineralizer will be removed from service for regeneration. Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to WC-19, the Intermediate Level Waste (ILW) System.	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 40 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow rate indicators for the pool demineralizers are located on the instrument rack on the north wall of the pipe tunnel.)
	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.23 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.10 for a schematic diagram of the regenerant-preparation equipment in Building 3004. Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration. NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.

Example 5.11. (continued)

Objective	Procedure	Remarks
2. Remove the demineralizer from service.	De-energize the demineralizer pump and place a "Do Not Operate" tag on the switch. Close the following valves: P-1, P-2, P-3, P-4, P-5, P-6, P-7, P-8, P-26, and ACV-3B. (ACV-3B is closed by turning the Solu-Bridge toggle switch to OFF.) Time ______________ This step was completed by: ______________ Date: ______ Remove the air-supply line from valve ACV-3B. Close the following valves: P-17, P-22, P-24, P-19, P-23, P-25, P-18, P-9, P-10, P-11, P-12, P-13, P-14, N-22, N-23, N-24, N-25, N-14, N-15, N-16, N-17, W-1, W-2, D-8, D-9, D-10, D-11, S-22, S-23, S-24, S-25, S-14, S-15, S-16, S-17, W-3, W-4, D-16, D-17, D-18, and D-19.	CAUTION: During the time that the demineralizer is removed from service, there will be no automatic makeup of water to the pool. Consequently, the pool water level should be checked occasionally. If the level decreases (due to evaporation, etc.) to approximately 1 in. below the overflow, open valve 409B on the north balcony. This will allow demineralized water from Building 3004 to enter the pool.
3. Compute the gallons throughput for the run completed.	Multiply the integrator reading by 1.8 and record the data in the ORR logbook.	The difference between this reading and the one recorded at the completion of the previous run will be the gallons throughput.

Gal. through ______________ Int. __________ x 1.8 = __________

This step completed by: ______________________ Date ________

Example 5.11. (continued)

Objective	Procedure	Remarks
4. Remove the spool pieces.	Remove the inlet and exit line spool pieces on the demineralizer system. (They are identified as K and L - red paint.)	NOTE: Ensure that the spool pieces are removed on the pool demineralizer; this will prevent regenerant solution from entering the pool cooling system.
	Verify that the dummy spool pieces D, E, I, and J are installed (D and E are in the north cell; I and J are in the south cell). (NOTE: Dummy spool pieces are color-coded - the bodies are painted blue.)	NOTE: Ensure that the dummy spool pieces are installed; they will prevent regenerant solutions from entering the reactor cooling system.

This step completed by: ______________________________ Date__________

5. Backwash the cation column using process water (or demineralized water).	In Building 3042 Open, in sequence, the following valves: P-15, P-16, P-17, and P-18. Close valve O.G.13. Using valve P-17, adjust the backwash flow rate to 30 gpm (as indicated on FE-6). Maintain this flow rate for 10 min. Time ___________________ Rate ___________________gpm This step was completed by: _______________Date:________	Process water (used in this phase of the procedure) enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed. (The manufacturer, Rohm & Haas Co., recommends a 50% expansion of the resin bed for an efficient backwash; and, a flow rate of 6 gpm/sq ft of flow area is required to effect this expansion. Since the anion column consists of a tank 4 ft in diameter and 6 ft high, containing 30 cu ft of IR-120 resin, the flow rate of 30 gpm satisfies the requirement.)

Example 5.11. (continued)

Objective	Procedure	Remarks
6. Stop the backwash.	In Building 3042	
	Close, in sequence, the following valves: P-18, P-17, P-16, and P-15.	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.
	Time ______________	
	Gal. WC-19 ______________	
This step completed by: ______________ Date______		
7. Check the acid-supply lines and valves for leaks.	In Building 3042	
	Open the following valves: P-9, P-10, P-11, P-19.	The valve and piping leak check should be made before establishing regenerant flow.
	This step was completed by: ______________ Date:______	NOTE: To open the three-way acid-supply valve, P-10, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.
	In Building 3004	
	Close valves A-3, A-4, A-6, A-10, A-11, and open W-2, A-9, and A-7.	
This step completed by: ______________ Date______		

Example 5.11. (continued)

Objective	Procedure	Remarks
	<u>In Building 3042</u> Check the following valves and associated piping for leaks: S-14, S-15, and S-16; N-14, N-15, and N-16; P-9, P-10, P-11, D-8, D-9, and D-10; <u>after</u> the leak check is completed, close W-2, A-9, and A-7. If leaks have developed, stop the regeneration and have repairs made as needed. When there are no leaks in the system, proceed with the regeneration.	
This step completed by: ______________________		Date________
8. Prepare the regenerant solution (nitric acid).	<u>In Building 3004</u> Complete procedural checklist for preparing acid regenerant solutions in mix tanks, Building 3004, Example 5.1.	
This step completed by: ______________________		Date________
9. Establish regenerant flow to the cation column.	<u>In Building 3004</u> Open the following valves: A-3, A-6, A-9, and A-7. Energize the recycle pump on the west wall panel.	

Example 5.11. (continued)

Objective	Procedure	Remarks
9. (continued)	Using valve A-7, adjust the acid flow rate to 13 gpm as indicated on rotameter and continue the flow for 5.7 min.	
	The specific gravity of the solution should now be between 1.03 and 1.06; however, it should be verified.	A sample may be obtained at the "sampling valve," A-8.
	Time ________________	

Rate: ________________________gpm Sp Gr: ___________________

This step completed by: ____________________________ Date________

Objective	Procedure	Remarks
10. Stop the regenerant flow to the cation column.	In Building 3004	
	Close valves A-3, A-6; open W-2 (process water)	
	Continue the process water flow for approximately 5 min to rinse the acid from the acid pump and lines.	
	De-energize the acid pump and close valves W-2, A-7, and A-9.	
	Time ____________________	
	Gal to WC-19 ________________	

This step completed by: ____________________________ Date________

Objective	Procedure	Remarks
	In Building 3042	
	Close, in sequence, the following valves: P-18, P-19, P-11, P-10, and P-9.	NOTE: The three-way acid-supply valve, P-10, is to be locked in the CLOSED position. (The handle will be in the horizontal position.)
	Open O.G.14.	

This step completed by: ____________________________ Date________

Example 5.11. (continued)

Objective	Procedure	Remarks
11. Rinse the cation column (using demineralized water).	In Building 3042	
	Open, in sequence, the following valves: P-20, P-19, and P-18.	This valving arrangement keeps the column filled with water (to minimize channeling) and routes the effluent to the ILW system.
	Using valve P-19, adjust the flow rate to 15 gpm (as indicated by FE-5). Rinse for about 15 min; then increase the flow rate to 30 gpm.	
	During the rinsing procedure, obtain a sample of the rinse effluent about every 10 min and determine the pH. When the pH increases to 3.8, stop the rinse.	

Time on 15 gpm ________________ Time off 15 gpm ________________

Gal to WC-19 ________________ Time on 30 gpm ________________

This step completed by: ____________________________ Date________

Objective	Procedure	Remarks
12. Stop the cation column rinse.	In Building 3042	
	Close, in sequence, the following valves: P-19, P-18, and P-20.	Closing the valves in this order will avoid pressurizing the waste system and will leave the cation column filled with demineralized water.
	Time ________	
	pH ________	
	Gal to WC-19 ________	

This step completed by: ____________________________ Date________

NOTE: If the pool anion resin bed is to regenerated, omit the remaining steps (Nos. 13, 14, 15, and 16) of this procedure. The next step is the start of the pool anion regeneration.

Example 5.11. (continued)

Objective	Procedure	Remarks
13. Rinse the cation and anion columns in series.	<u>In Building 3042</u> Open, <u>in sequence</u>, the following valves: P-20, P-8, P-7, P-23, and P-18. Using valve P-23, adjust the flow rate to 30 gpm (as indicated by FE-5). When the activity level of the effluent decreases to 1000 cpm/ml, close valve P-18 and open P-25; this will divert the flow from the ILW drain to the process drain.	 If practical, monitor the radiation level of the effluent at about 10-min intervals. <u>Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.</u>
This step completed by: ______________________ Date__________		
14. Stop the rinse.	<u>In Building 3042</u> When the pH of the effluent is less than 7, and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated. Close the following valves: P-25, P-23, P-7, P-8, and P-20 Open valves O.G.14 and O.G.16.	 The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 ± 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7, and the resistivity increases to 500,000 ohm-cm, the regenerant solutions have been rinsed from the columns. Further rinsing is of little advantage; and the parameters will be within the limits shortly after the unit is placed in service.
This step completed by: ______________________ Date__________		

Example 5.11. (continued)

Objective	Procedure	Remarks
15. Replace the spool pieces.	Reinstall the inlet and exit line spool pieces (K and L).	
	This step completed by: ______________________________	Date_________
16. Place the demineralizer in service.	<u>In Building 3042</u>	
	Replace the air-supply line to the automatic control valve.	
	Open the following valves: P-1, P-2, P-3, P-4, P-5, P-6, P-7, P-8, and P-26.	Opening valve P-26 will route the demineralizer effluent to the south "Xmas tree."
	Route the effluent water to either the west pool (by opening valve 507A), the center pool (by opening valve 205E), or the reactor pool (by opening valve 208A).	Normally, the demineralizer effluent is returned to the center pool.
	Turn the Solu-Bridge toggle switch to the ON position and set the indicator on 1.5.	The Solu-Bridge controls are located on the west wall by the anion column.
	Remove the "Do Not Operate" tag from the electrical switch for the demineralizer pump and energize the pump.	The automatic quality control valve for the pool demineralizer will close and the pump will deenergize when the initial flow from the demineralizer contacts the conductivity-sensing element. (The set point is 700,000 ohm-cm.) When this occurs, the unit may be returned to service by keeping the "override" button depressed. The button is located on the electrical switch box for the demineralizer pump.
	This step was completed by: ________________Date:______	

Example 5.11. (continued)

Objective	Procedure	Remarks
16. (continued)		(CAUTION: Do not leave the demineralizer in service by using the "override" feature for an extended period of time. If the unit fails to remain in service after about an hour, without using the override, check the pH and resistivity; if they are not within the specified limits, remove the unit from service and inform the supervisor in charge.)

Example 5.12. Procedural checklist for regenerating the pool's anion column

Objective	Procedure	Remarks
1. Prepare for regeneration.		Unlike the reactor-water demineralizers, the pool anion column must be regenerated approximately three times more frequently than the cation column. If the cation resin is not due for a regeneration, the cation resin should be backwashed for 5 min using demineralized water to fluff the cation resin before the anion resin regeneration is started.
	Determine the status of the demineralized water supply in Building 3004. Inform the reactor shift supervisor that the pool demineralizer will be removed from service for regeneration. Call the tank farm operator and obtain permission to send approximately 3000 gal of regenerant waste and rinse effluent to WC-19, the Intermediate Level Waste (ILW) System.	Demineralized water and regenerant solutions are piped from Building 3004 to Building 3042 via underground piping. During the regeneration operations, the demineralized water flow rate should not be allowed to exceed 40 gpm. If this rate is exceeded, the standby demineralizer in Building 3004 must be placed in service. (The flow-rate indicators for the pool demineralizers are located on the instrument panel on the north side of the demineralizer.)

Example 5.12. (continued)

Objective	Procedure	Remarks
1. (continued)	Initial each step in the procedure and record the date where indicated. Use margins or backs of pages to comment on needed equipment repairs or other items needing attention. Refer to Fig. 5.23 for a schematic diagram of the demineralizer in Building 3042; and refer to Fig. 5.7 for a schematic diagram of the regenerant-preparation equipment in Building 3004.	This procedure also serves as a checklist. It is provided to ensure that all valves in the demineralizer system are placed in the proper mode so that regenerant solutions are routed correctly and are not inadvertently injected into the reactor cooling system. The procedural checklist will be issued to the operator performing the regeneration.
	Throughout the procedure, encircle listed valve numbers to indicate that the required manipulation (open or close) has been done.	NOTE: Whenever any of the demineralizers are regenerated, a checklist must be filled out. Upon completion of the regeneration, the checklist must be returned to the supervisor in charge.
2. Remove the demineralizer from service.	De-energize the demineralizer pump and place a "Do Not Operate" tag on the switch. Close the following valves: P-1, P-2, P-3, P-4, P-5, P-6, P-7, P-8, P-26, and ACV-3B. (ACV-3B is closed by turning the Solu-Bridge toggle switch to OFF.) Time __________________ This step was completed by: ________________Date:______ Remove the air-supply line from valve ACV-3B.	CAUTION: During the time that the demineralizer is removed from service, there will be no automatic makeup of water to the pool. Consequently, the pool water level should be checked occasionally. If the level decreases (due to evaporation, etc.) to approximately 1 in. below the overflow, open valve 409B on the north balcony. This will allow demineralized water from Building 3004 to enter the pool.

Example 5.12. (continued)

Objective	Procedure	Remarks
2. (continued)	Close the following valves: P-15, P-16, P-17, P-18, P-19, P-22, P-23, P-24, P-25, P-9, P-10, P-11, P-12, P-13, and P-14.	
3. Compute the gallons throughput for the run completed.	Multiply the integrator reading by 1.8 and record the data in the ORR logbook.	The difference between this reading and the one recorded at the completion of the previous run will be the gallons throughput.

Gal through ____________________ Int. __________ x 1.8 = __________

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
4. Remove the spool pieces.	Remove the inlet and exit line spool pieces on the demineralizer system. (They are identified as K and L.)	
	Verify that the dummy spool pieces D, E, I, and J are installed (D and E are in the north cell; I and J are in the south cell). (NOTE: Dummy spool pieces are color-coded - the bodies are painted blue.)	NOTE: Ensure that the dummy spool pieces are installed; they will prevent regenerant solutions from entering the pool cooling system.

This step completed by: ______________________________ Date__________

Objective	Procedure	Remarks
5. Backwash the anion column with demineralized water.	In Building 3042 Open, in sequence, the following valves: P-27, P-21, and P-18. Use valve P-22 to adjust the flow rate to 37 gpm (as indicated on FE-6); then, close valve O.G.15. This flow rate should be maintained for 10 min.	Demineralized water enters the bottom of the column and exits at the top. The purpose of the backwash is to increase the efficiency of the regeneration by: (1) removing some of the foreign matter from the column and (2) "fluffing" the resin bed.

Example 5.12. (continued)

Objective	Procedure	Remarks
5. (continued)	Time ____________________ Rate ____________________gpm This step was completed by: ________________Date:_______	(The manufacturer, Rohm & Haas Co., recommends a 50% expansion of the resin bed for an efficient backwash; and a low rate of 3 gpm/sq ft of flow area is required to effect this expansion. Since the anion column consists of a tank 4 ft in diameter and 6 ft high, containing 37 cu ft of IRA-401 resin, the 37-gpm flow rate satisfies this requirement.)
6. Stop the backwash.	In Building 3042 Close, in sequence, the following valves: P-18, P-22, P-21, and P-27. Time ______________________ Gal to WC-19 _____________	Closing the valves in this order will leave the column filled with water and subsequently minimize "channeling" when the regenerant flow is established.
This step completed by: ________________________________ Date__________		
7. Check the caustic-supply lines and valves for leaks.	In Building 3042 Open the following valves: P-12, P-13, P-14, P-23, and P-18. This step was completed by: ________________Date:________	The valve and piping leak check should be made before establishing regenerant flow. NOTE: To open the three-way caustic-supply valve, P-13, the valve handle must be raised to the vertical position; to close, the handle must be placed in the horizontal position; to route the fluid to the waste system, the handle must be lowered to the vertical position.

Example 5.12. (continued)

Objective	Procedure	Remarks
7. (continued)	In Building 3004	
	Close the following valves: West tank (No. 1 unit) 232W, 231W, 230W, 229W, 228W, 267W, 244, 244D, 20W, and 300W.	
	Open valve 300W on the process-water supply lines and fill the caustic-mix tank with water to half-full.	The volume of the caustic-mix tank is approximately 250 gal; the west tank (No. 1 unit) is used for this procedure.
	Open the following valves: 228W, 230W, 232W, and 244.	
	Energize the recycle pump.	The electrical switch for the recycle pump is located on the north side of the mix tank.
	Use valve 224 to adjust the flow rate so that the level of the fluid in the mix tank decreases 1 in./min.	

This step completed by: ______________________________ Date__________

	In Building 3042	
	Check the following valves and associated piping for leaks: S-22, S-23, and S-24; D-16, D-17, and D-18; P-12, P-13, and P-14; and N-22, N-23, and N-24.	
	If leaks have developed, stop the regeneration and have repairs made as needed. If there are no leaks, proceed with the regeneration.	

This step completed by: ______________________________ Date__________

	In Building 3004	
	De-energize the recycle pump.	
	Close valves 244, 228W, 232W, and 230 W.	

This step completed by: ______________________________ Date__________

Example 5.12. (continued)

Objective	Procedure	Remarks
8. Prepare the regenerant solution (sodium hydroxide, NaOH).	In Building 3004 Open valve 300W and fill the 250-gal caustic-mix tank to the half-full marker with process water; then close the valve.	A total of about 500 gal of 5% caustic solution is required for the regeneration; approximately 20 1/2 gal of 50% sodium hydroxide are used to prepare one mix tank of the 5% caustic solution. CAUTION: The caustic solution is highly corrosive; all precautions regarding the handling of such chemicals (e.g., the wearing of a rubber apron, rubber gloves, shoe covers, and a face shield) must be acknowledged and adhered to.
	Energize the exhaust blower over the caustic-mix tank.	The electrical switch for the exhaust blower is located on the west wall, opposite the caustic-mix tank.
	Open the following valves: 239C, 237C, and 236W.	
	Energize the caustic pump. (This will start the flow of caustic from the 750-gal caustic-storage tank to the 17-gal caustic-measuring tank.) Fill the caustic-measuring tank (as indicated by the sight glass); then de-energize the caustic pump.	The electrical switch for the caustic pump is located on the north side of the caustic-mix tank.
	Close valve 236W and open valve 235W. (This will allow the caustic to flow from the measuring tank to the 250-gal mix tank.) After the measuring tank has drained, close valve 235W and open valve 236W.	Valve 236W is the overhead "T"-handle valve.

Example 5.12. (continued)

Objective	Procedure	Remarks
8. (continued)	Energize the caustic pump and refill the measuring tank to approximately 1/2 tank; then, de-energize the pump and close valve 236W.	
	Open valve 235W and again allow the contents of the measuring tank to drain into the mix tank.	
	Close the following valves: 239C, 237C, and 236W.	
	Open valve 300W and fill the caustic-mix tank with process water to within about 4 in. from the top of the tank.	
	Open valve 467W on the steam-supply line to the heating coil in the mix tank.	
	Heat the solution to 120°F.	
	Energize the stirring equipment in the mix tank during the heating operation.	The electrical switch for the stirring equipment is on the side of the motor positioned over the caustic-mix tank.
	De-energize the stirring equipment.	
	Check the specific gravity of the solution to verify that it is within the range of 1.05 to 1.06. If it is not within this range, add more caustic from the 750-gal storage tank as needed.	The hydrometer used for this purpose is located on the west work bench; it may be placed directly in the caustic-mix tank.

This step completed by: ______________________________ Date__________

9. Establish regenerant flow to the anion column.	In Building 3004 Open the following valves: 232W, 230W, 228W, and 244.	
	Energize the recycle pump.	

Time ________________________ Rate ________________________

This step was completed by: ________________________ Date:________

Example 5.12. (continued)

Objective	Procedure	Remarks
9. (continued)	Using valve 244, adjust the flow rate so that the level of the fluid in the mix tank decreases about 1 in./min. When the tank is empty, de-energize the recycle pump. Close valves 232W, 230W, 228W, and 244.	

This step was completed by: ________________ Date: __________

Objective	Procedure	Remarks
10. Prepare and send a second solution of caustic through the anion column.	Repeat steps 8 and 9. When the liquid level of the second solution in the mix tank is zero, open valve 300W and allow the tank to fill with approximately 10 in. of process water for rinsing purposes. Close valve 300W. When the level in the mix tank decreases to approximately 2 in., de-energize the recycle pump. Drain remaining water to sump. Rinse the caustic from the measuring tank and associated lines as listed in Example 5.2, "Procedure for rinsing caustic lines and overhead caustic measuring tanks after use." De-energize the exhaust blower.	The recycle pump, the caustic-mix tank, and the associated piping to the anion column (which includes the three-way valve) should be rinsed of residual caustic.

This step completed by: ______________________________ Date________

Objective	Procedure	Remarks
11. Stop the regenerant flow.	<u>In Building 3004</u> Stop the pump. Close the following valves: 244, 228W, 236W, and 232W.	

Time ____________________ Gal to WC-19 ___________

This step completed by: ______________________________ Date________

Example 5.12. (continued)

Objective	Procedure	Remarks
11. (continued)	In Building 3042 Close the following valves: P-18, P-23, P-14, P-13, and P-12. This step was completed by: ____________ on ________	NOTE: The three-way caustic-addition valve P-13, is to be locked in the CLOSED position. (The handle will be in the horizontal position.)
12. Rinse the anion column to ILW (WC-19).	In Building 3042 Open, in sequence, the following valves: P-20, P-8, P-7, P-23, and P-18. Using valve P-23, adjust the flow rate to 30 gpm (as indicated by FE-5).	This valving arrangement will allow both the cation and anion columns to be rinsed in series. Rinse the column to WC-19 for a minimum of 20 min to rid the effluent of a caustic smell.

Time ____________ Rate ____________ gpm

Rinse to WC-19 off ____________ Gal to WC-19 ____________

This step completed by: ____________________ Date ________

Objective	Procedure	Remarks
13. Rinse the anion column to the process drain for 1 h.	In Building 3042 When the activity level of the effluent decreases to 1000 cpm/ml (usually after 20 min of rinse), close valve P-18 and open P-25; this will divert the flow from the ILW drain to the process drain.	Monitor the radiation level of the effluent after 20 min of rinse to WC-19. Do not route water with an activity level in excess of 1000 cpm/ml to the process drain.

Time ____________ Rate ____________ gpm

Activity ____________ cpm/ml

This step completed by: ____________________ Date: ________

Example 5.12. (continued)

Objective	Procedure	Remarks
14. Stop the rinse to process drain.	<u>In Building 3042</u> Terminate the rinse to the process drain after 1 hour of rinsing operation. Close the following valves: P-25, P-23, P-20, P-7, and P-8; open valves O.G.13 and O.G.15.	
Time ________________	Gal to process drain ____________	
This step completed by: ____________________________		Date:_________
15. Start recycle rinse.	<u>In Building 3042</u> To place the pool demineralizer on recycle: <u>close</u> valves P-16, P-5, P-15, P-21, P-18, P-19, P-23, P-25, P-17, P-22, and P-24; <u>open</u> valves RP-1, RP-2, P-6, P-7, and P-8. Start recycle pump	
Time ____________________		
This step completed by: ____________________________		Date:_________
16. Stop recycle rinse.	<u>In Building 3042</u> When the pH of the effluent is less than 7, and the resistivity increases to 500,000 ohm-cm, the rinsing operation may be terminated.	The pH and resistivity limits of acceptability for the reactor primary-water systems are 6 ± 0.5 and >900,000 ohm-cm, respectively. However, if the effluent pH of the regenerated demineralizer decreases to 7, and the resistivity increases to 500,000 ohm-cm, the

Example 5.12. (continued)

Objective	Procedure	Remarks
		regenerant solutions have been rinsed from the columns. Further rinsing is of little advantage, and the parameters will be within the limits shortly after the unit is placed in service.
	Stop pool recycle pump. Close RP-1, RP-2, P-6, P-7, and P-8.	
	Time ____________________	
This step completed by: ______________________________ Date__________		
17. Replace the spool pieces.	Reinstall the inlet and exit line spool pieces (K and L).	
This step completed by: ______________________________ Date__________		
18. Place the demineralizer in service.	In Building 3042	
	Replace the air-supply line to the automatic control valve.	
	Open the following valves: P-1, P-2, P-3, P-4, P-5, P-6, P-7, P-8, and P-26.	Opening valve P-26 will route the demineralizer effluent to the south "Xmas tree."
	Route the effluent water to either the west pool (by opening valve 207A), the center pool (by opening valve 205C), or the reactor pool (by opening valve 208A).	Normally, the demineralizer effluent is returned to the center pool.
	Turn the Solu-Bridge toggle switch to the ON position and set the indicator on 1.5. This opens the automatic valve (ACV3B).	The Solu-Bridge controls are located on the west wall by the anion column.

Example 5.12. (continued)

Objective	Procedure	Remarks
18. (continued)	Remove the "Do Not Operate" tag from the electrical switch for the demineralizer pump and energize the pump. This step was completed by: ________________Date:________	The automatic quality control valve for the pool demineralizer will close and the pump will de-energize when the initial flow from the demineralizer contacts the conductivity-sensing element. (The set point is 700,000 ohm-cm.) When this occurs, the unit may be returned to service by keeping the "override" button depressed. The button is located on the electrical switch box for the demineralizer pump. (CAUTION: Do not leave the demineralizer in service by using the "override" feature for an extended period of time. If the unit fails to remain in service after about an hour, without using the override, check the pH and resistivity; if they are not within the specified limits, remove the unit from service and inform the supervisor in charge.)

5.6.4. Other Sources of Demineralized Water

Building 3004 Demineralizer Water

A continuous supply of demineralized water is necessary to: (1) provide make-up water to the overflow tank while the pool demineralizer is in service, (2) supply the shim-rod-drive O-ring seals in the subpile room, (3) service those reactor experiments for which an uninterrupted supply of demineralized water is required, and (4) supply the pools from the north balcony when needed. If an interruption becomes necessary due to an emergency, contact all experiment personnel involved.

1. Pool make-up

   When water is lost from the pool system, the overflow to the side gutters, which feeds the reservoir tank, is reduced. Since the pool demineralizer pump takes its suction from this tank, the level in the tank will fall. Make-up is then supplied by level control valve LCV-45, which supplies demineralized water directly from Building 3004. Shut-off valves No. 445a and No. 447b, on either side of LCV-45, should be fully opened. Without this make-up supply, if sufficient water were lost from the pool system through evaporation or other causes, the demineralizer pump could lose suction and be damaged. Should the make-up exceed the normal make-up rate without due explanation, the Reactor Supervisor should be notified immediately.

2. Water-level controller in the pool reservoir tank

   A water-level controller (Fig. 5.24) is located in the pool reservoir tank. A (0-100%) gauge located on the panel at the south end of the pool heat exchanger provides a local readout of the water level in the tank. A Foxboro instrument (0-100%) located in the ORR control room provides a remote readout of the water level in the tank and also the frequency of the make-up rate.

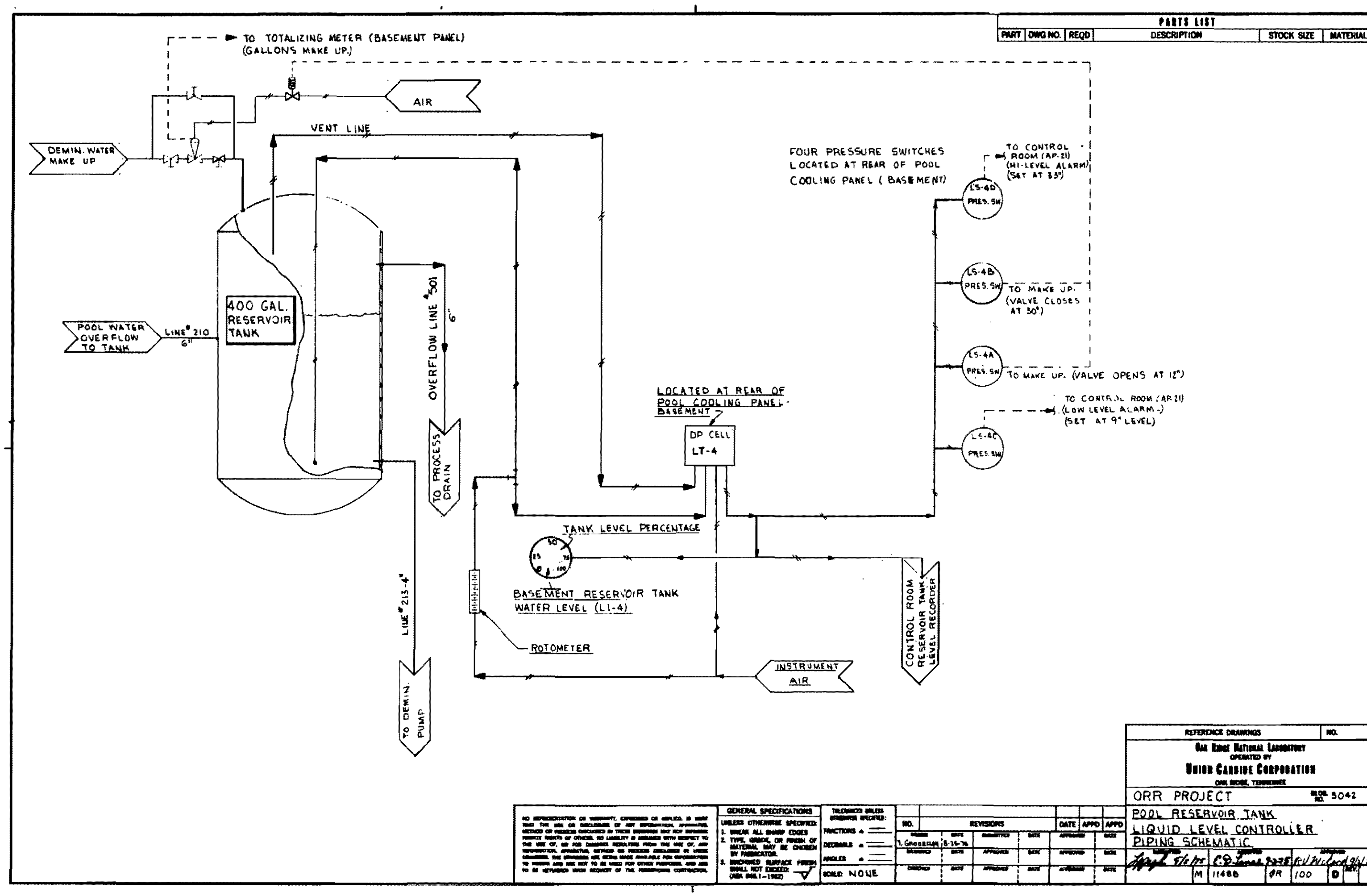

Fig. 5.24. Pool reservoir tank liquid level controller.

Four pressure switches are located at the rear of the basement panel which provide the following functions:

Low-level alarm	9 in.
Make-up valve open	12 in.
Make-up valve closed	30 in.
High-level alarm	33 in.

NOTE: Usable depth of the tank is 36 in.

The outputs of two pressure switches (low and high levels) are relayed to the ORR control room telealarm station AP21 to give an alarm condition on a tank level of $\leq$9 in. or $\geq$33 in. At $\leq$12 in. tank water level, the air-operated valve in the demineralized water make-up line opens; thereby adding water to the reservoir tank from Building 3004. At $\geq$30 in. tank water level, the air-operated make-up water valve closes.

A "totalizing meter" is located on the basement panel to indicate the total amount of make-up water to the reservoir tank. The readout of the "totalizing meter" is a timing device which runs during the time that the air-operated make-up valve is open. To convert the meter reading to gallons of water, multiply the meter reading by 1.13.

3. Variations in supply demand

Demineralized water usage at the ORR building varies from time to time, depending on many operations. It is important, however, that the supply of demineralized water to the ORR be continuous to provide water as needed. The mode of operation to the ORR should be as follows:

a. For normal operation, water to the ORR will be valved to permit flow from the Building 3004 storage tank. This will permit a continuous flow, regardless of the status of the units.

b. For abnormal conditions requiring large quantities of water, the valve may be opened to send water to the ORR, directly from a unit(s); however, the line from the Building 3004 storage tank should remain open at all times. The valves on this line are identified accordingly.

c. If it becomes necessary, due to an emergency, to interrupt flow to the ORR, contact all personnel involved.

4. Demineralizing process water for use in the cooling system

By passing process water through the pool demineralizer, another source of demineralized water is made available to fill the various parts of the two water systems. This can be used instead of, or in conjunction with, the normal demineralized supply from Building 3004. To do this, use the following procedure.

a. Stop the demineralizer pump and close valve No. P-3. This stops the normal operation of the pool demineralizer.

b. Close valves No. 228a and No. P-26.

c. Open valve No. 422b. This pressurizes the demineralizer system with process water.

d. Open valves No. P-26 and No. 143a to route the demineralized water to the reactor system.

e. Open valves No. P-26 and No. 208a to route the demineralized water to the reactor pool.

f. Open valves No. P-26 and No. 205c to route the demineralized water to the center pool.

g. Open valves No. P-26 and No. 207a to route the demineralized water to the west pool.

h. Open valves No. 228a, No. 204b, No. 204d, and No. 223a to route the demineralized water to the storage tanks.

5. Storage tank transfer via pool demineralizer

When high-quality water is stored for an excessively long time, it loses its quality through various mechanisms. When necessary, water stored in one of the storage tanks may be transferred to the other tank, by way of the pool demineralizer, to clean it.

To transfer water from the east tank to the west tank, use the following procedure.

a. Open valves No. 220a and No. 223a at the storage tanks.
b. Close valves No. 219a and No. 204d at the storage tanks.
c. Open valves No. 219b, No. 228a, and No. 204b in the basement of Building 3042.
d. Close valves Nos. 218a, 205b, 217a, P-2, P-26, 204a, and 206a in the basement of Building 3042.
e. Open valves Nos. P-3, P-4, P-5, P-6, P-7, and P-8 in the pool demineralizer circuit.
f. Start the fill and drain pump.
g. Open valve No. 227b on the exit side of the fill-and-drain pump.

CAUTION: Do not let the tank run dry or the pump will cavitate.

NOTE: To reverse this procedure, close valves Nos. 220a and 223a and open valves Nos. 219a and 204d.

5.6.5. The Secondary Loop

As has been explained, several kilowatts of heat are removed from the pool water by the shell-and-tube heat exchanger. This heat is transferred to process water which flows through the shell. The process water from the heat exchanger flows through a 6-in. line to a wooden spray tower west of the pump house. The water is pumped out of the spray tower sump and back to the shell side of the heat exchanger. The volume of water in the piping of the loop is 2,410 gal with the cooling tower basin and sump bringing the total capacity to 5,270 gal. The control of the pool secondary system is described in Section 5.6.6.

1. The secondary cooling system

Heat absorbed by the pool water due to conduction and radiation heating is transferred to a secondary water system in an aluminum heat exchanger. The secondary water flows from the heat exchanger to a redwood cooling tower where it is cooled and pumped back to the heat exchanger at a rate determined by the control system. Plant process water is used in the system with a make-up to provide for evaporation and drift from the tower.

To protect against corrosion and scale formation, particularly in the aluminum heat exchanger, and to eliminate microbiological growths in the cooling tower, water treatments recommended specifically for this system are used.

a. Phosphate treatment

The phosphate treatment should be started as soon as the tower basin is filled and circulation is established. The continuous injection of the treatment chemicals into the system is accomplished by a small pump, pumping from a 55-gal drum to the basin.

b. pH control

The pH of the secondary system water tends to rise, primarily due to the increased concentration of $CaCO_3$. A high pH is very deleterious to the wood in the cooling tower, so sulfuric acid is fed into the system to maintain the acidity at acceptable levels. Acid addition must be controlled very carefully since an excessive amount of acid would be harmful to the metallic components of the system.

A pH range of 7.3 to 7.8 is generally acceptable for both the tower and the piping. Control within this range is normally effected through an automatic control system as described below. Manual operation may become necessary at times and a constant watch must be maintained to ensure that the controls are operating properly. The control system is described in the following together with an outline of the daily operational procedures.

The pH control system for the pool secondary water includes or makes use of: (1) the BSR storage tank for concentrated H_2SO_4, (2) one variable-stroke metering pump (manual control of stroke), (3) a constant-flow pH monitor, (4) a control room pH recorder-controller with high and low control switches and high and low alarms, and (5) a switching station in the control room used to select manual or automatic control or to turn the system off.

When the system is in automatic, a signal from the probes is transmitted through appropriate wiring to the local indicating modifier, ApH IM-6. The output of the local indicating modifier is a 0-10 millivolt electrical signal to the control-room recorder, ApH R-6. Microswitches in ApH R-6 actuate an alarm if the indicated pH is outside the desired range (usually 7.3 to 7.8). Recorder ApH R-6 also contains microswitches which are connected to relays in the control circuit of the metering pump. The control microswitches serve to start and stop the metering pump and will be actuated at appropriate set points (usually 7.3 and 7.8, respectively). The stroke of the metering pump can be adjusted to provide a satisfactory pumping rate, i.e., a rate which will control the pH within the desired range.

(1) Placing the system in service

NOTE: The acid-metering pump will automatically stop when the secondary flow decreases to less than 275 gpm. This interlock prevents the pumping of acid into the tower basin when there is little flow over the tower. Generally, the acid-addition system should be readied for service before the secondary system is started. If it is not practical to ready the acid system, the acid-metering system be switched off before starting the secondary system.

(a) Open the inlet and exit valves at the metering pump, and the tower sump, respectively.

(b) Close the breaker for the metering pump (if open).

(c) Open the inlet valves to the pH probe and rotate the cleaner blade of the strainer.

(d) Place the system in AUTOMATIC or MANUAL (continuous) mode, as deemed necessary, by use of the switch in the control room.

(e) After secondary flow has been established over the tower for a period of 15 to 20 min, begin the sampling procedure as outlined below.

(2) Sampling procedure

To ensure proper operation of the automatic control or to provide a basis for adjustment if in MANUAL (continuous), it is normally necessary to sample the secondary stream at 4-h intervals. More frequent checks are necessary when the condition of the pool secondary system is undergoing rapid changes.

(a) Collect a sample of the secondary water from the sampling station provided in the ORR basement or the pool tower. Secondary water should flow through the sample line continuously; if not, then start a flow and allow sufficient time for the sample line to be cleared of stagnant water before sampling.

(b) Measure the pH of the sample using the portable pH meter provided in the ORR basement or the BSR pump house. Be assured that the meter is operating properly, using a buffer solution to check if necessary.

(c) Adjust the acid flow to obtain a pH of 7.3 to 7.8 if in MANUAL.

(d) If in AUTOMATIC, compare the reading obtained with the portable instrument with the indicated pH at the local panelboard. The two should agree within reasonable limits (difference of 0.2 pH units).

(e) Rotate the "tee" handle on the filter several times to clean the plates in the filter.

(f) Check that the flow across the probes is about 0.2 gpm.

(3) Removing the system from service

(a) No action is necessary for short-term shutdowns.

(b) For shutdowns lasting several days, or during which maintenance work will be done at the secondary system, the following steps are necessary:

(aa) Open the breakers supplying the metering pump. Tag with a properly completed "DO NOT OPERATE" tag.

(bb) Turn the control room switch to the OFF position.

(cc) Close the inlet and exit valves at the metering pump and the pool tower sump, respectively.

c. Biocide treatment

The periodic injections of biocide to control the microbiological growths should be performed as follows.

(1) After the tower basin is filled and water circulation is started, add 1 gal Microbiotreat DK520 to the sump.

(2) To treat the tower basin, add 3 gal of sodium hypochlorite on Tuesday and 1 gal of Microbiotreat DK520 on Friday of each week. Close the blowdown for 4 h after each treatment.

d. Total-solids control

The base for optimum control conditions is to maintain a concentration ratio of system water to make-up water of approximately 7 to 1 (900 to 1000 micromhos).

(1) Sample the system water and determine total-solids content.

(2) Compare results to total-solids content of make-up water. Adjust the blowdown rate to obtain optimum conditions, that is, if total solids is >1000 micromhos, increase blowdown; if total solids is <900 micromhos, decrease blowdown.

(3) Under normal operating conditions, the total-solids content of the tower water will be determined once each shift and the blowdown rate adjusted accordingly.

(4) The blowdown from the pool tower basin discharges to the air-conditioning tower sump through a 1.5-in. interconnecting line. A valve located just east of the A. C. tower pump labeled "pool tower blowdown" is used to adjust the blowdown rate.

2. <u>Draining secondary cooling loop</u>

On occasion, it may be desirable to dump the contents of this loop. Since this water is nonradioactive, its drain (a 4-in. vitrified clay pipe) is connected to the 18-in. concrete pipe just north of Building 3012. The procedure for dumping is as follows.

a. Stop the circulating pump.

b. Close valve No. 446a, the supply to the float-controlled valve.

c. Open valve No. 530a, located on the drain line.

d. Open valve No. 529a. This will open the inlet line of the heat exchanger to the sump.

e. Open valve No. 528a which will open the exit line of the heat exchanger and the inlet line from the cooling tower to the sump. This will drain the entire system.

3. Filling the secondary cooling loop

The secondary system is filled with plant process water. By opening valves No. 404a and 446a, water is admitted to the pump sump and cooling tower basin. Valves Nos. 528a, 529a, and 530a should all be closed. These valves are underground but have T-shaped extension handles and are located on three sides of the pump sump. Check to be certain that valves No. 226a and No. 224a, in the basement of Building 3042 at the heat exchanger, are fully open. Valve No. 226, on the pump discharge, and valve No. 224b, the cooling tower supply valve on the west side of the tower, should be open.

The sump pump may now be started and stopped a few times to fill the lines and force any entrapped air to the pump where it can be vented. The sump pump may be left running when the system flow is near normal (900 gpm) on the control room instrumentation. A control valve in the circuit allows the system flow to vary about the design value of 900 gpm.

5.6.6. ORR Pool Cooling Control System

References

Dwgs. Q-1594B-1 through Q-1594B-6, RC2-1-3F, and M-11488-OR-001-E.

1. Introduction

The ORR pool cooling tower fan is a vertical-axis, propeller-type fan driven through a 90° gear box by a shaft connected to a dual-speed, squirrel-cage ac motor rated at 20/5 hp, 480 V, 3 phase. The fan control circuit is designed to permit the fan to operate in any one of three modes; these are fast forward, slow forward, and slow reverse. Automatic electrical and mechanical interlocks are provided. Provisions are made to operate the fan either in manual control or in automatic control, as governed by signals from an instrument controller located in the basement of the ORR. Fan control and indicating devices are located in the ORR control room and at the fan-motor starter located at the pool cooling tower (Building 3086).

The instrument control system of the ORR pool cooling system is centrally grouped in an instrument panel located just south of the pool shell-and-tube heat exchanger in the ORR basement. This centralization of controls aids in reducing maintenance costs; and the design incorporated in this system provides excellent temperature control of pool water.

2. Mode of operation

The temperature of the demineralized water returning to the reactor pool from the heat exchanger is controlled by an automatic system located on the panel adjacent to the heat exchanger in the basement of Building 3042. This temperature is recorded on the basement panel (TR-42) and indicated on a gauge in the control room. The normal control point is 88°F with the pool high-temperature annunciator activated at 95°F.

The pneumatic throttling valve (TCV-42) in the secondary cooling loop may be positioned automatically by a controller on the rear of TR-42 or manually by moving the red index on TR-42 from 3 psi (valve open) to 15 psi (valve closed). The mode of valve control is selected by the transfer lever on the bottom of TR-42.

The spray-tower fan control may be automatic or manual as selected by the SB switch in the control room. The automatic fan controller is located on the basement panel beneath TR-42.

In the automatic-fan controller, cam switches are operated by a motor which is turned on or off by pressure switches (TX-42A and TX-42B) connected to the same pneumatic line as the throttling valve. As the air pressure to TCV-42 is decreased to 4 psi, the valve is allowing maximum cooling; therefore, fan speed must be increased. TX-42A closes at 4 psi to drive the cam switch assembly up (clockwise as observed on the pointer on the fan controller) and thereby increase fan speed. The fan starts on low at 60° rotation and shifts to high at 120° rotation. Motor limit switches are located at 0 and 120°.

If the cooling is excessive, air pressure to TCV-42 will increase to close the valve. At 9 psi, TX-42B will close to drive the cam switch assembly down (CCW) and reduce fan speed. However, as long as the pneumatic pressure to TCV-42 is between 4 and 9 psi, the fan speed will not be changed; and TCV-42 will provide the necessary control. If the pneumatic pressure is >9 psi, TX-42C prevents the spray tower pump from running. FX-4B prevents the fan from operating if the spray tower pump is not running.

Two toggle switches on the automatic fan-control panel allow it to be tested. The "auto-test" switch will remain in AUTO unless the controller is to be tested. If this switch is put in the TEST position, the cam switch assembly may be driven up or down by the second toggle switch which is marked "up-off-down."

The system can be operated in either the MANUAL or AUTOMATIC mode as follows:

To operate the system in AUTOMATIC:

a. Place the SB switch, located in the control room on the pool-system graphic panel, in the AUTO position.

b. The "auto-manual" lever, located inside TR-42 on the bottom, should be in AUTO. The TR-42 instrument is the Foxboro recorder located in the instrument rack of the subject system in the ORR basement.

c. The temperature control point, as indicated by the red index on TR-42, should be set to the desired point. Normally, this will be approximately 89°F.

d. The fan-controller "auto-test" switch, located on the front of the instrument rack of the subject system in the basement, should be in AUTOMATIC.

To operate the system in MANUAL:

a. The SB switch, located in the control room on the pool-system graphic panel, should be placed in MANUAL.

b. Select the desired fan speed by pushing the appropriate button in the control room.

c. The "auto-manual" lever, located inside TR-42 on the bottom, should be placed in "MANUAL" position.

d. TCV-42 should be adjusted to obtain the desired flow by using the red index on TR-42.

e. The fan controller "AUTO-TEST" position is blocked out of the circuit by the SB switch when actuated in step No. 1 above.

It is important to note that items a and b are necessary for manual operation of the fan. Items a, c, and d are necessary for manual operation of the secondary valve.

3. Reverse phase of spray tower operation on pool secondary system (Reference Dwg. RC2-13F, Rev. 11)

During cold weather, ice formation on the cooling tower distributors could cause severe damage and thus reduce the efficiency of the unit. To prevent this, a reverse mode permits a reversal of the fan to utilize the heat from the incoming water to melt ice which may form. This operation will be used at the discretion of the shift supervisor.

When it is necessary to use the reverse mode of operation, the following steps should be followed (in order):

a. In the ORR control room, place the pool-cooling selector switch from AUTOMATIC to the MANUAL position. The operation of the fan will be stopped. Should the fan be operating in the MANUAL mode, push the stop button on the fan controls at either the control room or the pool cooling tower.

b. Within approximately 2 min of stopping the fan operation, press the slow reverse button on the fan controls at either the control room or the pool cooling tower. After the time delay (approximately 2 min) has timed out, the reverse circuit will be made and the fan will start in the reverse direction on slow speed.

c. Upon the completion of the ice removal, the system should be placed in the normal operating mode. NOTE: The fan should be operated in the reverse mode only long enough to remove the ice. The fan gear box can be damaged if the fan is operated in the reverse mode for long periods of time. Place the fan in the normal operating mode in the following manner:

   (1) Press the "stop" button in either the control room or the pool cooling tower.

   (2) In the control room, move the pool-cooling selector switch from MANUAL to the AUTOMATIC mode. After the 2-min time delay, forward operation will be resumed as needed automatically.

   (3) If the fan forward operation is to be resumed in the MANUAL mode of operation, press the desired forward pushbutton after the 2-min timer has timed out.

4. Pool-secondary tower fan-vibration switch

A vibration switch on the pool tower fan is located on the outside of the fan cylinder near the fan motor. If the fan shuts down, pilot lights on the fan starter panel will indicate if the failure is due to vibration or fan overload. The same pushbutton used to reset the overload will also reset the vibration switch. If the failure is caused by the vibration switch, it will have to be reset locally and in the ORR control room. If the fan continues to kick out, loosen the set point lock screw on the vibration switch and turn the set point control knob 90° clockwise. Start the fan and observe for any excessive vibration. If the vibration is not abnormal, investigate the cause of trouble in the vibration switch. When the vibration switch set point control knob is turned as far clockwise as it will turn, it should allow the fan to operate, but will not offer any protection for excessive vibration.

5.6.7. ORR Air-Conditioning Cooling Tower and Tower Basin

The air-conditioning cooling tower basin holds approximately 4000 gal of water. This tower is used to supply chilled water to the centravac for the air-conditioning units in Building 3042.

The treatment of the tower basin water is performed by the maintenance personnel in the air-conditioning section; however, the reactor operating personnel will check and note abnormal operation of the tower fan, basin water level, and check steam tracing operation during freezing weather. The shift check sheets will contain these checks.

5.7. Nash-Hytor Vacuum Pumps

References

Dwgs. D-33558, Piping Plan and Details
D-33559, Piping Elevations and Details
D-33562, Water and Exhaust Piping for Vacuum Pumps
ORNL LR-34474, Major Water Lines

1. Introduction

This vacuum system was devised for the purpose of removing moisture from the area between the ORR aluminum pool liner and concrete and, in particular, from the annular spaces around the major water lines which are embedded in the concrete walls. The constant vacuum of about 20 in. of Hg causes a continuous movement of the air that leaks into these regions and, therefore, helps control condensation and possible corrosion when temperature changes occur. It also serves as a leak-detecting device since periodic measurements are made and records kept of the amount of condensate collected in cold traps.

2. Description

The system consists of three Nash-Hytor vacuum pumps with a capacity of 100 cfm at 26 in. Hg vacuum, three 10-hp, 1800-rpm GE motors, three exhaust-water separators, piping, valves, gauges, and cold traps. One vacuum pump, motor, separator, gauge, etc., is located in the basement on the north side of the pipe tunnel wall near the entrance to the north inlet (111) and exit (102) reactor primary water lines. The other two vacuum pumps, motors, etc., are located at the south wall of the pipe tunnel near the south reactor demineralizer. Of these two systems, the west vacuum system has evacuation lines running to the west pool liner, the reactor and center pool liners, and the pool inlet (203) and exit (201) water lines. The east vacuum system has evacuation lines to the south inlet (110) and exit (101) reactor primary water lines.

The evacuation lines of each system are brought together at a manifold on the suction side of each vacuum pump. The exhaust and condensate are dumped into the main sump in the basement in front of the pipe tunnel.

The only requirements necessary for normal operation (i.e., continuous evacuation of annuli) after the pumps are primed and operating are:

a. periodic oiling of the roller bearings,

b. constant supply of process water to seals, and

c. 220/440-V, 60-A, 3-phase power to the GE motors.

3. Procedures

a. Setting up a cold trap

A cold trap is set up by merely diverting the vacuum through a 50-gal carboy which is situated in an insulated container and surrounded by dry ice. The method is as follows:

(1) Place the carboy in an insulated container (GI can) and surround it with a layer of dry ice approximately 6 in. deep.

(2) The ends of two 1-in. diameter hoses should be connected with hose clamps to the lines which "T" off the evacuation line to be cold trapped. These are located before and after the line block valve.

(3) Place the other two ends of the hose through a rubber stopper, and place the stopper in the top of the carboy.

(4) Open both of the valves on the lines to which the hoses have been attached, and, at the same time, close off the evacuation line block valve.

(5) Keep the cold traps iced for the collection period.

(6) To remove the cold trap from the system, reverse the above procedure.

b. Starting evacuation system

To start an evacuation system after an extended shutdown period, the procedure is as follows:

(1) Turn the power switch to "on." This switch is located on the front of a switch box above each of the motors.

(2) Press the reset button on the same switch box.

(3) Open the process water valve to the pump seals.

(4) Press the start button located beside the manifold.

(5) Check the vacuum obtained at the suction side of the pump. While still watching this gauge, decrease the amount of seal water until a point is reached where the vacuum begins to decrease. Then open the seal water valve just enough to maintain the maximum vacuum and no more.

c. Taking a system out of service requires merely:

(1) Pressing the stop button.

(2) Shutting off the seal water.

d. Extended shutdowns

For extended shutdowns for dismantling, reassembling, repairing, etc.

(1) Take the unit out of service as above.

(2) See bulletin No. I-P-V-L-335-E, "Installation and Operation of Nash-Hytor Vacuum Pumps and Compressors," 1958, Nash Engineering Company, South Norwalk, Connecticut.

5.7.1. Corrosion Coupons

In order to obtain corrosion data from locations in the ORR cooling systems other than the reactor cooling-tower sump, a corrosion coupon holder was designed which could be adapted to several locations. Holders of this type are now in service in the pool-cooling tower sump, and the outlet of the secondary side of the pool-cooling heat exchanger.

All specimens are furnished by Dearborn Chemical Company which supplies the chemicals for the secondary cooling systems treatments. The company also checks and reports corrosion data to the reactor maintenance supervisor.

The test location identified as the heat-exchanger outlet is on the outlet side of the pool-cooling heat-exchanger shell. This exposes the test coupons to hot, treated process water from the cooling tower. Temperatures at this point range from 85 to 95°F. After being cooled in the tower, the water passes over another test location in the cooling-tower sump at temperatures ranging from 75 to 85°F.

5.8. Water Transfer Systems

References

Dwgs. D-19425, D-22318-R-2, D-22242, D-18774, D-22322-R-2, D-22321-R-3, and D-19941, ORNL 55-8-183 "Auxiliary Pumps for ORR Process Water Systems," and RC2-21-2B "Pool Cooling and Circulating System Flow Sheet"

5.8.1. Normal Valve Conditions

The valve conditions for the normal operation of the water transfer systems are:

1. Valves closed

   a. Valve banks in the basement of Building 3042

204a	205a
206a	207a
208a	209a
217a	218a
219b	227b
228a	502a

   b. Storage tank area

204d	223a
219a	220b
102b	109Xa
413c	418a
507a	

   c. North balcony

   410a

   411a

   409d

2. Valves Open

P-2	P-26
201a	204b
205c	

3. Demineralizer - see Section 5.6.2.1.

In the following sections, when only one pool is to be involved in a water transfer, it is assumed that the appropriate dams are in place.

5.8.2. Draining Storage Tanks to Process Drain

If for any reason the storage tanks need to be drained, the following procedure will be used:

1. Call the chemical operators at Building 3105.
2. Close valve No. 219b, located on the suction leg of the fill-drain pump in the basement of Building 3042. This valve is closed to prevent the draining of other parts of the system.
3. Close the valves on all inlet lines to the storage tanks. These are located at the storage tank area:

   204d, on the drain line from the pool system,
   223a, on the drain line from the pool system,
   413c, a demineralized water line from Building 3004,
   418a, a demineralized water line from Building 3004,
   109b, water from the reactor system, and
   109Xa, water from the reactor system.
4. Open these valves which are also located at storage tank area:

   219a, drain for the west storage tank,
   220a, drain for the east storage tank, and
   507a, main drain valve to the process drain.

   This valve arrangement will drain water from the storage tanks to the process drain.
5. After the storage tanks have drained, return the valves to their normal positions.

5.8.3. Filling the Storage Tanks

To fill the storage tanks with demineralized water from Building 3004:

1. Close valves No. 204d, 219a, 202a, 223a, and 507a.
2. Open valves No. 413a and 418a.

5.8.4. Draining Reactor Pool Through Primary Cooling Loop to Storage Tanks

The purpose of this procedure is to drain the water in the reactor pool to a level equal to the elevation of the suction leg of the pool circulating pump. This is slightly below the top of the reactor vessel. Occasionally, during shutdown work, this may be necessary. When such an operation is required, the following procedure should be used:

1. The following valves are normally closed (check to be sure they are closed):

   valve No. 201a, suction of the pool cooling pump,

   valves Nos. 204a and 206a (they are 2-in. drain lines from the center and west pools located in the north bank of valves),

   valve No. 502a, a bypass line to the process drain - located in the north bank of valves,

   valve No. 218a, suction of the (fill-drain pump),

   valve No. 217a, in the north bank of valves,

   valve No. 228a, discharge line of the demineralizer, and

   valves Nos. 219a and 220a, storage tank area.

2. The following valves are normally closed but should be opened for this operation:

   valves Nos. 223a (west) and/or No. 204d (east), depending on which storage tank is to be used (these are located in the vicinity of the storage tanks), and valve No. 209a which is in the connecting line No. 209 between lines No. 201 and No. 204.

3. Valve No. 204b, a normally open valve, should be open.
4. Valve No. 209a can be used as the "shut-off" valve. This valve is located in Building 3042 basement in the north bank of valves.

5.8.5. Draining the Center Pool to the Storage Tanks

Occasionally, it may be necessary to drain the center pool. It can be drained either to the storage tanks or to the process drain system. If the water is of good quality, it is put in the storage tanks for further use. To permit the transfer of this water to the storage tanks, the following step-wise procedure should be followed:

1. The center pool will be drained through line No. 204
2. The following valves, normally closed, should be checked in the closed positions:

   No. 209a, in the north bank of valves, basement of Building 3042,

   No. 502a, in the north bank of valves,

   No. 206a, drain from the west pool,

   No. 228a, in the north bank of valves, basement of Building 3042 [Line No. 228 (3 in.) is an interconnecting line from No. 204 (4 in.) to No. 216 (3 in.)],

   No. 218a, near the suction of the fill-drain pump,

   No. 217a, in the north bank of valves,

   Nos. 219a and 220a, in the storage tank area,

   No. 507a, the drain of the storage tanks to the process drain, and

   No. 205c, the fill line for the center pool.

3. The following valves, normally closed, should be opened:

   No. 204a, on the drain leg of the center pool in the north bank of valves in the basement of Building 3042, and

   Nos. 223a and 204d, on the west and east tanks, respectively (one or both may be opened, depending upon where water is to be sent).

4. Valve No. 204b, located on line 204 (4 in.) in the north bank of valves in the basement of Building 3042, should be used for controlling the flow. A maximum flow rate of 200 gpm through the 204 (2 in.) line is available due to the difference in elevation.

5. After completion, restore all valves to their normal positions.

5.8.6. Draining the West Pool to the Storage Tanks

Occasionally, it may be necessary to drain the west pool to the storage tanks. This will be done only if the water is of such quality that it should be saved.

1. Check to see if the storage tanks have the necessary space.

2. The following valves, normally closed, should be checked in the closed position:

   No. 204a, in the north bank of valves, basement of Building 3042,

   No. 209a, in the north bank of valves,

   No. 502a, in the north bank of valves,

   No. 228a, in the north bank of valves,

   No. 218a, in the north bank of valves,

   No. 217a, in the north bank of valves,

   No. 219a, in the storage tank area, and

   No. 220c, in the storage tank area.

3. Valve No. 207a, normally closed, should be closed.

4. Open the following valves:

   No. 206a, on the north bank in the basement of Building 3042,

   No. 204b, on the north bank in the basement of Building 3042, and

   No. 204d and/or 223a, located in the storage-tank area.

5. After the desired amount of water has been drained, return the valves to their original positions.

5.8.7. Draining the Reactor Pool to the Process Drain

In the event it becomes necessary to drain the water from the reactor pool and there is no storage space available in the storage tanks, it must be drained to the process drain at a controlled rate.

If the gates are in place, the water in the reactor pool will drain only to the level of the exit line of the primary cooling loop. There is no drain line below this point in the reactor pool. The procedure for draining the reactor pool to the process drain is:

1. Call the chemical operators at Building 3105.
2. Close the following valves:

   No. 201a, in the suction side of the reactor pool cooling pump,

   No. 204a, in the north bank,

   No. 502a, in the north bank,

   No. 206a, in the north bank,

   No. 228a, in the north bank,

   No. 204b, in the north bank, and

   No. 410a, demineralized water supply to the reactor pool.

3. Open the following valves:

   No. 209a, in the north bank, and

   No. 502a, in the north bank.

4. After the water has been drained, return the valves to their original positions.

5.8.8. Draining the Center Pool to the Process Drain

To drain the center pool to the process drain at a controlled rate:

1. Notify the chemical operators at Building 3105.
2. The following valves, normally closed, should be checked to ensure that they are in the closed position.

   No. 209a, in the north bank of valves, basement of Building 3042,

   No. 502a, in the north bank of valves, basement of Building 3042,

   No. 228a, in the north bank of valves, basement of Building 3042,

   No. 218a, near the suction of the fill-drain pump,

   No. 205c, in the south bank of valves, basement of Building 3042,

   No. 204b, in the north bank of valves, basement of Building 3042,

   No. 411a, in the fill line for center pool, second level balcony, and

   No. 206a, in the north bank of valves, basement of Building 3042.
3. Open valve No. 502a.
4. Open valve No. 204a which will send the water into the process drain via lines 204 and 502. If valve No. 204a is fully open, water will be drained from the pool at approximately 200 gpm.
5. When the pool water has been lowered to the desired level, close valves:

   No. 204a, in the north bank of valves, basement of Building 3042, and

   No. 502a, in the north bank of valves, basement of Building 3042.

5.8.9. Draining the West Pool to the Process Drain

To drain the west pool to the process drain at a controlled rate:

1. Close the following valves:

   No. 409b, the demineralized water supply to the west pool, located on the north balcony,

   No. 207a, the fill line to the west pool, located in the south bank of valves,

   No. 204a, the drain line of the center pool, located in the north bank of valves,

   No. 209a, the drain line of the primary cooling loop, located in the north bank of valves,

   No. 218a, on the suction leg of the fill-drain pump and in the north bank of valves,

   No. 204b, on the main drain line from the storage pools to storage tanks in the north bank of valves, and

   No. 228a, in the north bank of valves.

2. Open the following valves:

   No. 502a, on a direct line to the process drain, located in the north bank of valves, and

   No. 206a, located in the north bank of valves, on the drain line to the west pool (this valve should be used to regulate the flow rate).

4. Following the completion of this operation, all valves should be returned to their normal positions.

5.8.10. Filling Reactor Pool from Storage Tanks Through the Pool Demineralizer

To fill the reactor pool, from water stored in the storage tanks, by passing it through the pool demineralizer if the water in the storage tanks is not of adequate quality:

1. Open valves No. 219a and No. 220a at the storage tanks.
2. Open valve No. 219b at the suction side of the fill-drain pump.
3. Valve No. 507a at the storage tanks must be closed.
4. Open valve No. 208a in the basement of Building 3042.

5. Open valves Nos. P-3, P-4, P-5, P-6, P-7, P-8, and P-26 at the pool demineralizer.

6. Close valves Nos. 205b, 218a, 217a, 205c, 207a, 143a, 228a, and P-2 in the basement of 3042.

7. Start the fill-drain pump.

8. Open valve No. 227b.

CAUTION: Do not let storage tanks run completely dry or the pump will cavitate.

5.8.11. Filling Center Pool from Storage Tanks Through the Pool Demineralizer

In filling the center pool from the storage tanks, a flow system can be obtained which will pass the storage-tank water through the pool demineralizers enroute to the pool. This will further demineralize the water, which may have been standing in the storage tanks for some time.

1. The following valves must be closed:

   No. 204a, center pool drain line,

   No. 218a, located on the suction side of the fill-drain pump,

   No. 205b, located on the discharge side of the fill-drain pump,

   No. 217a, located on the discharge to pool drain line No. 204, an interconnecting line from the fill-drain pump,

   No. P-2, located on the discharge side of the main demineralizer pump,

   (NOTE: The main demineralizer pump must be shut down while the center pool is being filled from the storage tank through the pool demineralizer.)

   No. 227b, located on the discharge side of the fill-drain pump on the line going to the pool demineralizer (this valve is used as a throttle valve and will be opened at full throttle after the pump is started),

   No. 507a, located at the storage tanks,

No. 208a, located on an interconnecting line between the discharge line of the fill-drain pump and the primary cooling loop,

No. 207a, located on the fill line of the west pool,

No. 143a, located on an interconnecting line between the discharge line of the fill-drain pump and line No. 110 of reactor cooling, and

No. 228a, north bank of valves, Building 3042.

Before the flow is started, a valve arrangement must be made on the pool demineralizer. See Section 5.6.2.2 for "through-flow" valving.

2. The following valves must be opened:

No. 219a, on the drain line of the west storage tank,

No. 220a, on the drain line of the east storage tank,

No. 219b, on the main line of the east and west storage tanks at the point where the main drain lines connects to the suction side of the fill-drain pump,

No. P-26, on the discharge line from the pool demineralizer, and

No. 205c, on the fill line to the center pool.

3. Start the fill-drain pump and open the throttle valve No. 227b all the way.

5.8.12. <u>Filling the West Pool from Storage Tanks Through the Pool Demineralizer</u>

To further demineralize the water in the storage tanks at the time of filling, the water can be passed through the pool demineralizers enroute to the pools. This will permit water of high specific resistance to be used in the pool.

In using the circuits necessary for this operation, it is imperative to isolate all other branches.

1. Isolate the demineralizer pump by closing valve No. P-2, which is the discharge of the demineralizer pump. The pump should be stopped.
2. The following valves should be closed:

   No. 507a on the drain line of the storage tanks to the retention ponds,

   No. 218a, in the north bank,

   No. 205b, in the south bank,

   No. 217a, in the north bank,

   No. 205c, the fill line of the center pool, located in the south bank of valves in the basement of 3042,

   No. 208a, in the south bank of valves in the basement of 3042,

   No. 228a, in the north bank of valves in the basement of 3042,

   No. 227b, in the north bank of valves in the basement of 3042, and used as the throttling valve of the pump,

   No. 143a, to the reactor system, and

   No. 206a, west pool drain line.
3. Open the following valves:

   No. 219a and/or 220a, at the storage tank site on the tank drain line,

   No. 219b, in the south bank of valves in the basement of 3042 (prepare demineralizers for "thru-flow"),

   No. P-26, in the north bank of valves in the basement of 3042, and

   No. 207a, fill line to the west pool, located in the south bank of valves.
4. Start the fill-drain pump and open valve No. 227b, located in the north bank of valves, to adjust the desired flow rate.

5. It must be pointed out that the storage tanks should never be pumped completely empty with the pump. This is to protect the pump from cavitation.
6. Upon completion, restore all valves to their normal positions.

5.8.13. Filling the Reactor Pool from the Storage Tanks

This procedure is used only if the water in the storage tanks is of good quality. If the pool is completely dry, the water in the storage tanks will not be sufficient for filling the pool directly.

1. Open valves Nos. 219a and 220a at the storage tanks.
2. Valve No. 507a at the storage tanks must be closed.
3. Open valves Nos. 219b and 208a in the basement of Building 3042.
4. Valves Nos. 143a, 217a, 205b, 207a, 218a, 204a, 227b, 205c, 201a, and P-26 in the basement of Building 3042 must be closed.
5. Start the fill-drain pump.
6. Open valve No. 205b.

CAUTION: Do not let the storage tanks run completely dry, to avoid pump cavitation.

5.8.14. Filling the Center Pool from the Storage Tanks

If at any time water has been removed from the center pool due to contamination or for working in the pool with a lower water level than normal, the following procedure for filling the pool will be used.

1. Close the following valves:

    No. 207a, on the inlet line to the west pool,
    No. 204a, on the drain line from the center pool,
    No. 507a, on the drain line from the storage tanks,
    No. 208a, on the inlet line to the reactor pool cooling system,
    No. P-26, on the line from the demineralizers to the discharge side of the fill-drain pump,

No. 218a, on the bypass line from the main drain line to the inlet side of the fill-drain pump,

No. 143a, on the line from the fill-drain pump to No. 110, the 24-in. inlet to the reactor,

No. 217a, on the discharge line from the fill-drain pump to the main drain line, No. 217, and

No. 227b, on the line from the discharge side of the fill-drain to the demineralizers.

2. Open the following valves:

   No. 205c, on the inlet line to the center pool, and

   No. 219b, on the inlet line to the fill-drain pump.

3. Start the pump and control the flow at 300 gpm with valve No. 205b on the discharge side of the pump.

4. After completion, restore all valves to their normal positions.

5.8.15. Filling the West Pool from the Storage Tanks

This procedure is used only if the water is of good quality. If the pool is completely dry, the water in the storage tanks will not be sufficient for filling the pool completely.

1. Make sure valves Nos. 219a and 220a, at the storage tanks, are open.
2. Valve No. 507a at the storage tanks must be closed.
3. Open valves Nos. 219b and 207a in the basement of Building 3042.
4. Close valves Nos. 143a, 217a, 205c, 208a, 218a, 205b, 206a, and P-26 in the basement of Building 3042.
5. Start the fill-drain pump.
6. Open valve No. 205b.

CAUTION: Do not let storage tanks run completely dry, to avoid pump cavitation.

5.8.16. Sending Water from Building 3004 Storage Tank or Demineralizers to the West, Center, or Reactor Pool

If water is needed for one or more of the three pools and the ORR storage tanks are empty, it can be obtained from Building 3004. There are two sources in Building 3004 from which demineralized water can be obtained. One is from the main storage tank and the other is directly from the demineralizers.

1. Make sure the following valves are closed to prevent water draining out at the same time it is being put in:

   No. 204a, gate valve on the north bank in the basement of Building 3042,

   No. 206a, gate valve on the north bank in the basement of Building 3042, and

   No. 209a, gate valve on the north bank in the basement of Building 3042.

2. Open one or more of the following valves to send water to the desired pool:

   a. No. 410a will permit the flow of demineralized water to the reactor pool. It is located on the wall of the north balcony of the reactor structure.

   b. No. 411a will permit the flow of demineralized water to the center pool. Same location as above.

   c. No. 409b will permit the flow of demineralized water to the west pool. Same location as above.

3. After obtaining the desired amount of water, return the valves to their original positions.

5.9. Auxiliary Systems

References

Dwgs. ORNL D-32991, 32894, 32895, 32896, 32899, 36161, P-10143F-001-D

5.9.1. Beam Holes

1. Introduction

The beam-hole facilities consist of the following: HB-1 through HB-6, HN-1, and HN-4. It should be noted that the HB (horizontal beam) holes are part of the original reactor design. The HN (horizontal north) holes are part of the engineering test facility located on the north side of the reactor and were modified in 1963 to be used as beam-hole facilities.

The HB holes are of circular cross section, decreasing in diameter in one step from approximately 9 1/8 in. at the face of the concrete to approximately 6 3/4 in. at the reactor vessel. The pipe which encases a beam hole is designated as the liner. Each beam hole is equipped with a collimator plug or, in its absence, a dummy plug. The plug seals the outer end of the beam hole and extends inward to within approximately 3 ft of the reactor vessel. Service piping enters through the outer flange of the plug, except for the liner vent-return line, which is embedded in the concrete shield.

The HN holes are of circular cross section 10 in. in diameter. A plug extending to within 1/4 in. of the reactor vessel seals the hole. Service piping enters through the plug.

During installation or operation of experiments at the beam holes, it sometimes becomes necessary to fill the liner, the plug, or both with water to provide biological shielding. Subsequently, the plug and/or liner must be drained, dried, and possibly placed under continuous air or helium purge. A separate system added in 1978 provides for purging or pressuizring the liners at HB-1 through HB-6 with helium to prevent the buildup of aluminum oxide.

The purpose of this procedure is to describe the facilities provided to accomplish the above operations and to set down in step-by-step sequence the method by which the operations are to be done. This procedure includes draining the plugs and liners to the off-gas system and, consequently, to the off-gas seal tank. The reason for draining to the off-gas system is to prevent the release of airborne activity to the building proper from the floor drains.

a. Service piping (general)

The service piping to the ORR beam holes is depicted on the ORNL drawings, as referenced, and schematically shown on Figs. 5.25 through 5.30. Six piping headers are located in the basement adjacent to the east end of the reactor wall and directly under the beam holes. These headers consist of:

(1) water supply from the pool cooling system,

(2) water return to the pool cooling system,

(3) plant air reduced to 15 psi,

(4) process drain,

(5) off-gas, and

(6) helium supply from outside the building.

ORNL-DWG 84-8175

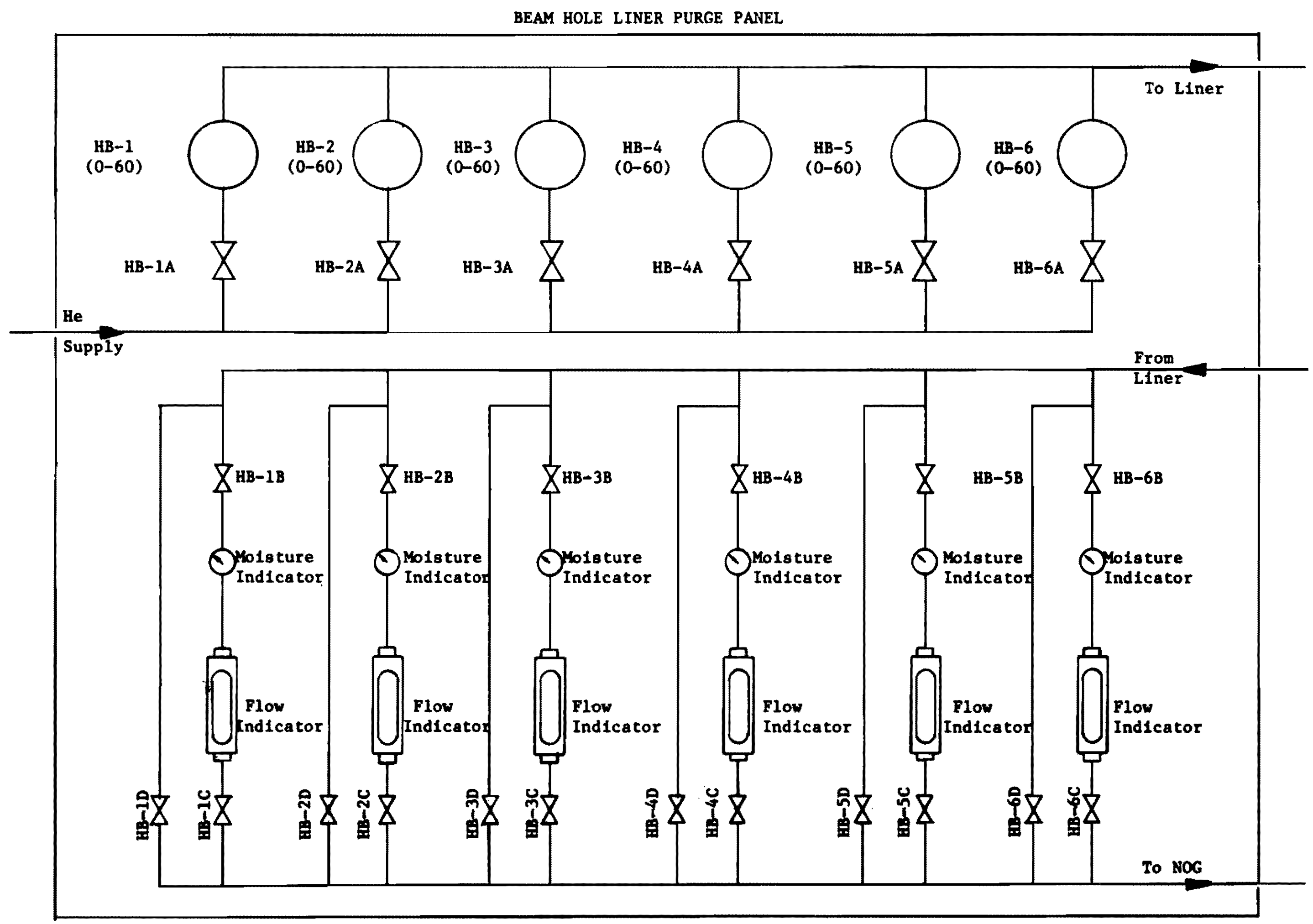

Fig. 5.25. HB-1 through HB-6 liner service panel (in use).

ORNL-DWG 84-8148

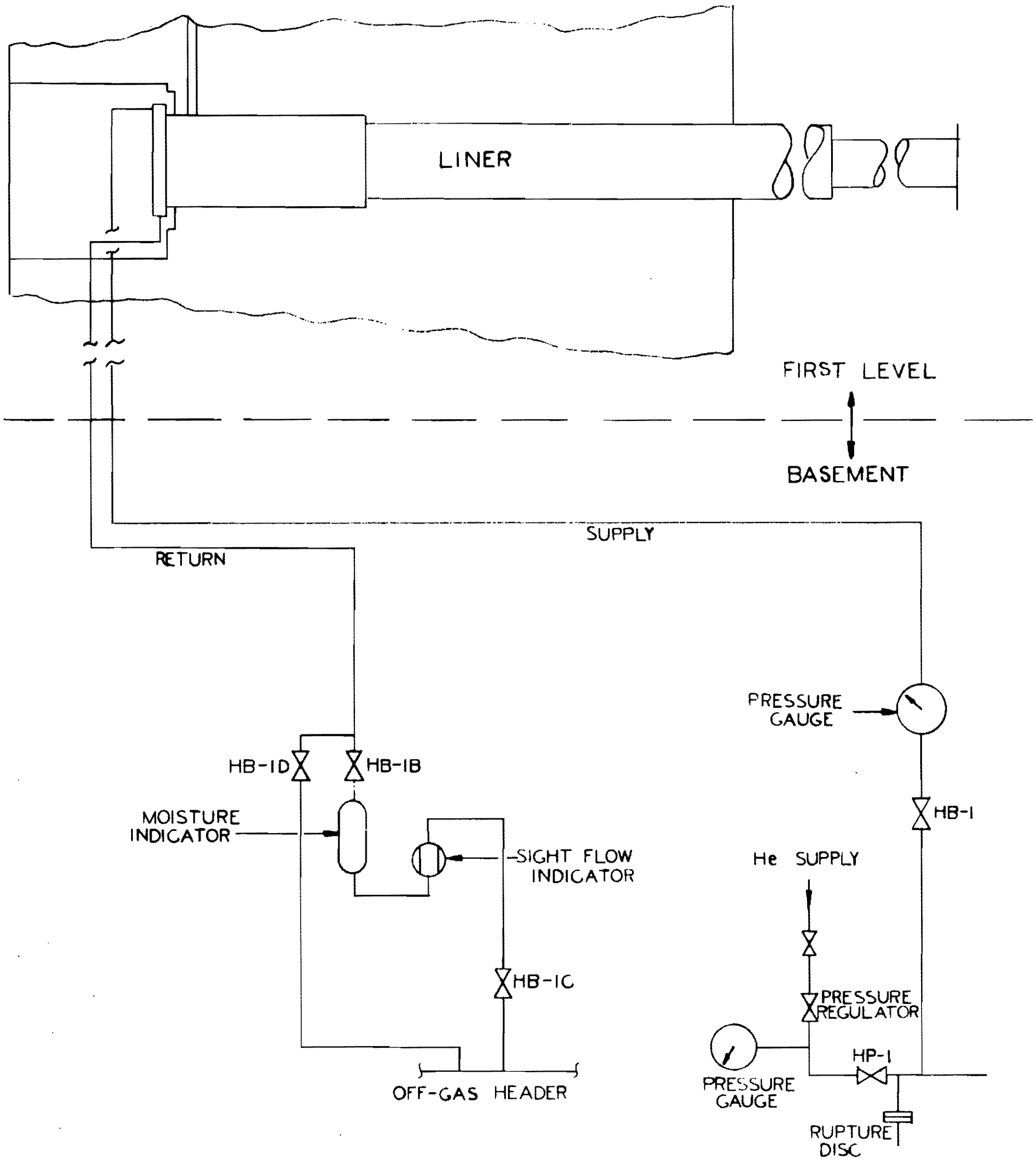

Fig. 5.26. HB-1 thru HB-6 liner service piping (in use).

ORNL-LR-DWG 64-8207R

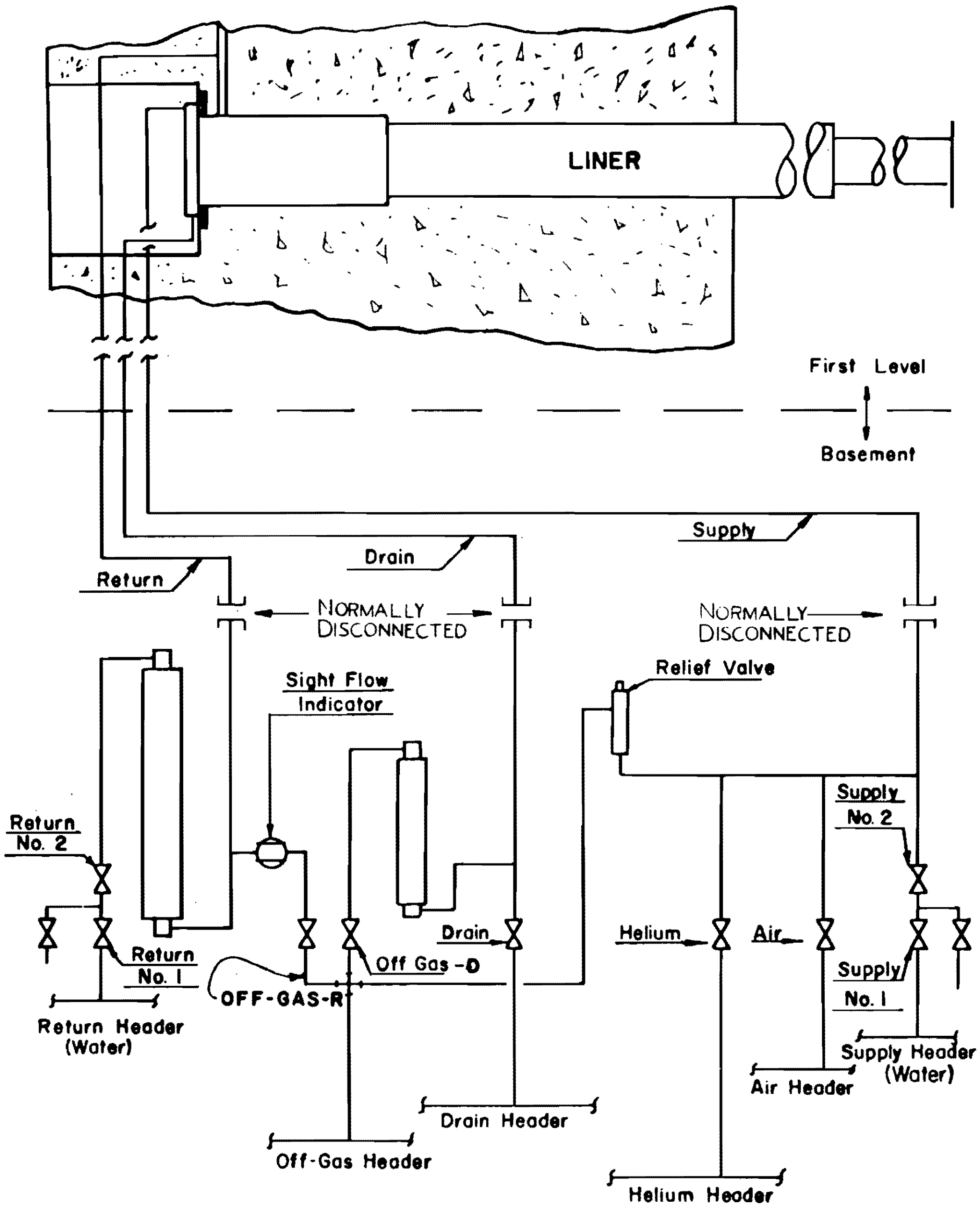

Fig. 5.27. HB-1 thru HB-6 liner service piping (not in use).

ORNL-DWG 84-8173

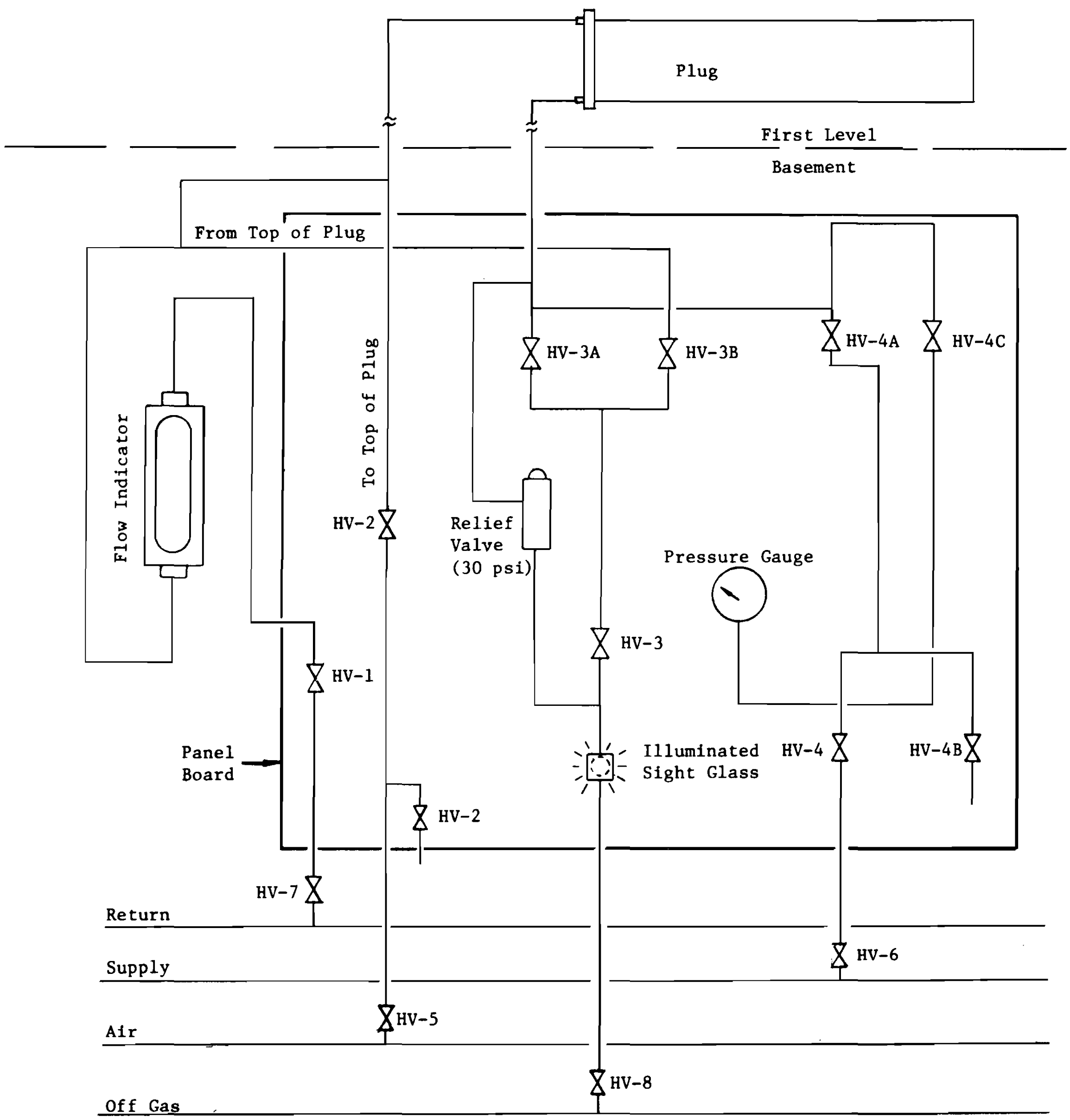

Fig. 5.28. HB-1 thru HB-6 plug service piping (in use).

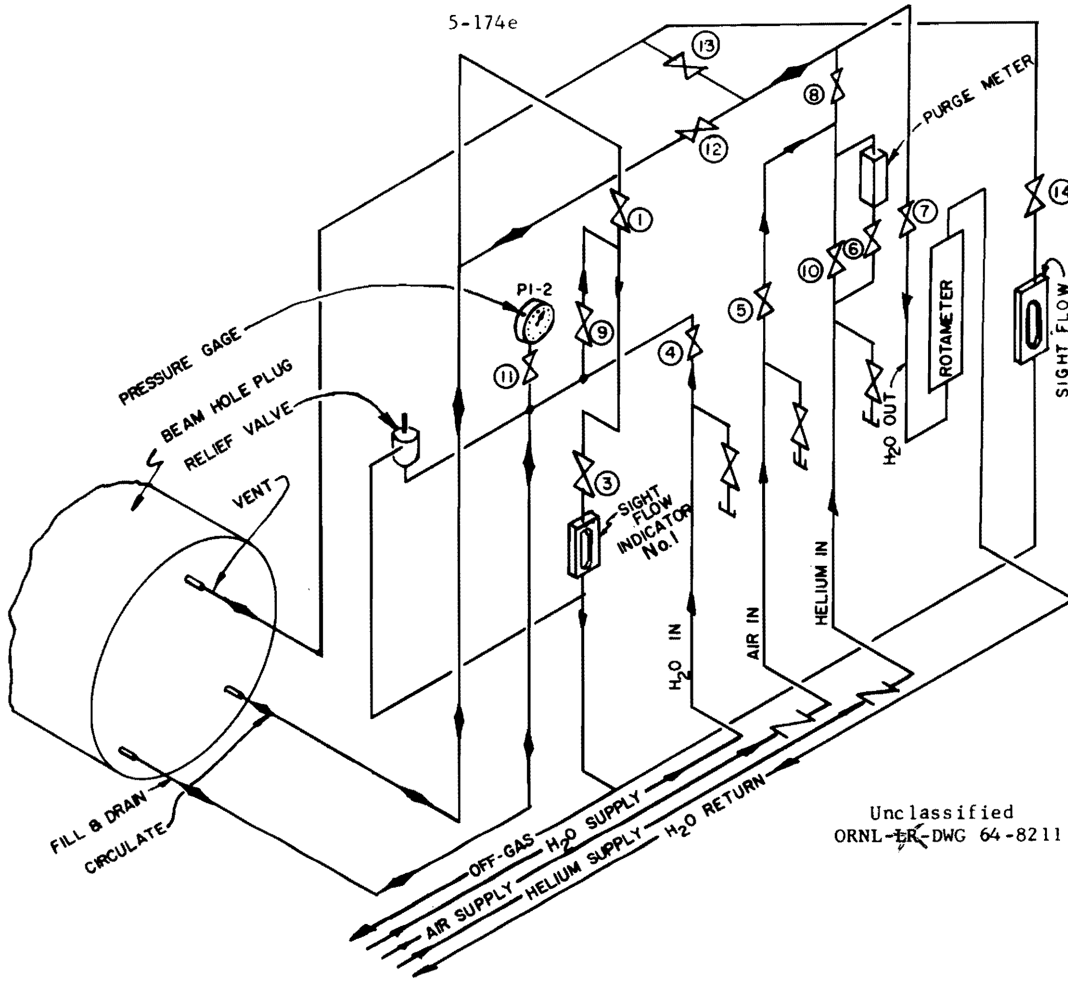

Fig. 5.29. HN-4 plug service piping (in use).

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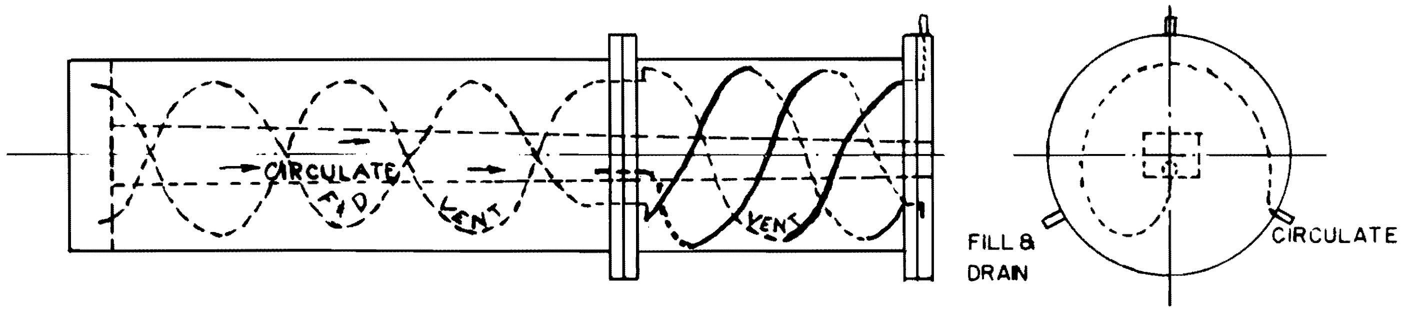

Fig. 5.30. HN-4 plug flow diagram.

b. Service piping (original)

Lines from the above listed headers originally were connected to each liner (HB-1 through HB-6) and plug (all beam holes) in such a way that they could each be separately:

(1) filled with water, air, or helium;

(2) purged with air or helium (continuously); or

(3) filled with continuously recirculated water.

The liner at HN-4 is supplied with water from the facility cooling system and is maintained full.

c. Service piping (revisions)

Various revisions to the service piping, however, have resulted in the following piping arrangements.

(1) The beam-hole liners at HB-1 through HB-6 are connected to a helium purge system as depicted in Figs. 5.25 and 5.26. Use of a helium purge will prevent buildup of aluminum oxide in the liner.

(2) The beam-hole plugs at HB-1 through HB-6 are connected to the service headers as shown in Fig. 5.28.

2. <u>Filling and draining</u>

Should it be necessary to fill a beam-hole liner with water, then special procedures must be issued to accomplish changes in the piping, i.e., reconnecting service lines to the headers.

a. Precautions

Certain very serious adverse effects will result from draining and/or filling one or more beam-hole liners or plugs unless the precautions listed below are strictly followed. It is expected that personnel from the Reactor Operations Section will perform all operations at the beam holes because of potential hazards which include: (1) severe radiation exposure of personnel; (2) false and dangerous signals to the reactor nuclear instrumentation; (3) sudden changes in reactor power; and (4) damage to experiments.

(1) Liner

NOTE: The beam-hole liners Nos. 1 through 6 have special piping (Figs. 5.25 and 5.26) which allows purging or pressurizing the liner with helium gas. To fill a liner with water requires approval by the Reactor Supervisor, a special piping arrangement (Fig. 5.27), and special procedures.

(a) Liner draining and filling

(aa) Always be certain that the reactor is not operating when filling or draining a beam-hole liner.

(bb) Always have Health Physics coverage when draining a liner.

(cc) Always maintain a flow of water through a liner if that liner is to stay full for several hours.

(dd) Always close the supply water valves and the return-water valves tightly when a liner is to remain drained.

(b) Liner purging or pressurizing

Do not exceed the design pressure of 30 psig.

(2) Plug

(a) Plug filling and draining

(aa) Always have Health Physics coverage when draining a plug.

(bb) Always maintain a flow of water through a plug if it is to remain full of water for several hours.

(b) Plug purging or pressurizing

Do not exceed the design pressure of 30 psig.

b. Procedures

The following procedures are quite complicated, and several different valving arrangements are used at the various plugs. An overall procedural outline is given below to facilitate the use of the procedures. The leading numbers do not match those of the detailed procedures.

(1) General

(2) Beam-hole liners, HB-1 through HB-6 (Fig. 5.27)

  (a) Normal operation - purge or pressurization with helium (Figs. 5.25 and 5.26)

  NOTE: Presently not in service.

  (b) Special operation (requires reconnecting service lines, Fig. 5-27)

    (aa) Filling the liner with water, HB-1 through HB-6 only.

    (bb) Draining water from the liner.

    (cc) Purging the liner with air or helium.

    (dd) Stopping the air or helium purge of the liner.

(3) Beam-hole liners HB-1 through HB-6 (Fig. 5.26)

  NOTE: Presently in service.

  (a) Purging the liner with helium.

(4) Beam-hole plugs

  (a) Filling the plugs with water

    (aa) Filling HB-1 and HB-6 plugs with water (Fig. 5.28)

    (bb) Filling the HN-4 plug with water (Fig. 5.29)

  (b) Draining water from the plugs

    (aa) Draining water from HB-1 and HB-6 plugs (Fig. 5.28)

    (bb) Draining water from the HN-4 plug (Fig. 5.29)

  (c) Purging the plugs with air

    (aa) Purging HB-1 and HB-6 plugs with air (Fig. 5.28)

    (bb) Purging the HN-4 plug with air or helium (Fig. 5.29)

c. Operation

(1) General

(a) All operations performed in connection with the beam-hole services are the responsibility of the Reactor Operations Section. Valving is to be done by the Reactor Operations Section personnel. Any deviation from this practice will require a supplement or revision to this procedure.

(b) The importance of item (a), above, was very evident from tests during which the beam-hole liners were drained and filled with the reactor at a low but constant power level. Nuclear instrument readings were observed to vary by a factor of five.

(2) Beam-hole liners, HB-1 through HB-6 (refer to Fig. 5.27). All valves for the beam-hole liner services are located in the basement immediately adjacent to the headers. The water supply and return lines for each liner have been disconnected to prevent inadvertent filling. It will be necessary to reconnect these lines to perform the filling operation described below. (This operation must be approved by the Reactor Supervisor.)

(a) Filling the liner with water, HB-1 through HB-6 only (to be done only when the reactor is not operating)

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine the status of the liner to be filled (i.e., purging, empty, etc.) from the Beam-Hole Status Sheet in the control room.

(cc) Referring to the applicable part of this procedure, stop the operation in progress.

(dd) Determine without doubt that all valves to the liner concerned are tightly closed.

(ee) Open the valve connecting the water-return line to the off-gas header. This valve is identified as "Off-Gas -- R."

(ff) Open completely both water supply valves identified as "Supply No. 1" and "Supply No. 2."

(gg) Observe the flow through the sight flow indicator in the off-gas line. When gas ceases to flow and water flow is established, close the off-gas valve.

(hh) Open both valves to the water-return lines identified as "Return No. 1" and "Return No. 2." Adjust the flow to approximately 40% of full scale on the rotameter. (100% scale reading is 8.8 gpm.)

(ii) Record the status of the beam-hole liner on the Beam-Hole Status Sheet in the control room.

(jj) Using the applicable procedure, empty the off-gas catch tank.

(b) Draining water from the liner. (This must be done only when the reactor is not operating.)

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine the status of the liner to be drained from the Beam-Hole Status Sheet in the control room. Water should be continuously flowing.

(cc) Close both water-return valves: "Return No. 1" and "Return No. 2."

(dd) Close both water supply valves: "Supply No. 1" and "Supply No. 2."

(ee) Open the valve connecting the drain to the off-gas header; this valve is labeled "Off-Gas -- D."

(ff) Open the air supply valve identified as "air" and the air-supply-adjustment valve. This will force water from the liner to the off-gas seal tank. Adjust and observe the flow in the small rotameter.

(gg) When air flow is established to the off-gas, adjust the air flow through the small rotameter to 0.8 of full scale and purge the liner for 30 min (use the "off-gas" valve for adjusting the flow).

(hh) If the liner is to be left drained without purge,

(aaa) close the "off-gas" valve,

(bbb) close the "air" valves, and

(ccc) record the status on the Beam-Hole Status Sheet in the control room.

(ii) If the liner is to be left under continuous purge, proceed to the applicable part of this procedure.

(jj) Using the proper procedure, drain the off-gas catch tank.

(c) Purging the liner with air or helium (applies to HB-1 through HB-6 only).

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine that the liner is properly drained and that all liner valves are closed. <u>NOTE</u>: <u>If the liner has just been drained, air purge will have been established</u>.

(cc) Open the valve connecting the drain to the off-gas header labeled "Off-Gas -- D." Adjust and observe the flow through the small rotameter.

(dd) Open the air supply and adjustment valve or the helium supply valve as desired.

(ee) Adjust the air or helium flow to the desired level using the valve indicated in (4) above.

(ff) Record the status on the Beam-Hole Status Sheet in the control room.

NOTE: Presently not in service.

(d) Stopping liner, helium, or air purge.

(aa) Close the valve connecting the drain line to the off-gas header labeled "Off-Gas -- D."

(bb) Close the air or helium supply valve as applicable.

(cc) Record the status of the liner on the Beam-Hole Status Sheet in the control room or proceed to the applicable part of this procedure.

(3) Beam-hole liners HB-1 through HB-6 (Fig. 5.26)

NOTE: Presently in service.

The beam hole liners presently have a piping arrangement as depicted in Fig. 5.26 which permits the liners to be purged with helium. The liners are not purged during reactor operations due to the resultant high exhaust radioactivity associated with the exposed NOG header; therefore, all purging operation of the liner are scheduled during reactor downtime.

(a) Purge the liner with helium as follows:

(The No. 1 is associated with the HB-1 liner, No. 2 is associated with the HB-2 liner, and so on for HB-3 through HB-6 liners.)

(aa) Arrange for Health Physics coverage.

(bb) Open the supply valve on the helium cylinder

(cc) With HP-1 closed, adjust the pressure regulator for a 10-psig reading on the pressure gauge between the regulator and HP-1 on the helium supply header.

(dd) Open HP-1.

For each liner and one at a time, perform the following steps on the purge panel.

(ee) Open HB-1A and allow the liner to pressurize to 10 psig as indicated on HB-1 pressure gauge.

(ff) Open HB-1B and HB-1C.

(gg) Open the valve on the flow indicator until it reads approximately 3/4 full scale and observe that no water is present.

(hh) Close the flow indicator valve, HB-1B and HB-1C.

(ii) Open HB-1D and purge until radiation levels decrease to normal as indicated on the Health Physics monitors on the off-gas header.

(jj) Close HB-1D and allow the liner to repressurize to 10 psig as indicated on the HB-1 pressure gauge.

(kk) Close HB-1A.

Repeat steps (ee)-(kk) for liners 2-6.

After all liners have been purged and repressurized, secure the helium supply as follows:

(ll) Close HP-1.

(mm) Close the supply valve on the helium cylinder.

(4) Beam-hole plugs

Service piping for the beam-hole plugs (HB-1 through HB-6) extends from the headers in the basement through the first floor to the respective HB plug. There are service valves in the basement for each HB plug and also one common set for HN-4. At the first level, north side, the HN-4 air, helium, off-gas, and water headers are divided to provide service to each plug. All service valves for HB-1 through HB-6 plugs are located on panels in the basement near the service piping.

There are three panel boards at the service piping catwalk area as follows: HB-1 and HB-2 on the south panel, HB-3 and HB-4 on the center panel, and HB-5 and HB-6 on the north panel. The service valve numbers on all of the panels are identical; however, the panels are distinctively identified as to HB-1, HB-2, HB-3, HB-4, HB-5, and HB-6. The HN-1 and HN-4 service valve panels are located on the first level north near the north facility. The HN-1 panel is presently not in service.

(a) Filling HB-1 through HB-6 plugs with water (Fig. 5.28)

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine the status of the beam-hole plug from the Beam-Hole Status Sheet in the control room. The plug should be on air purge.

(cc) Referring to the applicable part of this procedure, stop the operation in progress.

(dd) Close all valves on the basement panel for the beam hole to be filled which will stop the air purge.

(ee) Open valves HV-6, HV-4, HV-4A, HV-4C, HV-3B, HV-8, and HV-3.
This will flow pool water from the water supply through the plug into the NOG (off-gas) header. Turn on the light behind the sight glass and observe the flow until all indications of air have disappeared. This will prevent trapped air from entering the pool cooling system in the next step.

(ff) Close valves HV-8, HV-3, and HV-3B.

(gg) Open valve HV-7.

(hh) Open HV-1 and adjust flow on the flow indicator to approximately 10% of full scale which allows water to return to the pool via the water return.

(ii) Recheck that valves HV-6, HV-4, HV-4A, HV-4C, HV-1, and HV-7 are open. Valves HV-2, HV-2A, HV-5, HV-3A, HV-3, HV-3B, HV-8, and HV-4B should be closed.

(jj) Water flow should remain established as long as the plug is filled with water.

(kk) Lock valves HV-6 and HV-7.

(ll) If the external shielding is to be removed or work is to be done at the facility, Health Physics
coverage is mandatory.

(mm) Record the status of the beam-hole plug on the Beam-Hole Status Sheet in the control room.

(b) Draining water from the HB-1 through HB-6 plugs (Fig. 5.28)

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine the status of the plug from the Beam-Hole Status Sheet in the control room. Water should be continuously flowing.

(cc) Close all valves on the basement panel for the beam hole to be drained which will stop the water flow.

(dd) Open valves HV-8, HV-3, HV-3A, HV-5, and HV-4C.

(ee) Open valve HV-2 to establish an air flow to the top of the plug.

(ff) Turn on the light behind the sight glass and observe the water being forced from the plug via the sight glass to the NOG (off-gas) header. When the water is no longer visible in the sight glass, turn the light off.

(gg) Recheck that valves HV-8, HV-3, HV-3A, HV-5, HV-4C and HV-2 are open. Valves HV-7, HV-1, HV-3B, HV-4A, HV-4B, HV-4, and HV-6 should be closed.

(hh) The plug is drained and should remain on air purge.

(ii) If the external shielding is to be removed or work is to be done at the facility, Health Physics coverage is mandatory.

(jj) Record the status of the beam-hole plug on the Beam-Hole Status Sheet in the control room.

(c) Filling the HN-4 plug with water (Fig. 5.29).

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine the status of both the HN-4 and HN-1 plugs from the Beam-Hole Status Sheet in the control room.

(cc) Referring to the applicable part of this procedure, stop the operation in progress.

(dd) Determine that all valves at the first-level manifold are closed tightly.

(ee) Determine that the plug service valves in the basement are as follows:

(aaa) Water supply and return - open and locked.

(bbb) Off-gas - open.

(ccc) Purge (air or helium) - open if the HN-1 plug is on purge and closed if the HN-1 plug is filled with water.

(ff) Perform the following valving at the first-level manifold:

(aaa) Open valve No. 11 to the pressure gauge.

(bbb) Open valve No. 14.

(ccc) Unlock valves No. 4 and 7.

(ddd) Open valve No. 4. This will start water into the plug at the bottom rear. Air or other gases will leave via the vent line through valve No. 14 and sight flow indicator No. 2 to off-gas. MONITOR THE OFF-GAS FOR RADIOACTIVITY.

(eee) When water (no bubbles) is observed to flow through sight flow indicator No. 2, close valve No. 14 and open valves Nos. 1 and 3. This will vent the "circulate" line to the off-gas through sight flow indicator No. 1.

(fff) When water (no bubbles) is observed to flow through sight flow indicator No. 1, close valves Nos. 1 and 3 and open valves

Nos. 12 and 7. This will allow water (some air initially) to return to the pool-cooling pump through the rotameter.

(ggg) Adjust the flow to approximately 10% of full scale using valve No. 7.

(hhh) Recheck valveing. Numbers 4, 7, and 12 should be open and locked. No. 11 should be open. All other valves, HN-4 first-level manifold, should be tightly closed.

(gg) Return at 1-h intervals for 3 h to determine that no air is trapped in the plug by:

(aaa) Opening valve 14;

(bbb) Observing that no bubbles flow through sight flow indicator No. 2; and

(ccc) Closing valve 14 after full water flow is observed through sight flow indicator No. 2.

(hh) If the external shielding is to be removed or work is to be done at the facility, Health Physics coverage is mandatory.

(ii) Record the status of the beam-hole plug on the Beam-Hole Status Sheet in the control room.

(d) Draining water from the HN-4 plug (Fig. 5.29).

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine the status of both the HN-4 and HN-1 plugs from the Beam-Hole Status Sheet in the control room. Water should be continuously flowing through HN-4.

(cc) Perform the following valving at the first-level manifold: Unlock and close valves Nos. 4 and 7 - relock in closed position.

(dd) Determine that the plug service valves in the basement are as follows:

(aaa) Off-gas and air - open

(bbb) If either HN-1 or HN-4 plug is filled with water, be sure that the water supply and return valves are left open since both plugs are serviced by common headers.

(ee) Perform the following valving at the first-floor manifold:

(aaa) Open valve No. 11 to the pressure gauge, PI-2.

(bbb) Open valves Nos. 5 (air), 8 (purge), and 13 which will allow air to the top of the plug. No. 12 should already be open.

(ccc) Open valve No. 9. This valve connects the bottom of the plug to the off-gas line.

(ddd) Slowly open valve No. 3 while observing the flow through sight flow indicator No. 1. Water should flow until the lines are blown clear, and then air flow should be established. If this does not occur, close the off-gas valves and recheck the preceding steps. NOTE: It should take approximately 45 min to blow the water out of the plug if HN-1 is also on purge. The drain time will be reduced approximately one-third if HN-4 plug is the only one using the common air header.

(eee) Purge the plug with air for 30 min after air flow is established.

(fff) Recheck the valving. Numbers 3, 5, 8, 9, 11, 12, and 13 should be open. All other valves should be closed. NOTE: Regulate flow with No. 5.

(ff) If the plug is to be left drained without purge (the plug should be left without purge for only a few minutes):

(aaa) Close the following valves at the first-level manifold: Nos. 3 and 9 (off-gas), No. 5 (air), and No. 8 (purge).

(bbb) Determine that all unneeded plug service valves in the basement are closed; but, if either HN-1 or HN-4 plug is filled with water, then be sure that the water supply and return valves are left open since both plugs are serviced by common headers.

(ccc) Record the plug status on the Beam-Hole Status Sheet in the control room.

(gg) If the plug is to be left under continuous purge, proceed in accordance with the applicable part of this procedure.

(hh) Using the proper procedure, drain the off-gas catch tank.

(e) Purging the HN-4 plug with air or helium (Fig. 5.29).

(aa) Be certain that the necessary precautions are observed (see "Precautions" of this procedure).

(bb) Determine that the plug concerned is properly drained. NOTE: If the plug has just been drained, an air purge will have been established.

(cc) Close all valves at the first-level manifold.

(dd) Determine that the basement valving is as follows:

(aaa) Air (if air purge is desired) and off-gas - open.

(bbb) Water supply and return (if HN-4 plug is filled with water) - open and locked.

(ccc) Helium (if air purge is desired) - closed.

(ddd) Close air and open helium if helium purge is desired.

(ee) Perform the following valving at the first-level manifold:

(aaa) Open valve No. 5 (air) or valve No. 6 (to the small rotameter-helium supply) as desired.

(bbb) Open valves Nos. 12 and 13 (circulate and vent, respectively).

(ccc) Open valve No. 8 (purge).

(ddd) Open valve No. 9 (off-gas).

(eee) Slowly open valve No. 3 (off-gas) until the desired flow is obtained. With helium, the purge rotameter will indicate flow.

(fff) Close valve No. 13 after flow is established.

(ggg) Recheck the valving. Numbers 3, 8, 9, 12, and 5 or 10 should be open. All others should be closed tightly.

(ff) If any water entered the off-gas header, empty the catch tank using the applicable procedure.

(gg) Record the plug status on the Beam-Hole Status Sheet in the control room.

(hh) To stop plug helium or air purge at HN-4 perform the following valving at the first-level manifold:

(aaa) Close valve No. 3 (off-gas).

(bbb) Close valve No. 9 (off-gas from bottom of plug).

(ccc) Close valve No. 5 (air) or No. 10 (helium), as applicable.

(ddd) Close valve No. 8 (purge).

(eee) Close valve No. 12 (circulate).

(ii) Record the status of the plug on the Beam-Hole Status Sheet in the control room or proceed to the applicable part of this procedure.

5.9.2. Freezing Precautions

1. Introduction

The freezing of water in unsheltered portions of the ORR water system could lead to reactor shutdown, extensive damage to equipment, and costly maintenance. The prevention of freezing, therefore, is considered an essential part of operation.

Precautions against freezing in these areas include steam and electric heating and steam tracing. It is the purpose of this procedure to describe these systems and their operation.

The main steam lines to the following systems have thermostat controlled valves in addition to a hand-operated valve for each system (Fig. 5.31):

a. BSR cooling tower
b. Air-conditioning tower
c. Primary bypass filter housing
d. Storage tanks
e. Reactor secondary cooling tower and heat exchanger pit

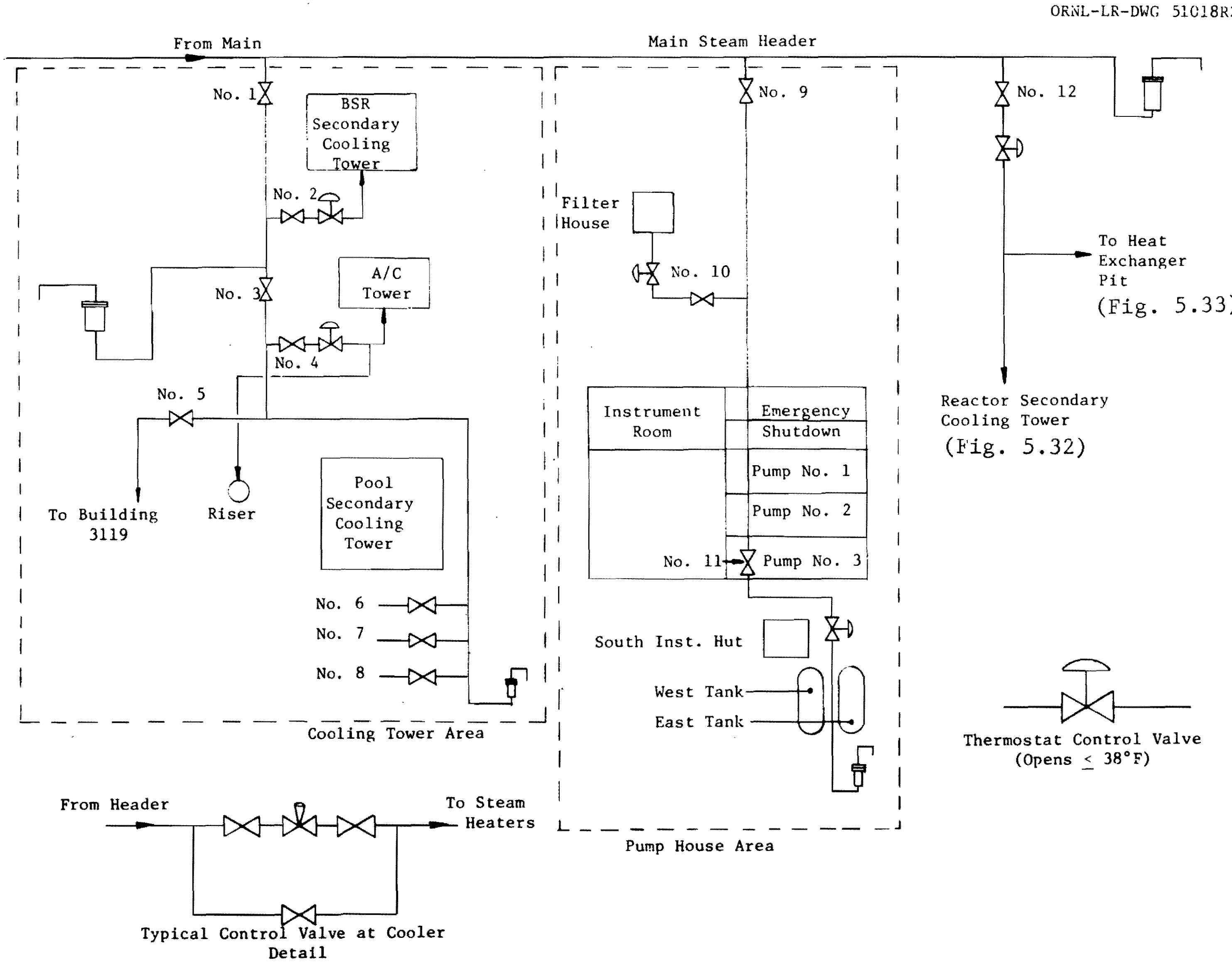

Fig. 5.31. Steam tracing system.

Normally, all the hand-operated valves are opened at the beginning of freezing outside temperatures and remain open until the end of freezing temperatures in the spring. The thermostat-controlled valves and steam traps virtually eliminate steam waste. The ORR-BSR maintenance supervisor will determine the shutdown date for the steam-tracing system. He will also have the system checked out and turned on before freezing weather starts.

2. General procedures

a. When to initiate freezing precautions:

(1) The control-desk operator will notify the Reactor Supervisor when outside temperature drops to 35°F.

(2) The Reactor Supervisor will, upon receiving notification of near-freezing temperatures, ascertain that the precautionary operations are effected.

b. When to recheck the area:

(1) Steam trace lines. Check for steam flow at least once per shift during freezing weather.

(2) Electric and steam heaters. Check for proper operation at least once per shift during freezing weather.

(a) Check temperatures of steam traps on exit of steam heaters.

(b) Check temperatures of electric heaters.

3. Pump house area

a. Pump cubicles

(1) Description. Each room in the pump house is heated by thermostatically controlled steam heaters. The normal set point for heaters in this area is 65°F. Power for fans is supplied from lighting panel LP-1, breakers 12 and 16, located in the instrument room of the pump house.

(2) Operation

(a) Open main supply valve No. 9, the main supply valve for the pump house area.

(b) Check the temperatures and operation of the steam traps at each heater (6 traps).

(c) Check the operation of the heater fans by raising or lowering the set point at the thermostat. Return to the 65°F setting after the test.

b. Bypass area

(1) Description. A steam trace line is provided for the bypass filters, which are located just north of the pump house.

(2) Operation

(a) Open valve No. 10 (outside north wall of pump house).

c. Storage tanks

(1) Description. Steam trace lines are provided for piping at the storage tanks. The instrument hutment in this area is electrically heated. Power for the strip heater and heatlamp is supplied from cabinet number LP-1, breaker 20, located in the instrument room of the pump house.

(2) Operation

(a) Open steam valve No. 11, located inside the pump house directly over No. 3 pump.

(b) Check the temperatures and operation of the steam trap at the end of the trace header (between the tanks at the south end).

(c) Check the temperature of the steam trace lines to:

(aa) Storage tank inlet lines Nos. 204 and 223.

(bb) Demineralized water make-up lines Nos. 413 and 418.

(cc) Drains from the air coolers lines Nos. 109 and 109X.

(dd) Return line to fill and drain pump, line No. 219.

(d) Turn the heater switch (inside the instrument hutment) to "on" position.

4. <u>Spray towers</u>

a. Air-conditioner tower

(1) Description. The inlet and exit lines at the air-conditioner cooling tower are steam-traced.

(2) Operation:

(a) Open valve No. 1, the main supply valve for the towers.

(b) Open Valve No. 4 (overhead, southwest corner of tower), the main supply valve to the air-conditioner tower.

(c) During extreme cold (25°F or less) check the inlet air baffles for ice formation. The air-conditioner tower fan cannot be reversed to de-ice the tower; therefore, use good judgment when dealing with the problem of de-icing the tower. It is possible for the removal of ice to cause more damage than if left alone. If the tower is heavily iced, knocking the ice loose can damage louvers and possibly the tower structure. In this situation, a steam hose should be used. Personnel safety should always be of prime importance. If it is imperative that ice be removed, get help rather than risk injury. The de-icing should be done on the 8-to-4 or early 4-to-12 shift when lighting is good.

b. Pool secondary-loop spray tower

(1) Description. The secondary-loop spray-tower area consists of the tower, the sump, and the pump. Steam trace lines are installed around the fill line (No. 409), the makeup line (No. 446), and the pump suction and discharge line (No. 226). It is anticipated that some ice may form on the inlet air baffles at the spray tower during extremely cold weather. In the event that this happens, it may become necessary to reverse the tower fan.

(2) Operation:

(a) Open valve No. 1, the main supply valve for the towers.

(b) Open valve No. 3, the supply valve to the pool cooling tower.

(c) Open valve No. 6, the supply valve to the float valve for the process-water makeup.

(d) Open valve No. 7, the supply valve to the secondary pump.

(e) Open valve No. 8, the supply valve to the steam radiator.

(3) During extreme cold (25°F or less), check the inlet air baffles for ice formation. It may become necessary to reverse the tower fan. Refer to Section 5.6.6.

c. Reactor secondary-loop cooling tower, Fig. 5.32.

(1) Description. This system consists of the reactor cooling tower and pump house. The steam line follows HB-6 flight tube past the heat exchangers and turns toward the secondary pump house where it enters the building at the southwest corner. The line follows the west wall and leaves the building at the northwest corner. It then parallels the west side of the tower.

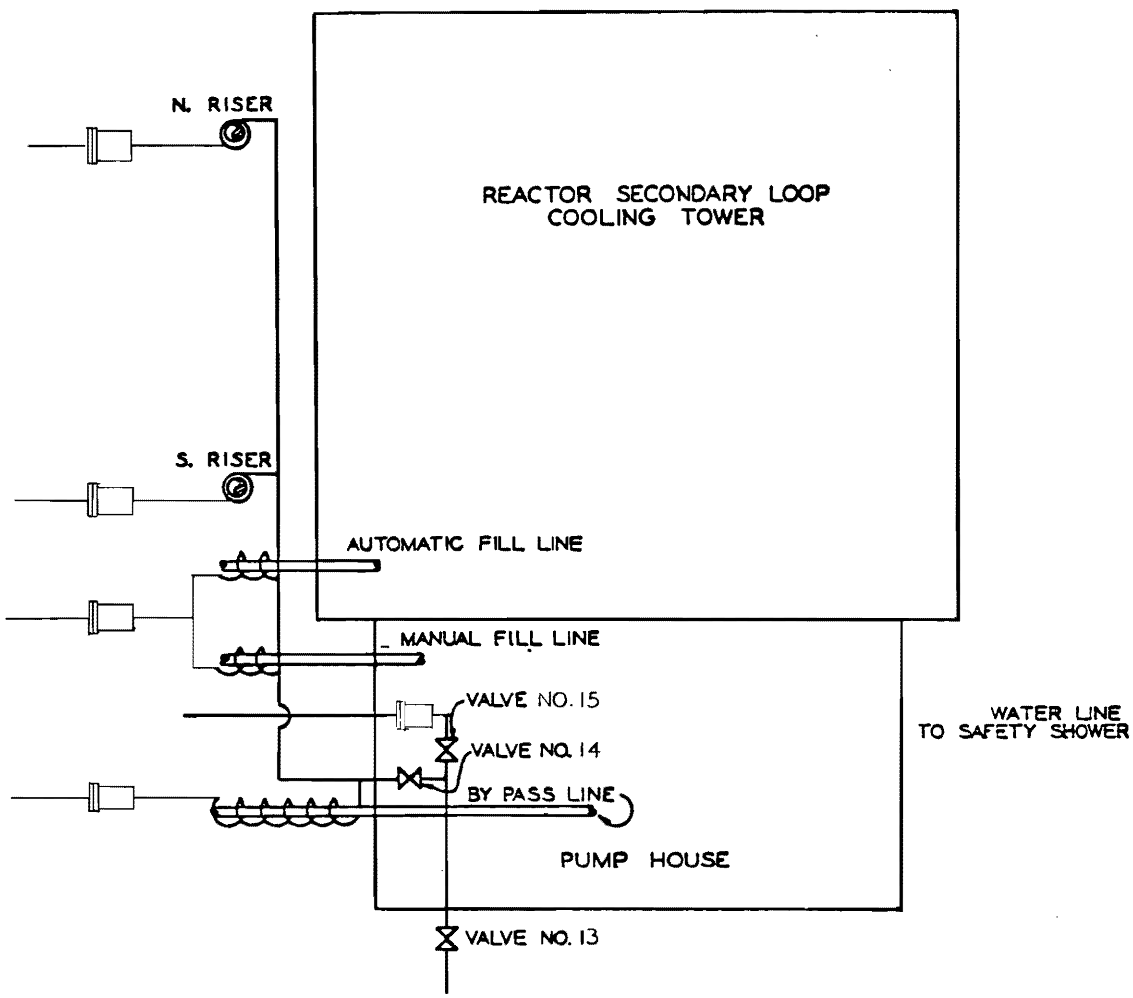

Fig. 5.32. Steam tracing for reactor secondary loop cooling towers.

Trace lines branch to the following components: the bypass line, the manual and automatic fill lines, and the risers.

(2) Operation:

(a) Open valve No. 12, the main supply valve for the reactor secondary tower and the heat exchanger pit.

(b) Open valve No. 13, located just outside the northwest corner of the tower pump house.

(c) Check the steam trace lines for temperature and flow.

(d) During extreme cold (25°F or less), check the inlet air baffles for ice formation. It may become necessary to reverse the tower fan. Refer to Section 5.3.5.

5. Reactor heat exchangers

a. Primary side, Fig. 5.33.

(1) Description. The main 2-in. steam line comes in overhead on the south side of the pit, through a 2-in. line and into a 1-in. line, via valves MB-1 and MB-2, which branches into the insulation on the west end of each exchanger. This 1-in. steam line terminates at the valves (SS-1 and SS-2) to the secondary steam headers. The individual heat-exchanger steam line splits three ways after passing through a valve (PS-1, PS-2, PS-3, or PS-4) and enters the insulation. One branch goes in east-west zigzags around the north side of the exchanger, ending at a steam trap. A second branch goes directly to the secondary exit tube header, then around the east primary inlet line to a steam trap. The third branch goes in east-west zigzags around the south side of the exchanger, around the primary exit line, and to a steam trap.

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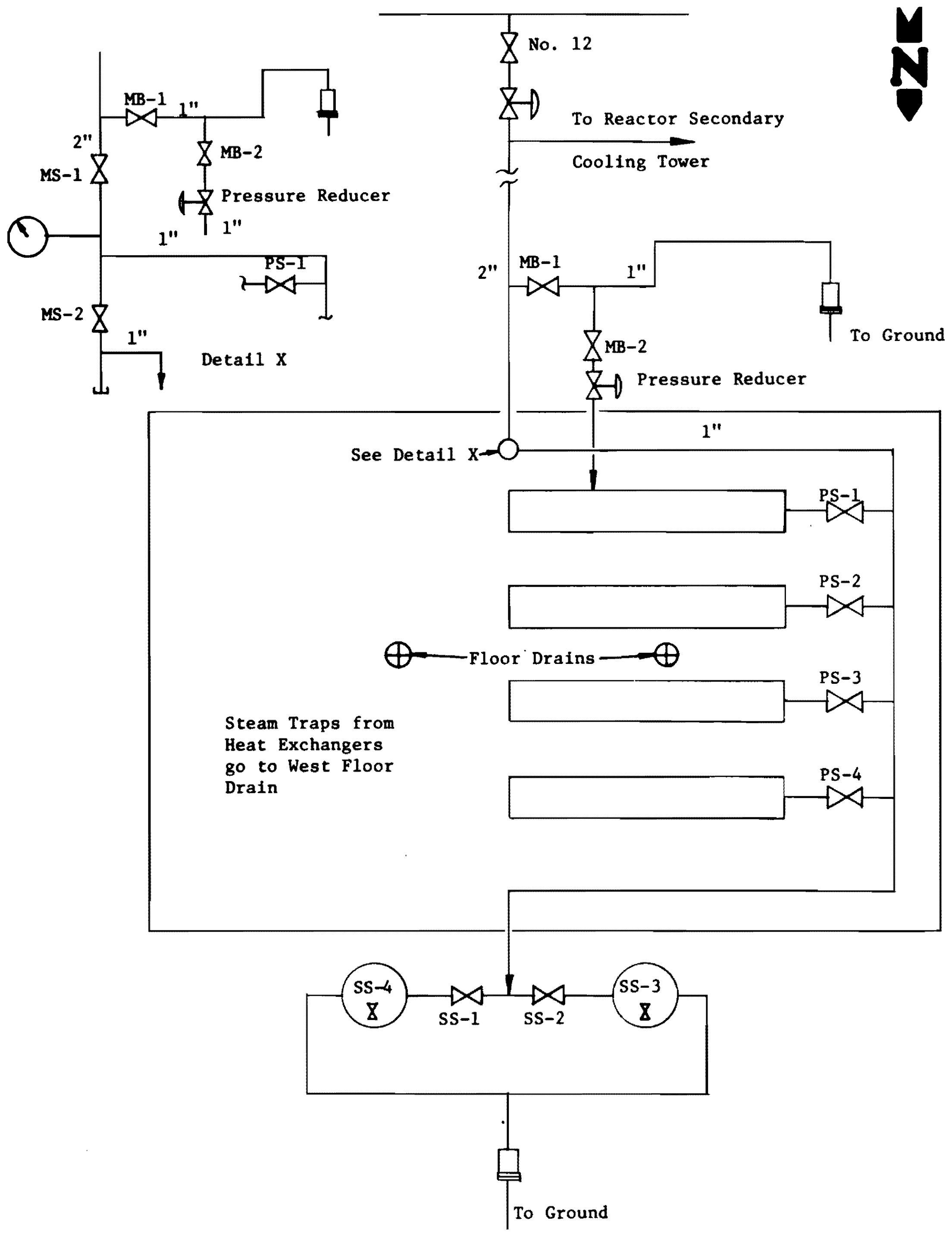

Fig. 5.33. Steam tracing for reactor heat-exchanger pit.

(2) Operation:

(a) Open the main steam line valves MB-1, MB-2, MS-1, and MS-2.

(b) Open the steam valve (PS-1, PS-2, PS-3, and PS-4) to each heat exchanger and open the steam valves (SS-1 and SS-2) to the secondary on the north side of the heat-exchanger pit.

b. Secondary side, Fig. 5.33.

(1) Description. The 1-in. line that feeds the primary side of the heat exchangers terminates in a "tee" at the north side of the pit; each branch has a valve (SS-1 or SS-2) which allows flow to either inlet (east) or exit (west) secondary-coolant steam headers. These inlet/exit headers, in turn, have one valve (SS-3 or SS-4) which feeds steam to the trace on the 16-in. inlet/exit line outside the pit where the trace bends and enters a steam trap. The other five lines from the header are 1/2-in. copper tubes, which run down the main 16-in. secondary line. One tube per exchanger goes to a steam trap on the northeast side of the exchanger, after winding around the individual 10-in. inlet/exit line and cut-off valve. The fifth line terminates in a steam trap on the south heat exchanger.

(2) Operation: Same as for primary side.

6. <u>Cell-ventilation filter pit area</u>

a. Sensor element housing. The housing is electrically heated by a strip heater.

b. Backflow preventor housing for seal tank. The housing is electrically heated by a strip heater and heat lamp.

5.9.3. Water Activity Readings, Scintillation Counter

1. Introduction

The various water systems in the Reactor Operations Section are sampled on a routine basis for the purpose of making radioactivity measurements. These measurements are made by using a well-type scintillation counter with an aluminum absorber. The counter is located underneath the stairwell in the basement (southeast corner) of Building 3042.

To ensure accurate sample measurements, it is important to keep the well free from contamination and to maintain an accurate record on the background and calibration factor. A clip-board has been placed on the front of the counter for the purpose of recording the date, background, and calibration factor when taking each set of measurements. This will allow the operator to have a record of the previous data. Should the background increase appreciably above the previous readings, there is a possibility that the counter well may have become contaminated. If so, it should be decontaminated immediately. In most cases, a piece of damp cheesecloth will be sufficient for decontaminating the well.

To prevent the counter well from becoming contaminated, the scintillation sample tubes should be cleaned with facial tissue before being placed in the well for counting. A box of facial tissue will be kept at the counter for this purpose. If decontamination of the well doesn't correct the condition, the counter should be checked for possible instrument trouble. The background counts for a given measurement should not vary more than ±7 1/2% from the average of the previous five measurements.

The operation of the counter is on a routine schedule and consists of calibrating the counter, inserting the sample of water, counting the sample, and adjusting the results by using the calibration factor. Each of these phases will be discussed in detail.

2. Voltage adjustments

Under normal circumstances, the power to the equipment will always remain on. This is to ensure stablization of the high-voltage supply. Normally, the equipment will not require adjustments, except for perhaps a monthly high-voltage adjustment to ensure that operation is within the plateau region of the counter.

This plateau region will be determined by supervisory personnel on a monthly basis. The method of plateau determination will be to take a series of 1-min counts at various high-voltage settings. A curve of cpm vs voltage can then be plotted and the plateau will be the flat part of the curve. The high voltage should be set midway on the plateau.

To turn the power on:

a. Turn the super-stable high-voltage power supply to + H.V.

b. Increase the high-voltage control slowly, starting at position A, until the desired level is obtained.

c. The desired operating voltage will be determined in the manner described above.

3. Calibration

As is the case for all types of counting equipment, this unit must be calibrated to give an absolute measurement. This is accomplished by using the cesium source, with a calibration supplied by the Analytical Chemistry Group, as a standard.

To determine the calibration factor:

a. Insert the cesium standard into the counter well.

b. Replace the lead plug which shields out excessive background counts.

c. Reset the timer; reset the total-count register.

d. Take a 1-min count, by using the timer "off" switch.

e. Record data.

f. Remove the cesium standard; replace the lead plug.

g. Reset the timer; reset the total-count register.

h. Take a 1-min count for general background.

i. Record the data.

j. The total count obtained in step i is due to background and should be subtracted from the number obtained in step e to give the net counts due to the cesium standard.

k. The current value of the standard is obtained from a chart of the value of the standard as a function of time. Use the date closest to the current date to find the current value of the standard.

l. After the current value has been determined, it should be divided by the net count obtained in step j. This will give the calibration factor to be used.

4. Sampling

In preparing the water samples for counting, observe the following procedure:

a. Using the scintillation sample tube, place 1 ml of water in the tube.

b. Place a cork stopper in the tube.

c. Label each tube to ensure proper identification of samples.

d. Dry each sample tube with facial tissue before placing it in the counter well.

e. Observe the following sample decay time on the various water systems.

(1) ORR water samples, 20 min.

(2) The Graphite Reactor canal and filter house seal-tank water samples require no specific delay or decay time prior to counting.

5. Counting

The scintillation counter is located near the steps in the southeast corner of the basement of Building 3042. The method of operation for counting a sample is as follows:

a. Determine the calibration factor.
b. Insert the sample into the well of the counter.
c. Reset the timer; reset the total-count register.
d. Turn on the counter and count for 1 min.
e. Subtract the background count, which is posted on the scaler, from the counts obtained in step d.
f. The count obtained in step e should be multiplied by the calibration factor, which is posted on the scaler, to give the counts min^{-1} ml^{-1} (cpm).
g. The results should be posted in their respective places: clipboard, logbook, etc.

5.9.4. Catch Tank Use and Purge

Reference

Dwg. D-33567

The catch tank is used for trapping moisture that has collected in the normal off-gas system. It is located in the ORR basement near the east wall, southeast corner. Purging or removing any trapped water from the catch tank is normally done once during every 12-to-8 shift.

The piping to the catch tank is shown on both the referenced drawing and schematically on Fig. 5.34.

To purge the catch tank, perform the following operation:

1. Close valves Nos. 1 and 2.
2. Open valve No. 3.
3. Open valve No. 4.
4. After approximately 2 min, reverse the procedure by closing valve No. 4, etc.; and the purge will be stopped.

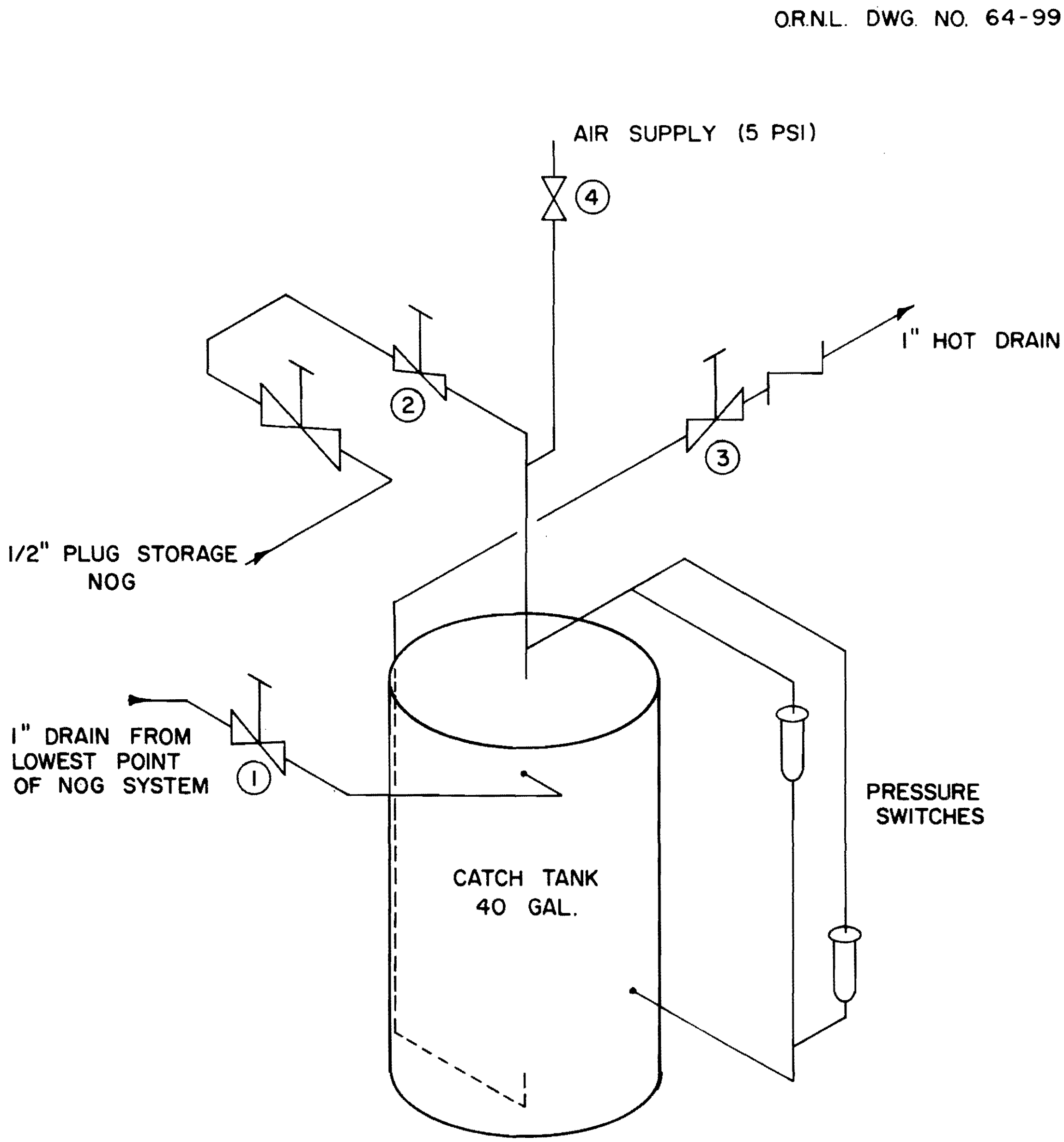

Fig. 5.34. NOG catch tank service piping.

NOTE: As a check to see that the system is functioning properly, there are two signals actuated when valve No. 4 is opened. One is a neon lamp located on the east wall approximately 4 ft above the basement floor, southeast corner; and the other is a control-room annunciator marked "Catch Tank."

5.9.5. Integrating Flow Meter for the ORR Demineralized Water Makeup from Building 3004

Reference

Dwgs.: Q-1594-3, sheet 2, and M-11488-OR-100-D

Although there are manually operated valves to allow the addition of demineralized water to the pool primary water system, during normal operation the volume of water in the system is, in essence, maintained automatically by a pressure-control valve located in the 400-gal reservoir tank in the basement (refer to Section 5.6.4).

Since the exit water line of the reservoir tank enters the pool demineralizer, the water leaving the tank is pumped back into the pool. The pool overflow lines route the water to the inlet of the reservoir tank, thus completing the flow scheme for this portion of the pool primary-water system.

If water is lost from the pool primary-water system (by evaporation, exchange with the reactor primary-water system, or leakage), the water level in the reservoir tank will decrease and subsequently actuate a pressure switch (LS-4A). The related instrumentation will, in turn, actuate a 2-in. diaphragm control valve located above the tank. An integrating digital readout located on the instrument panel directly south of the pool heat exchanger indicates the total makeup water volume. The control valve will remain open and allow the demineralized water from the storage tank in Building 3004 to flow into the reservoir tank until the water level actuates the pressure switch (LS-4B).

To compute the total volume of makeup water required during any period of time, multiply the difference in integrator readings (obtained preceding and following the time interval in question) by 1.13 (result in gal). To compute the flow rate, divide the volume by the time interval over which the integrator readings were obtained. It may be noted that the particular digital readout being used for this instrumentation has units of time (seconds) inscribed on the face. This has no significance in the above computations.

Since this readout is a valuable "trouble-shooting" device, it should be checked frequently if any abnormal loss of water is suspected in either the reactor or pool primary-water systems. The operator should also observe the readout as he performs his routine checks and once a day on the 8-to-4 shift; record the integrator reading on the log sheet kept in the control room.

5.9.6. Monitoring Reactor Area Waste System

The plant process waste system handles between 5.5×10^5 and 7×10^5 gal of low-level radioactive waste per 24-h period.

The system is designed as a containment for waste that might be contaminated although normally clean since its influent is from locations where a high-level radioactivity release could occur.

The waste discharge is constantly monitored for radioactivity at several collection points in the process system. These monitors serve several areas. The collection point in the system that serves the reactor areas, Fig. 5.35, also includes Buildings 3012, 3044, and the old decontamination area. To isolate and maintain a record of the radioactive waste discharged from the reactor area, the following procedure will be followed.

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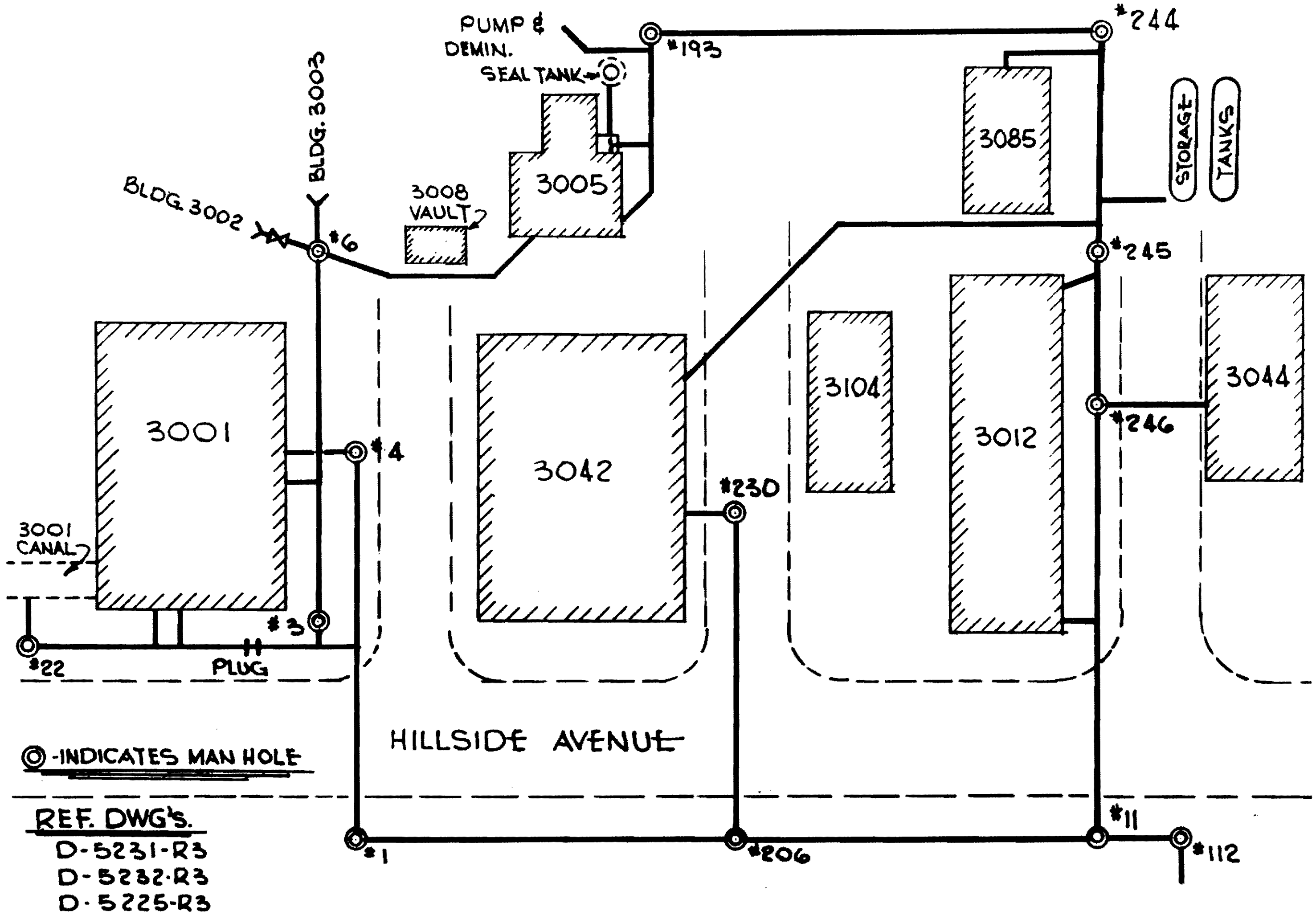

Fig. 5.35. Process waste system.

1. Routine sampling

On the 8-4 shift each Tuesday, a 1-ml sample of water should be taken from each of the designated locations. Each sample is checked for radioactivity on the scintillation counter, and the results in disintegrations per min are plotted.

Routine sampling locations are:

a. Manhole No. 1.

b. Manhole No. 206, at weir overflow.

c. Manhole No. 245.

2. Special sampling

Should an unaccountable increase be detected in the radioactivity level of the process waste discharge, a more thorough sampling of the system must be taken. Samples will be taken from the locations listed below, and appropriate action should follow.

Special sampling locations are:

a. From the LITR (Building 3004)

(1) Manhole No. 6 at the stream entering from the east

(2) Manhole No. 193

b. From the OGR (Building 3001)

(1) Manhole No. 6 at the stream entering from the north and the stream entering from the west

(2) Manhole No. 4

(3) Manhole No. 3

(4) Manhole No. 1

(Average the counts for the two samples from manholes Nos. 6, 4, and 3. The average should be the same as the counts for manhole No. 1.)

c. From the ORR (Building 3042)

(1) Manhole No. 206 at weir overflow

(2) Manhole No. 245 at stream entering from the north

The results of these will be counted and plotted following the procedure outlined above.

5.9.7. Water Supply to Shim-Rod Drives

References

Dwgs. D-33080, E-48669, and Fig. 5.36.

1. Introduction

A water supply with pressure slightly greater than reactor-water pressure is provided in the subpile room to the drive mechanisms for all rods. This is necessary to provide a low-rate sweep of water around the shock absorbers, wipers, and bottom-plug annulus to minimize stagnant conditions, and to provide a positive pressure between the seals to prevent leakage of contaminated water from the reactor vessel to the mechanical controls.

The arrangement consists of two water systems: a demineralized water supply which pressurizes the volume between the two seals in each seal housing; and reactor primary water from the facility cooling pump circuit which supplies a flow of reactor water to the shock absorbers, wipers, and bottom-plug annulus. Valves are provided so that the entire systems or any segment can be completely isolated during the replacement of major components of the rod-drive mechanisms.

2. Demineralized water system

During normal operation, all valves in this system should be open to provide a positive pressure of clean demineralized water beween the O-rings in the seal housing of each shim-rod drive. The pressure between the O-rings is kept higher than the reactor-water pressure so that clean water will flow into the reactor if an O-ring fails rather than contaminated reactor water flowing outward. There will be no flow of the clean water to the region between the O-rings. The valves in the "normally open" position are as follows:

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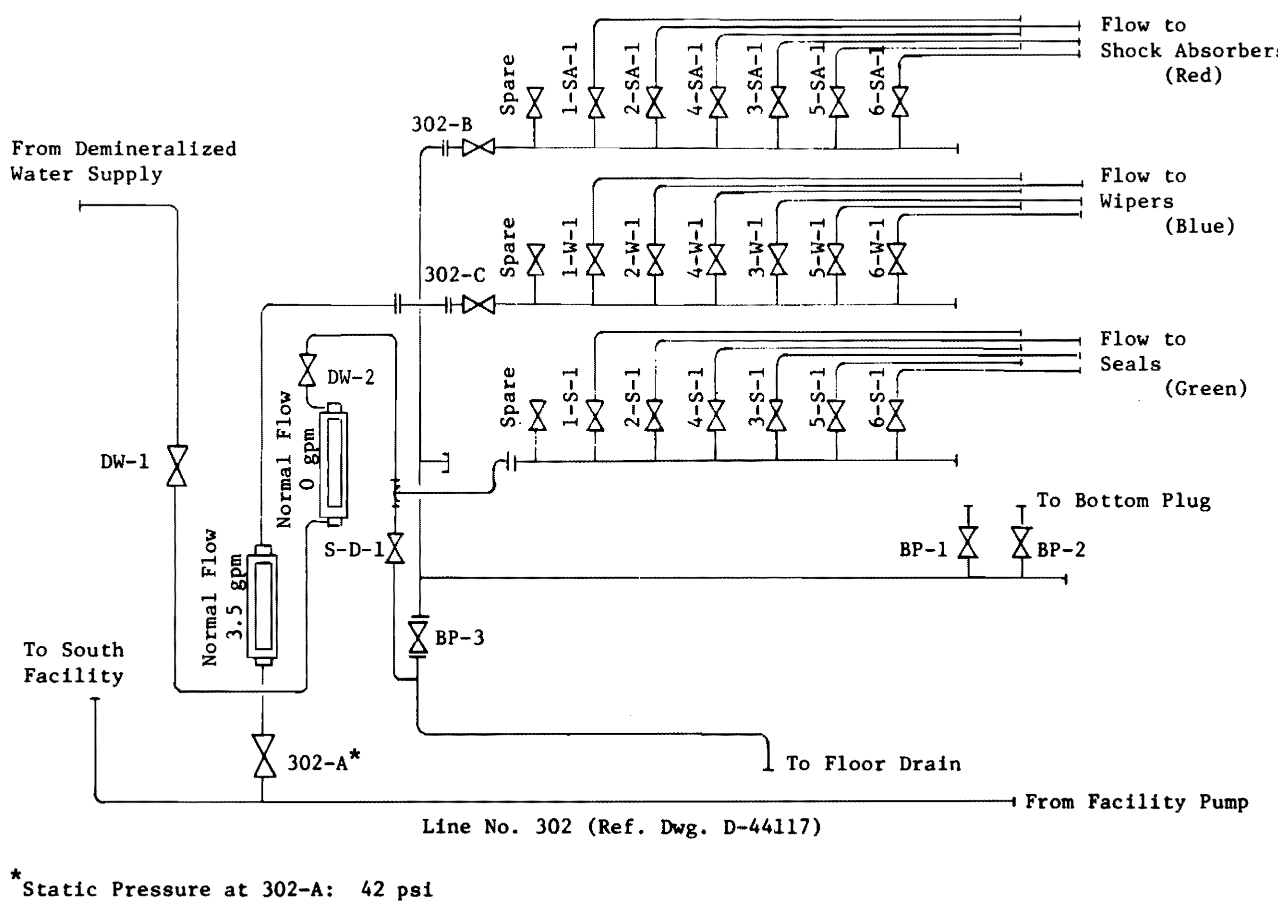

Fig. 5.36. Water supply to shim-rod-drive mechanisms.

valve DW-1 - the master valve on the demineralized water supply located upstream from the rotameter,

valve DW-2 - on the downstream side of the rotameter,

valves 1-S-1 and 1-S-2 - on the 1/4-in. supply to the No. 1 shim-rod seals,

valves 2-S-1 and 2-S-2 - on the 1/4-in. supply to the No. 2 shim-rod seals,

valves 3-S-1 and 3-S-2 - on the 1/4-in. supply to the No. 3 shim-rod seals,

valves 4-S-1 and 4-S-2 - on the 1/4-in. supply to the No. 4 shim-rod seals,

valves 5-S-1 and 5-S-2 - on the 1/4-in. supply to the No. 5 shim-rod seals, and

valves 6-S-1 and 6-S-2 - on the 1/4-in. supply to the No. 6 shim-rod seals.

3. Facility cooling water circuit

During normal operation, all valves on the downstream side of the rotameter should be open to allow flow to the shock absorbers, wipers, and bottom plug annulus; the one valve to "floor drain" should be closed. Valve 302-A should be opened to obtain a flow of 3.5 gpm on the rotameter in this system.

Identification of the valves in this circuit is as follows:

valve 302-A - the master valve upstream of the rotameter on this branch from the facility pump,

valve 302-B - the master valve downstream of the rotameter on the supply to the "shock-absorber manifold,"

valve 302-C - the master valve downstream of the rotameter on the "wiper manifold," valves 1-W-1 and 1-W-2 - on the 1/4-in. supply to the No. 1 shim-rod tube wiper,

valves 2-W-1 and 2-W-2 - on the 1/4-in. supply to the No. 2 shim-rod tube wiper,

valves 3-W-1 and 3-W-2 - on the 1/4-in. supply to the No. 3 shim-rod tube wiper,

valves 4-W-1 and 4-W-2 - on the 1/4-in. supply to the No. 4 shim-rod tube wiper,

valves 5-W-1 and 5-W-2 - on the 1/4-in. supply to the No. 5 shim-rod tube wiper,

valves 6-W-1 and 6-W-2 - on the 1/4-in. supply to the No. 6 shim-rod tube wiper,

valves 1-SA-1 and 1-SA-2 - on the 1/4-in. supply to the No. 1 shim-rod shock absorber,

valves 2-SA-1 and 2-SA-2 - on the 1/4-in. supply to the No. 2 shim-rod shock absorber,

valves 3-SA-1 and 3-SA-2 - on the 1/4-in. supply to the No. 3 shim-rod shock absorber,

valves 4-SA-1 and 4-SA-2 - on the 1/4-in. supply to the No. 4 shim-rod shock absorber,

valves 5-SA-1 and 5-SA-2 - on the 1/4-in. supply to the No. 5 shim-rod shock absorber,

valves 6-SA-1 and 6-SA-2 - on the 1/4-in. supply to the No. 6 shim-rod shock absorber,

valves BP-1 and BP-2 - on the supply line to the annulus of the bottom plug (valve BP-1 is closed due to malfunction of valve),

valve BP-3 - on the drain line of the bottom plug annulus, and

valve SD-1 - drain on the demineralized water supply.

4. Procedure

Prior to startup of the reactor, the water systems previously described shall be valved as follows:

a. Demineralized water system. All valves (excluding SD-1) will be fully open to supply water pressure to the seals.

b. Facility cooling pump. All valves (excluding BP-1, closed due to faulty valve, and BP-3 drain valve) should be opened with valve BP-2 used to adjust the flow on the rotameter to 50% scale reading (4.4 gpm).

5.9.8. Nitric Acid Storage Tank

1. Introduction

There are nine demineralizer systems serving the ORR-BSR complex. A total of 225 ft^3 of cation resin is in use in these systems. Ten lb of HNO_3/ft^3 is required for each regeneration. A 1000-gal storage tank, located at the northeast corner of Building 3004 has been provided so that nitric acid will be available for cation column regeneration.

2. Description

The material used in construction of the tank is 347 stainless steel and the tank has a pressure rating of 75 psi (reference Dwg. D-23150).

The acid tank is normally filled from an acid transport tank which has a volume of 500 gal. The driving force used to transfer the acid from the truck's tank to the storage tank is furnished by low pressure regulated air. It has been found that 10 psi air pressure will cause the acid to flow from the truck's acid tank to the storage tank at an acceptable rate. The storage tank should be filled when the liquid level is at the 1/4 full mark.

3. Procedure for transferring acid to the storage tank (Example 5.13)

Protective clothing must be worn while performing any of the following work (face shield, rubber apron, and rubber gloves). To transfer acid from the transport acid tank to the storage tank, this procedure must be followed in detail.

Example 5.13. Procedure for transferring acid from the transport acid tank to the storage tank

Objective	Procedure	Remarks
1. Connect transfer tube and air supply line to the transport tank.	Connect the SS flex tube from acid valve No. 2 to connection at acid valve No. 1 on the truck's tank. Connect the air supply line from air valve No. 3 to the transport tank connection at air valve No. 4.	Caution must be exercised while handling the flex tube. There may be some residual acid remaining in the tube from prior use.
2. Establish acid transfer flow.	Open acid valves Nos. 1 and No. 2. Open air valve No. 4, close air valve No. 1. Turn air valve No. 2 approximately three turns counterclockwise. This will reduce the air pressure and avoid overpressurizing the air supply line. Open air valve No. 2. Note the air pressure as indicated on the pressure gauge located on the air line between valves No. 2 and No. 3. Using air valve No. 2, adjust the pressure to 10 psig as indicated by the pressure gauge. After 10 psig pressure has been established on the truck's acid tank, the acid should start transferring. Note the liquid level in the storage tank as indicated by the sight glass. The time normally required to transfer 500 gal of acid is 3.5 to 4.0 h.	Air valve No. 2 is an air-regulator-type valve.

Example 5.13. (continued)

Objective	Procedure	Remarks
3. Determine when the transport tank is empty.	The pressure will decrease on the pressure indicator approximately 2 psi when the truck's acid tank liquid level has decreased to a point that will permit air to flow from the truck's acid tank to the storage tank. Note the liquid level in the storage tank as indicated by the sight glass; the increase in the liquid should be approximately 50% of the total volume of the tank if amount received is 500 gal.	
4. Remove connection from the transport tank.	Close air valves No. 1 and No. 3. Turn air valve control counterclockwise approximately four full turns. Close air valve No. 4. Wait 5 min after closing air valve No. 4 before closing acid valve No. 1. This will permit both tanks' pressures to decrease to atmospheric pressure. Close acid valve No. 1 on the transport tank. Remove air supply tube. The transport tank connection for the flex tubing is the highest point in the system, but normally there will be a low spot in the flex tubing between acid valves No. 1 and No. 2.	

Example 5.13. (continued)

Objective	Procedure	Remarks
4. (continued)	The flex tubing must be raised to a point that will permit the residual acid to flow to either the transport acid tank or the storage tank. CAUTION: Due to the connections in the tube, the acid will not completely drain from the tubing. Remove the flex tubing from the transport tank.	
5. Rinse the transport tank.	a. Check valve V-6053 to see that it is fully closed. This valve is located on the drain line from the bottom of the tank (1.5-in. line). b. Remove the 2-in. pipe cap and open the valve on the fill line to provide access into the tank. Using a dipstick-type measuring device, determine if the transport acid tank contains only approximately 1.5 to 2 in. of acid. c. Start a flow of water under the truck of at least 10 gpm. d. Remove the pipe cap on the line downstream from valve V-6053 and under the floor of the truck.	

Example 5.13. (continued)

Objective	Procedure	Remarks
5. (continued)	Caution must be exercised while removing the pipe cap. If valve V-6053 should leak, the pipe between the valve and pipe cap will be filled with acid. Install special tubing and route the transport tank drain to the storm drain. e. Open valve V-6053 until all the residual acid has been drained from the tank. Then rinse the tank thoroughly with process water. Use the tank fill line for tank access. After sufficient rinse, stop the process water and permit the tank to drain. Then close valve V-6053, replace the pipe cap at valve V-6053 and on the fill line, and close the fill line valve. (NOTE: Be sure to put on protective clothing before beginning this operation.)	

5.9.9. Acid and Caustic Storage Tank Containment Basins

The acid and caustic storage tanks in the ORR operating area are listed as follows:

Building 3004

one 1000-gal acid storage tank

one 780-gal caustic storage tank

Building 3117

one 850-gal acid storage tank

Building 3103

one 1625-gal acid storage tank

Each storage tank is in a contained concrete enclosure that will hold the contents of a full tank should a failure of the respective tank occur. Each containment basin contains a drain line and valve that is normally in the "closed" position. The acid tanks are located on the outside of the buildings; therefore, due to collection of rainwater, they must be drained periodically. The following precautions are to be observed. The containment basin drains will only be opened to drain rainwater from basins while personnel are in attendance. Immediately following draining of basin, the drain valves are to be closed and remain closed. Under no circumstances will the drain valves be left open without personnel in attendance.

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