#43

CONTROLLED

# FEEDWATER/HPCI SYSTEM

(FROM FEEDWATER BOOSTER PUMPS TO REACTOR)

SYSTEM DESCRIPTION

REVISION 0

NINE MILE POINT UNIT 1

NIAGARA MOHAWK POWER CORPORATION

SYSTEM NUMBERS: 26, 29, 29.1, 30
30.1, 31, 49, 50, 51

| | | | |
|---|---|---|---|
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## 1.0 SYSTEM FUNCTION/PURPOSE

The feedwater system serves as the main source of processed, high pressure water to the reactor during normal and emergency operations. The system automatically maintains the proper water level in the reactor vessel during operation and protects the core in the event of a small line break by serving as part of the High Pressure Coolant Injection (HPCI) System.

## 2.0 SYSTEM DESIGN

The feedwater system is composed of the following equipment:

- Three half-capacity feedwater booster pumps
- Three parallel strings of horizontal closed feedwater heaters, each string consisting of one drain cooler, four low pressure heaters and one high pressure heater
- One turbine shaft driven feedwater pump and two motor driven feedwater pumps
- Associated piping, valves, instrumentation, controls and monitors

A simplified system diagram is shown on Figure 1.

The booster pumps take suction on a common 24" header which is supplied water from the condensate system. The condensate system is described in a separate system description. The booster pumps provide net positive suction head (NPSH) to the feedwater pumps and increase system pressure to prevent the water from flashing to steam as it passes through the various feedwater heaters. The booster pumps discharge to a common 16" header and then through the tube side of three parallel closed heater strings. Each string consists of a drain cooler and four low pressure (LP) heaters. The three heater strings discharge to a common 20" header that provides suction for the three feedwater pumps.

The feedwater pumps take independent suction on the header (through 8" lines for the two motor driven pumps and a 18" line for the turbine shaft driven pump) and discharge through flow control valves to a common 20" header. Final feedwater preheating is accomplished using three high pressure (HP) feedwater heaters downstream of the flow control valves. Once through the HP heaters the feedwater flow divides into two 18" headers that provide water to the reactor vessel. Located on each header (outside the drywell) is a flow element and two isolation valves, one motor-operated and one check valve. Each header splits into two 10" lines prior to entering the reactor vessel feedwater sparger.

During normal operation at 100% power, feedwater flow is maintained at approximately $7.29 \times 10^6$ lb/hr. The feedwater flow to the reactor is controlled by throttling the flow control valves in the discharge lines of the respective operating feedwater pumps. At 100% power, normally two feedwater pumps, the shaft driven and one motor driven, and two booster pumps, are operated to provide the required flow. Three (3) parameters, steam flow, feedwater flow and reactor water level are combined to form a three (3) element control system wherein reactor level is a demand for feedwater with steam flow and feedwater flow providing a "fine-tune" correction factor to the final control system (i.e. system is level dominant).

Feedwater temperature, although indicated in the control room, is not input into the control system because this input varies only slightly over a wide range of temperatures. Also, a failure of such an input into the control system could result in an error in the signals to the flow control valves, possibly impacting HPCI and normal feedwater flows.

Feedwater flow is divided into three (3) parallel heater strings. There are four (4) low-pressure feedwater heaters and one high-pressure feedwater heater in each string. A separate drain cooler is provided for each of the first LP heaters, while the other LP heaters and the HP heaters have integral drain coolers. Each feedwater heater string is based upon the design criterion that the plant has the ability to operate at 80 percent of design rating on two heater strings in the event that one heater string is removed from service. The heaters are horizontal, closed U-tube heat exchangers. The fifth heaters (HP heaters) receive drainage from the first and second stage reheaters and extraction steam from the high pressure turbine seventh stage as the shell side heating medium. The fourth heaters (LP) use drainage from the fifth heaters, the moisture separators, and extraction steam from the low pressure turbines as the heating medium on the shell side. The first, second and third heaters (LP) use drainage from the upper heaters and extraction steam from the low pressure turbines as their shell side heating medium. The drain coolers receive the drainage from the HP and LP heaters and return the condensate to the main condenser using a level control system.

The heater strings are located in separate concrete shielded compartments in the turbine building, enabling maintenance work to be undertaken on an isolated string of heaters during operation. The design radiation level is 5 mr/hr outside the compartments except in the valve operating corridors between compartments where the design level is 30 mr/hr. The shell side of each heater is continuously vented to the condenser to remove air and disassociated oxygen and hydrogen from the extraction steam. Valve handwheel extensions projecting outside the shielded area are provided on valves required for remote manual actuation on startup a... shutdown of the heaters.

Feedwater piping from (1) the feedwater booster pump discharge to the feedwater pump inlet is designed for 600 psig at 315°F, (2) the feedwater pump discharge to the 5th feedwater heaters is designed for 1800 psig at 315°F, (3) the 5th feedwater heaters to the external isolation valve is designed for 1400 psig at 360°F, and (4) the external isolation valve to the reactor inlet is designed for 1425 psig at 575.

Material specifications for the feedwater system can be found on drawing C-18600-C (S11).

## 2.1 Feedwater Booster Pumps

The three feedwater booster pumps are motor-driven, horizontally mounted, single-stage, centrifugal pumps each with a capacity of $4 \times 10^6$ lbm/hr, or approximately 50% of total system capacity. These pumps supply feedwater to the suction of the reactor feedwater pumps through three parallel strings of low-pressure feedwater heaters. They take suction from the discharge of the condensate pumps. The following design information is provided.

| | | |
|---|---|---|
| Number | | 3 |
| E.P. Nos. | | 51-01, 51-02, 51-03 |
| Type | | Horizontal Centrifugal, Double Suction |
| Manufacturer | | Worthington |
| Model # | | 12LN-25 |
| Number of Stages | | 1 |
| Normal Operation (100% power) | | 2 continuous, 1 standby |
| Rated Capacity | | 4,000,000 lb/hr (8,000 gpm) |
| Suction Pressure | | 37 psig min. required at rated capacity<br>200 psig max. at recirculation flow |
| Total Head | | 245 psi |
| Shutoff Head | | Approximately 298 psig |
| Inlet Temperature | | 140F max. |
| Recirculation Flow | | 200 gpm |
| Motor | Hp | 1500 |
| | Speed | 1800 rpm |
| | Current | 160 amps |
| | Voltage | 4160 vac |
| Cooling Reqm't for Oil Coolers | | 8 gpm per oil cooler (RBCLC) |

Minimum flow for pump protection is obtained by recirculation to the condenser through a 2" line with a flow control valve. A differential pressure indicating switch located downstream of each booster pump provides the input signal to open or close the flow control valve.

The booster pump power supplies are as follows:

- Pump #11 (51-01) - PB #11
- Pump #12 (51-02) - PB #101
- Pump #13 (51-03) - PB #12

The booster pumps are located in the Turbine Building on Elevation 261 north of the first feedwater heater bays.

## 2.2 Feedwater Pumps

There are three centrifugal reactor feedwater pumps. One pump, rated at 6,000,000 lb/hr, is driven from the shaft of the high-pressure turbine through a combination friction-dental clutch. The other two feedwater pumps, each rated at 1,370,000 lb/hr, are AC motor driven through step-up gears. The feedwater pumps take suction on a common header from the discharge of the feedwater booster pumps. The following design information is provided.

| | Shaft Driven Pump | Motor Driven Pump |
|---|---|---|
| Number | 1 | 2 |
| EP Nos. | 29-01 | 29-02, 29-03 |
| Type | Barrel Centrifugal | Barrel Centrifugal |
| Manufacturer | Worthington | Worthington |
| Model # | 18WNC-191 | 8WNC-141 |
| Number of Stages | 1 | 1 |
| Normal Oper. (100% power) | Continuous | 1 Continuous, 1 Standby |
| Rated Capacity | $6.00 \times 10^6$ lb/hr (12000 gpm) at 1125 psig and 72°F | $1.37 \times 10^6$ lb/hr (2750 gpm) at 1125 psig and 72°F |

| | | |
|---|---|---|
| Normal Suction Head at Rated Flow (2 booster pumps) | 170 psig | 170 psig |
| Maximum Suction Head | 600 psig | 600 psig |
| Total Discharge Head | 1035 psig | 1035 psig |
| Shutoff head | 1380 psig | 1330 psig |
| Inlet Temperature | 311°F | 311°F |
| Recirculation Flow | 750 gpm | 1600 gpm |
| Motor hp | | 2500 |
| Speed | | 7000 rpm |
| Current | | 600 amps |
| Voltage | | 4160 vac |

Minimum flow for pump protection is obtained by recirculation to the condenser through both a 2" and 6" line for the motor-driven feedwater pumps and a 4" line for the shaft-driven pump. Recirculation flow is controlled by air-operated flow control valves. Flow control valves in the recirculation lines receive a signal from a flow element located on the discharge of each pump to open or close. Recirculation is used for low flow control during startup to prevent thermal cycling of the reactor feedwater nozzles.

The feedwater pump suction piping is provided with relief valves (51-77, 51-78 & 51-79) set at 600 psig (24 gpm flow capacity) to protect the suction piping against overpressure on pump warmup. The relief valves discharge through a 3/4" line to the condenser.

Cooling water for the motor-driven feedwater pump seals is provided from a 2" line off the discharge of #13 feedwater booster pump. Cooling water for #11 & #12 feedwater pump jackets (12 gpm per pump) and pump oil coolers (16 gpm per cooler) is provided by reactor building closed loop cooling. Cooling water for the shaft driven pump is provided by Turbine Building closed loop cooling.

Feedwater pump #12 (29-03) and #11 (29-02) are powered from PB #12 and #11, respectively. The motor-driven pumps are located in the Turbine Building on elevation 261 next to the Reactor Building air lock. The shaft-driven pump is located on Turbine Building elevation 300 at the east end of the turbine.

As stated earlier, pump #13 is driven from the shaft of the high pressure turbine through a combination friction-dental clutch. Figure 2 is a simplified cross-sectional view of the feedwater pump clutch. A combination friction plate - dental tooth clutch is used to bring the feed pump up to speed, and then engage it with the turbine shaft. The clutch is hydraulically operated by oil supplied at 32 gpm and 225 psig from the turbine lube oil system. The friction plate will engage to begin acceleration of the feed pump up to turbine speed. When the input shaft speed equals the output shaft speed, the dental clutch, which uses male and female straight cut gears, can be engaged. The male teeth are arranged around the periphery of the output shaft and the female gear teeth are arranged inside a sliding sleeve geared to the input shaft. After the friction plates have matched the relative speed of the input and output shafts, hydraulic oil is applied to the actuating piston of the sleeve. It slides along the length of the input shaft until its open end, with the female gear teeth, slides over the male teeth of the output shaft. The input shaft torque is now transmitted via the gear teeth, to the sliding sleeve via gear teeth, to the output shaft. A hydraulically-operated (operating pressure 2000 psig) disc brake is provided on the output shaft of the pmp. The control system for the shaft-driven pump clutch is further discussed under Section 2.8.1.

## 2.3 Feedwater Heaters

As stated earlier, there are three parallel strings of feedwater heaters. Each string consists of a low pressure drain cooler, four low pressure heaters and one high pressure heater. The heaters are horizontal, closed U-tube heater exchangers which (except for the first heater) have integral drain coolers. The following design parameters are provided.

| | DC | 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|---|---|
| Heat Transfer Surface Area (thousands of square feet) | 6.7 | 9.0 | 14.3 | 10.4 | 6.3 | 7.2 |
| Shell Pressure (psig) | 50 | 50 | 50 | 75 | 125 | 200 |
| Heat Transfer Capacity (million btu-hr) | 49 | 89.1 | 135 | 149 | 78.8 | 105 |
| Tube Material | ---------stainless steel---------- | | | | | |

The drain coolers are protected with relief valves on the tube side set to lift at 600 psig. Heaters 1 through 4 have relief valves on the shell side that lift sequentially as follows:

- Heaters 1 & 2 — reliefs set at 50 psig
- Heater 3 — reliefs set at 75 psig
- Heater 4 — reliefs set at 125 psig

The fifth heaters have relief valves provided with a 200 psig setpoint on the shell side and a 1400 psig setpoint on the tube side. The relief valves discharge to the main condenser.

The following additional design information on the heater relief valves is provided.

| | DC (4) | 1st (2) | 2nd (2) | 3rd (2) | 4th (3) | 5th (4) |
|---|---|---|---|---|---|---|
| Manufacturer(1) | CV&G | CV&G | CV&G | CV&G | CV&G | CV&G |
| Type | JR-C(A) | JO-35(A) | JO-35(A) | JO-35(A) | JO-25(A) | JR-C(A) Tube JO-25-3(A) shell |
| Drawing Ref. (Vendor | G-48616-1 | B-43398 | B-43398 | B-43398 | HV-96 | G-48616-1 tube B-43398 shell |
| Capacity (Water) (gpm) | 24 | 330 | 330 | 403 | 336 | 36 tube 660 shell |

(1) CV&G - Crosby Valve and Gage Company

(2) Pressure & temperature design limits are 720 psig at 100°F or 650 psig @ 450°F

(3) Pressure & temperature design limits are 275 psig at 100°F or 165 psig at 450°F

(4) Pressure & temperature design limits of the shell side relief valves are 275 psig at 450°F. Pressure & temperature design limits of the tube side relief valves are 2000 psig at 400°F.

(5) Valves are designed to operate under condition of seismic forces of 0.11 horizontally and 0.055 vertically.

Each of the feedwater heaters in the three strings of heaters is equipped with a level control system.

## 2.4 Isolation Valves

Each feedwater discharge header to the reactor vessel is provided with two isolation valves (IV). One valve (31-07 or 31-08) is an AC motor-operated valve and the other (31-01 or 31-02) is a check valve. Both valves on each header are located outside the drywell. The motor-operated IV's are welded directly to the drywell penetration, with the check valves directly welded to the motor-operated valves.

The check valves (31-01 and 31-02) are Chapman Valves Model #SP923V designed for 1425 psig and 575°F. The motor-operated valves (31-07 and 31-08) are Rockwell International Special Class 900 with Limitorque operators (Model SMB-2) designed for 1425 psig and 575°F. Valves 31-07 and 31-08 are powered from PBS 161B and 171B, respectively.

## 2.5 Feedwater Flow Control Valves

Feedwater flow to the reactor is regulated by air-operated flow control valves (ID12A, ID12B, ID11A and ID11B) which are automatically positioned (electric-pneumatic controllers) by the feedwater control system (Section 2.8.2). Two of the flow control valves operated in parallel, are located downstream of the shaft-driven pump. One each is located downstream of each of the motor-driven pumps. Each of the flow control valves associated with the motor-driven pumps (ID12A & B) have a 4-inch bypass line with an air-operated valve. This bypass is used for low flow control during startup.

A FCV lock-up circuit locks the air-operated flow control valves in the "as-is" position on the loss of either electrical signal or air to the valve. A lighted pushbutton above each bias M/A station (F-panel) is used to reset the respective lock-up circuit in the event the electrical signal or air is restored.

## 2.6 High Pressure Coolant Injection (HPCI)

The purpose of the HPCI system is to ensure that the core is adequately cooled to limit fuel clad temperatures under loss-of-coolant conditions which do not result in a rapid depressurization of the reactor vessel.

The HPCI system utilizes the following major components; motor-driven feedwater pumps (#11 and #12), two feedwater booster pumps (#11 and #13), two condensate pumps (#11 and #13), main condenser hotwell, condensate storage tanks, an integrated control system, feedwater heater strings (which are only in the flowpath, they perform no function in the HPCI mode), condensate demineralizers (also only in the flowpath), and associated piping and valves. This system is capable of delivering 3800 gpm into the reactor vessel at reactor pressure (from one (1) train of HPCI pumps).

The HPCI mode of operation is initiated on any of three conditions:

- turbine trip (RPS signal), or
- low reactor water level of 53" (RPS signal), or
- anytime feedwater flow exceeds $1.9 \times 10^6$ lbm/hr on the discharge of either motor-driven feedwater pump, the respective flow control valve goes into the HPCI mode of operation.

During normal operation, the shaft driven pump and one motor driven feedwater pump are in operation. If HPCI initiation occurs with no loss of off-site power, the condensate pumps, feedwater booster pumps and the motor-driven feedwater pump that are running remain in operation. The idle motor-driven feedwater pump will start and be up to speed capable of delivering 3800 gpm in approximately 10 seconds.

If HPCI initiation occurs when off-site power is not available, the sequence of events is as follows. Power is restored from a 6000 KVA generator from Bennetts Bridge Hydro Station with a load capacity for half of the HPCI components. These components are identified as the "preferred" HPCI components. Upon receipt of an initiation signal undervoltage relays on the secondary side of transformers 101S and 101N trip breakers R1011 and R1014 feeding PB101. Auxiliary relays on PB11 and PB12 strip unnecessary operating components. When power becomes available from Bennetts Bridge via Lighthouse Hill, preferred HPCI components will start sequentially. The preferred HPCI components are:

- #13 condensate pump - if running, the pump will remain running and the non-preferred pump (#11) will trip and its low discharge header pressure auto-start feature will be blocked.

- #13 feedwater booster pump - will start on receipt of an HPCI signal, if not already running, provided the following permissive start interlocks are satisfied:

    - time interval of a few seconds to allow a condensate pump to start

    - suction pressure above 35 psig

- #12 feedwater pump - will start on receipt of an HPCI signal, if not already running, provided the following permissive start interlocks are satisfied, (1) auxiliary oil pump pressure established, (2) one feedwater booster pump breaker is closed, and (3) time interval to permit a booster pump to start (6 seconds).

If a preferred component fails to start, its non-preferred component will receive a start signal.

- #11 condensate pump
- #11 feedwater booster pump
- #11 feedwater pump

If neither the "preferred" or "non-preferred" components start, automatic initiation of HPCI will not occur.

In addition to the above, HPCI initiation will signal the feedwater pump auxiliary oil pumps to start. They supply oil to the motor-driven feedwater pumps' bearings and gear drive. They are powered from PB 1671 and therefore can receive power from the diesel generators. The auxiliary oil pumps automatically start on a turbine trip or low reactor water level.

The HPCI initiation logic (simplified) is shown in Figure 4. Dual K-relay circuits (channel 11 and channel 12) are provided to initiate the corresponding HPCI channel. The initiation signal automatically transfers the normal feedwater control instrumentation to the HPCI instrumentation. Prior to this time the HPCI instrumentation "tracks" the feedwater system. Each HPCI channel is provided with a reset button located on control console "E". These pushbuttons allow the operator to return feedwater control to normal after the HPCI initiation signals are cleared. With two separate relay circuits and reset buttons, a single failure will not prevent HPCI initiation.

The HPCI control logic (simplified) is shown in Figure 5. Each HPCI controller (channel 11 and channel 12) is provided with its own reactor vessel water level column. The HPCI control system is based on a single element control with a maximum flow limit. The controller will attempt to maintain reactor vessel water level at a constant value (FWP #11 at 65 inches, FWP #12 at 72 inches). This constant value is pre-determined by the level setpoints and entered into the HPCI controllers. The feedwater flow signal to the HPCI controllers provides a limit input at 3800 gpm, thus preventing further opening of the flow control valves.

If the HPCI mode of control is initiated, valves 29-51, 29-52, 30-31 and 30-32 automatically go closed. Valve 30-31 cannot be reopened until HPCI K-relays are reset. Valves 30-32, 29-51 and 29-52 cannot be reopened until the low water level signal clears or HPCI is reset.

The power supply for initiation of HPCI control is from RPS Bus #11. The power supply for control of HPCI flow is from RPS Buses #11 & #12. As an alternate power supply, isolated power transfer circuits for RPS-11 and RPS-12 power feeds to the feedwater control system have been provided. Upon a low voltage condition in either RPS-11 or RPS-12, the respective transfer circuit will automatically transfer its components to the alternate supply, computer MG set 167. The circuit remains on the alternate supply until manually reset from the control room.

When the feedwater pumps are operating, the HPCI controller "tracks" the normal feedwater control signal. Since the HPCI controller is tracking the feedwater control signal, the FCVs will remain open if HPCI is initiated.

When the feedwater pumps are idle, the controller output is held at its minimum point. When the system is required to function in the HPCI mode, the controller output is held at a minimum until discharge pressure (980 psig) is produced at the feedwater pump. At this time, the air operated control valve is allowed to open to provide the necessary HPCI flow to maintain level. The control system design thus ensures that the flow limiting design feature for pump protection is not overridden due to the pump starting against a wide open control valve.

In addition to HPCI initiation being blocked by pump lockouts, other interlocks will also prevent an automatic start. The feedwater pump automatic start is blocked by auxiliary oil pressure less than 8 psig. The feedwater pumps will trip if suction pressure drops below 200 psig or if auxiliary oil pressure drops below 3 psig. The feedwater booster pump automatic start is blocked by suction pressure less than 35 psig.

When operating in the HPCI mode, makeup to the main condenser hotwell is necessary as the hotwell level decreases. Condensate is transferred from one of two condensate storage tank whose combined inventory is maintained at greater than 105,000 gallons. Normally, the minimum hotwell level allowed is 57" (75,000 gallons). As the hotwell level drops, an 8-inch makeup valve automatically opens at 62 inches. If level continues to fall, a 12-inch makeup valve automatically opens at 60 inches. Each of these valves can be manually operated using a handwheel, if necessary.

If level should increase above the normal operating band, the condensate rejection valve will open at the 68 inch level to discharge excess to the condensate storage tanks. There is also a high level alarm set at 70 inches.

## 2.7 System Instrumentation

Feedwater system instrumentation is located on panels "F" and "H" in the main control room, and includes:

- Feedwater Booster Pump #11 amps — 0-300 amps
- Feedwater Booster Pump #12 amps — 0-300 amps

| | |
|---|---|
| ° Feedwater Booster Pump #13 amps | 0-300 amps |
| ° Feedwater Booster Header Pressure | 0-600 psi |
| ° ~~Feedwater Pump Discharge Header Temperature~~ | ~~50-400°F~~ |
| ° Feedwater Pump Discharge Header Pressure | 0-20 x $10^2$ psig |
| ° Feedwater Temperature Entering Reactor | 50-400°F |
| ° Feedwater Pump 11 amperage | 0-600 amps |
| ° Feedwater Pump 11 pressure | 0-20 x $10^2$ psig |
| ° Feedwater Pump 11 flow | 0-2 x $10^6$ lbm/hr |
| ° Feedwater Pump 12 amperage | 0-600 amps |
| ° Feedwater Pump 12 pressure | 0-20 x $10^2$ psig |
| ° Feedwater Pump 12 flow | 0-2 x $10^6$ lbm/hr |
| ° Feedwater Pump 13 pressure | 0-20 x $10^2$ psig |
| ° Feedwater Pump 13 flow | 0-7 x $10^6$ lbm/hr |
| ° Total Feedwater Flow Chart Recorder (Diff. Speed) | 0-8 x $10^6$ lbm/hr |
| ° Reactor Level; Channel 11&Channel 12 | 0-100 inches |
| ° Reactor Press.; Channel 11&Channel 12 | 0-1600 psig |

Located on 1S34 and 1S35 are indicating lights to indicate the status of the transfer circuits for the AC power supplies to the feedwater instrumentation.

| | |
|---|---|
| ° Feedwater Channel 11 Instr. | Green - On |
| AC Power Supply | White - Standby |
| Alternate Normal | |
| (same for Channel 12) | |

The annuciators associated with the feedwater system are provided below:

| | Alarm Setpoint |
|---|---|
| ° Feedwater Booster Pump Trip/Overload/Low Suction | 35 psig |
| ° Motor Driven Feed Pump Trip/Overload/Low Suction | 200 psig |

| | |
|---|---|
| ° Motor Driven Feed Pump Low Oil Pressure | 5 psig |
| ° Shaft Driven Feed Pump Low Suction Alarm | 175 psig |
| ° Shaft Driven Feed Pump Low Oil Pressure | 8 psig |
| ° Shaft Driven Feed Pump Low Discharge Pressure | 1000 |
| ° Motor Driven Feed Pump Seal Water Strainer dP | 15 psid |
| ° Shaft Driven Feed Pump Seal Water Strainer dP | 13 psid |
| ° Feedwater Heater Level High (3) | |
| Heater 111-114 | |
| 121-124 | 17 psig |
| 131-134 | |
| Heater 115 | |
| 125 | 19 psig |
| 135 | |

° Feedwater Heater Level High High (3)

| | |
|---|---|
| Heaters 111, 121, 131 | 3" below center line |
| Heaters 112, 122, 132 | 3 1/2" below center line |
| Heaters 113, 123, 133 | 2" below center line |
| Heaters 114, 124, 134 | 1 1/4" below center line |
| Heaters 115, 125, 135 | 1 1/4" below center line |

° Feedwater Control Valves Trouble (HPCI Trouble) - This indicates loss of power air or control signal (i.e. valve lockup).

° HPCI Auto Operate (located on E console)

## 2.8 System Controls

The controls for the Reactor Feedwater System, which are located on Panels "E", "F" and "H", include:

| | |
|---|---|
| • Feedwater Booster Pump 11 | stop-start |
| • Feedwater Booster Pump 12 | stop-start |
| • Feedwater Booster Pump 13 | stop-start |
| • Feedwater Pump 11 Blocking Valve | close-open |
| • Feedwater Pump 12 Blocking Valve | close-open |
| • Feedwater Pump 13 Blocking Valve | close-open |
| • Feedwater Pump 11 | stop-start |
| • Feedwater Pump 12 | stop-start |
| • Feedwater Pump 13 Friction Clutch | disengage-engage |
| • Dental Clutch | engage (push) |
| • Feedwater Recirc. to Condenser Blocking Valve | close-open |
| • Feedwater Pump 11 Flow Control Valve | GEMAC Controller (M/A) |
| • Feedwater Pump 12 Flow Control Valve | GEMAC Controller (M/A) |
| • Feedwater Pump 13 Flow Control Valve | GEMAC Controller (M/A) |
| • Feedwater Recirc. to Condenser | GEMAC Manual Station |
| • Master Level Controller | GEMAC Controller |
| • Feedwater Pump 11 Reactor High Level Trip | Normal-Bypass |
| • Feedwater Pump 12 Reactor High Level Trip | Normal-Bypass |
| • Reactor Pressure Compensation | 11-12 |
| • Feedwater Level Column | 11-12 |
| • Feedwater Mode | 1(single)-3(three) element control |
| • Feedwater (Ch. 11) Instr. Reset to Normal Supply | Alternate-Normal |
| • Feedwater (Ch. 12) Instr. Reset to Normal Supply | Alternate-Normal |

- HPCI Reset Channel 11 — Pushbutton
- HPCI Reset Channel 12 — Pushbutton
- Feedwater Low Flow Control #11 — Manual/Auto (Foxboro)
- Feedwater Low Flow Control #12 — Manual/Auto (Foxboro)

The reactor pressure compensation two position (keylocked) switch is used to determine which reactor pressure channel is recorded on the chart recorder on F-Panel and is displayed on the control console. The switched signal is used to pressure compensate the steam flow and reactor level signals.

The feedwater level column two-position (keylocked) switch is used to determine which channel of vessel level is recorded on the chart recorder on F-Panel and indicated on the control console, and "K" panel (cleanup section).

The feedwater mode switch (keylocked) determines whether the feedwater control system is in single-element or three-element control. However, initiation of HPCI will automatically instate single-element control, regardless of the position of this switch.

A high reactor water level trip (RPS signal), utilizing the 95" high water level turbine trip logic relays, is provided for the two motor-driven feedwater pumps. A one out of two taken twice logic is used. Therefore, a failure of one of the high level trip channels will not inadvertently trip off one or both of the motor-driven pumps. Once the high level trip signal is actuated, a 10 second timer delays the pumps from tripping. At the end of the 10 seconds, the pump(s) will trip provided the following has not occurred:

- reactor water level falls below high level setpoint (95")
- flow control valve(s) have closed
- operator has used bypass switch

Any one of the above occuring will reset the trip signal without tripping the pumps.

The flow control valve permissive is achieved using two limit switches per valve to monitor each flow control valve position. If both valves are closed, then the pumps will not be tripped. In the event one of the valves is open concurrent with sustained high vessel level, only the motor-driven pump associated with the open valve will be tripped.

The 10 second time delay is based on the stroke time of 8 seconds for the flow control valves to fully close.

Should the reactor water level reach the low water level scram setpoint (53" indicator scale), the motor-driven pump that tripped on high level will automatically restart.

In the event a pump has tripped and assuming the high level condition has cleared, that pump can also be manually restarted from the control room by turning the NORMAL-BYPASS switch to the bypass position then back to the normal position. This resets the trip circuit and clears the trip signal if high level has cleared. The pump can then be started using the normal pump start switch.

If it is desired to run a feedwater pump even if the high level signal has not cleared, the operator may leave the bypass switch in bypass.

### 2.8.1 Feedwater Pump 13 Clutch

Normally, feedwater flow is shifted to the shaft-driven pump at approximately 250 Mwe. The feedwater pump clutch assembly is shown in Figure 2.

To engage the pump clutch as this point, the pump clutch pistol grip switch is turned to "engage". This energizes solenoid V-1 allowing oil at 90-110 psig to be admitted to the friction disc piston, mating the friction discs to begin acceleration. At 50 psig oil pressure, the red "Oil Pressure To Fricton" light above the switch comes "on". When the output shaft speed equals the input shaft speed, the white "synchronized" light comes on and the digital differential speed meter reads "1.000", indicating equal speeds. Now the dental clutch can be engaged by depressing its pushbutton. Solenoid V-2 shifts, directing oil to the dental clutch piston to drive it into engagement against spring tension. There are two limit switches, LS-1 and LS-2, associated with the dental clutch. The leading edges of the dental teeth are chamfered to allow them to slide into full engagement. This requires some amount of relative motion between the input and output shafts. The "a" contact of LS-1 allows the friction clutch to momentarily disengage to allow the required slippage, and the "b" contact of LS-1 extinguishes the green disengaged light. LS-2 extinguishes the white "synchronized" light, energizes the red "engaged" light, and re-engages the friction clutch. The clutch disengages if oil pressure reaches 110 psi before the pump discharge pressure reaches 800 psig.

Solenoid V-2 is de-energized by placing the pump clutch pistol grip switch to "disengage". De-energizing V-2 shifts it to port oil to the outer side of the dental clutch piston, driving it out of engagement. As the sliding sleeve moves back, limit switch LS-1 repositions causing the friction clutch to disengage.

The "engage" light goes "off", the "friction oil pressure" light goes "off", and the green "disengaged" light comes "on".

Solenoid V-3 operates the disc brake. V-3 bleeds oil pressure off the brake when the control switch is placed in the "engage" position. Once the clutch is disengaged by the operator, a timer is energized and 60 seconds later V-3 shifts, engaging the brake. Upon an automatic clutch trip, the brake will remain "off" until the clutch control switch is placed in the "disengage" position.

Several interlocks must be satisfied before clutch engagement.

- Brake must be OFF
- Rotation Lock (Maintenance switch) in run
- Turbine at 1800 RPM
- Feedwater suction pressure 300 psig
- Clutch oil pressure 200 psig
- Turbine bearing oil pressure 15 psig

The clutch trips automatically if feedwater discharge pressure drops below 800 psig. In an emergency, the clutch may be disengaged locally by manually positioning the solenoid valves. A keylocked switch on panel "F" can bypass the differential speed circuit in the event it malfunctions.

A high reactor water level trip is also provided for the shaft-driven pump. The signal de-energizes solenoid 'V-2' which results in dental clutch disengagement.

### 2.8.2 Feedwater Control System

The feedwater control system, shown in Figure 3, monitors feedwater flow, steam flow and reactor vessel level to maintain vessel level between 65 and 83 inches (indicator scale). Reference level is 297'-4".

The system consists of the following major components; feedwater flow detectors, steam flow detectors, vessel level sensing instruments, a master level controller and individual manual/automatic controllers for each flow control valve.

The feedwater pumps provide the pressure necessary for water to enter the reactor. The flow rate is controlled by a pneumatic flow control valve (FCV) on the discharge of each pump. The FCV position is adjusted by an error signal generated by comparing the feedwater flow and steam flow mismatch with vessel level.

There are four (4) modes of feedwater control; single element, three element, HPCI and low flow. The single element mode uses reactor level as the only controlling signal for positioning the FCVs. This mode of control is used during low steam/feedwater flow operations (startup), when the flow would be erratic/sensitive.

The three element mode is used during normal operations. The level error and flow error signals are compared to each other to provide a signal to the flow control valves.

The HPCI mode bypasses all other modes of operation. It also uses its own redundant single element controllers. The HPCI mode using "blind" controllers will signal the FCVs to modulate in an attempt to maintain reactor vessel level at 65" or 72" (depending on the pump). See Section 2.6 for more detail on the HPCI mode of operation. A brief discussion is provided on each of the major components of the feedwater control system.

Low flow control is a form of single element control using reactor level as the parameter for controlling the signal to the low flow control FCVs.

- **Feedwater Flow Transmitters**

  Feedwater flow rate is monitored by the use of venturi type flow elements. There is one flow element on the discharge of each feedwater pump. The flow elements create a differential pressure which is then measured. Feedwater flow rate is proportional to the square root of the measured dP. The flow rate from each pump is used as a signal to a feedwater flow summing circuit.

- **Steam Flow Transmitters**

  Steam flow rate is detected and measured the same way as the feedwater flow rate. A venturi type flow element is located in each steam line between the vessel and the inboard isolation valve.

  Since the density of the steam varies with temperature and pressure, the steam flow signal is pressure compensated to be accurate over a wide range of vessel pressure and temperature. Reactor pressure is used as an input signal to the steam flow sensing network to provide pressure compensation.

  The density compensated steam flow rate in the two mainsteam lines is summed to provide a total steam flow signal.

- **Vessel Level Transmitters**

  The reactor vessel level signal is the third element in the three element feedwater control system. It is also density compensated by using reactor pressure.

The operation of the level sensing device is described in the Reactor Vessel Instrumentation System Description.

There are two compensated level channels, either of which can be selected for use in the feedwater control system. In addition, each level channel supplies a level signal to one of the HPCI controllers.

- Flow Comparator

The flow comparator receives signals from the total steam flow and total feedwater flow circuits. An error signal is generated when there is a mismatch between the two signals. This error signal is transmitted to the three element amplifier for comparison with desired reactor level.

- Three Element Amplifier

The three element amplifier is used to compare flow error and level error. An appropriate signal is then sent to the master level controller. The system is level dominant meaning that on a loss of a feedwater flow signal or steam flow signal, the water level will not vary more than twelve inches.

- Master Level Controller

The master level controller, located on the control console, positions any one or all of the feedwater control valves when their individual manual/automatic controllers are in automatic (assuming no HPCI initiation). It has automatic, manual & balance positions associated with it. The desired vessel level is maintained by adjusting the master level controller. The controller action is from single or three element control depending on the position of the mode selector switch. The "balance" position is used to match the manual valve signal with the process signal (as indicated by a meter on the controller) prior to placing the unit in automatic.

- Individual Manual/Automatic Stations

Each manual/automatic (M/A) station, located on panel "F", controls one feedwater flow control valve. Each M/A station contains a manual, automatic and balance position on it. When the M/A station is in automatic, the valve is controlled by the master level controller. When the M/A station is in manual, the operator has manual control of its associated flow control valve position.

- Feedwater Control Valve Sequencing Module

The feedwater control valve sequencing module, or computation module, is located on panel "F". It provides for smoother transfer of flow between the feedwater pumps, and provides smooth parallel operation of the motor-driven feedwater pumps.

The module has two control switches; the "Mode" switch and the "sequence" switch. The "Mode" switch is used to control flow when the shaft-driven feedwater pump supplies feedwater. The position of the "sequence" switch determines the sequence in which the motor-driven feedwater pumps are loaded.

The "Mode" switch has two extremes; "S" and "R". In the "S" position, used during startup, the master level controller output is allowed to pass unchanged to the individual M/A stations. This allows direct control of the motor-driven feedwater control valves. After the shaft-driven pump is operating, this switch is placed in the "R" position. In the "R" position, the output of the master level controller operates to maintain vessel level by using the feedwater control valves on the shaft-driven feedwater pump while the motor-driven feedwater pump control valves are closed. If additional feedwater is required, it will be supplied by the motor-driven pumps.

Placing the "Mode" switch in the "R" position not only preferentially loads the shaft-driven pump, but it also sets up a bias such that the control valves on the shaft-driven pump operate with less travel than the control valves on the motor-driven pumps when in automatic. This is necessary to prevent level oscillation in the vessel, since the shaft-driven pump has a much larger capacity than the motor-driven pumps.

The Feedwater Control Valve Sequence switch also located on panel "F", has the following positions: "11-12", "Normal", and "12-11". In the "11-12" position, #11 flow control valve operates first and is fully open before #12 flow control valve opens. This is known as series operation. In the "12-11" position, the reverse is true. This minimizes oscillations of the control valves. In the "normal" position, no preferential bias is sent to the control valves and they operate in parallel. The "normal" position is used whenever the M/A stations of the motor-driven pumps are in manual.

Upon initiation of HPCI, feedwater control automatically switches to single-element HPCI control. Flow control valve #11 operates to maintain 65 inches of reactor level and #12 operates to maintain 71 inches of level.

### 2.9 System Interconnections

The feedwater system is interconnected to the following systems:

- Main Condenser
- Reactor Vessel
- Main Turbine and its associated oil system
- Condensate System
- Reactor Building Closed Loop Cooling System
- Turbine Building Closed Loop Cooling System
- Reactor Cleanup System
- Fire Protection

## 3.0 TECHNICAL SPECIFICATIONS

Technical Specifications are required by 10CFR50.36. For Nine Mile Point Unit 1 they are Appendix A to operating license DPR-63. The main technical categories of the Technical Specifications are the Safety Limits (SL), Limiting Safety System Settings(LSSS), Limiting Conditions for Operation (LCO) and Surveillance Requirements (SR). Each category is defined in 10CFR50.36, as follows:

- Safety Limit - Limits upon important process variables which are found to be necessary to reasonably protect the integrity of certain of the physical barriers which guard against the uncontrolled release of radioactivity.

- Limiting Safety System Settings - Settings for automatic protective devices related to those variables having significant safety functions.

- Limiting Condition for Operation - Lowest functional capabilities or performance levels of equipment required for safe operation of the facility.

- Surveillance Requirements - Requirements relating to the test, calibration or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within the safety limits and that the LCO's will be met.

Specific Technical Specifications with regard to the Feedwater System are listed below:

| Specifications For: | Applicable Section Including Bases | | | |
|---|---|---|---|---|
| | SL | LSSS | LCO | SR |
| High Pressure Coolant Injection | - | - | 3.1.8 | 4.1.8 |
| Reactor Coolant System Isolation Valves | - | - | 3.2.7 | 4.2.7 |
| Protective Instrumentation | - | - | 3.6.2 | 4.6.2 |

The objectives of the above specifications are to:

1. Assure the capability of the high pressure coolant injection system to cool reactor fuel in the event of a loss-of-coolant accident.

2. Assure the capability of the reactor coolant system isolation valves to minimize coolant loss in the event of a rupture of a line connected to the nuclear steam supply system.

3. Assure the operability of the instrumentation required for safe operation.

Also provided with the above specifications is a description or "Bases" for the high pressure coolant injection, feedwater isolation valves and the protective instrumentation. As stipulated in 10CFR50.36, the Bases is not formally part of the Technical Specifications and therefore is not part of Niagara Mohawk's license. The bases include a brief description on the design features of the HPCI mode of operation, isolation valves and protective instrumentation.

## 4.0 LICENSING CRITERIA

The original licensing criteria for the Feedwater System were stipulated in the Final Safety Analysis Report with all applicable supplements and addendums. Additional licensing requirements have been incorporated over the operating span of the plant. These licensing requirements include, but are not limited to, applicable sections of 10CFR50, Regulatory Guides and NUREGs.

## 4.1 NRC Regulations (10CFR50)

These regulations are required by law to be addressed by the licensee. Specific regulations that pertain to the Feedwater System are:

- 10CFR50.49 - Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants.

  NMPC Position - An environmental qualification is currently in progress. Specific qualification requirements for feedwater system components are available through the Equipment Qualification Program Manager.

- 10CFR50 Appendix A - General Design Criteria. These General Design Criteria establish minimum requirements for the principal design criteria for nuclear power plants.

  NMPC Position - The Technical Supplement to Petition for Conversion from Provisional Operating License to Full-Term Operating License, Section III - Adequacy Relative to Current Standards (July 1972) provides NMPC's position on each of the 64 criterion.

- 10CFR50 Appendix B - Quality Assurance Criteria. This regulation also applies in a generic manner to the Feedwater System.

NMPC Position - The Quality Assurance Program which was adopted for use at the station is designed to ensure that continuing activities are conducted in accordance with the applicable requirements of this Appendix.

° 10CFR50 Appendix J - Primary Reactor Containment Leakage Testing

NMPC Position - By letter dated August 27, 1984 from NMPC to NRC, the testing requirements for the feedwater isolation valves were outlined.

## 4.2 Other Licensing Commitments

### 4.2.1 F.W.P. #13 High Level Trip

By letter dated February 1, 1978, the NRC requested that older operating BWRs review the possibility of incorporating reactor vessel high level trips. NMPC's response, dated March 2, 1978, stated that a high level trip of the two motor-driven pumps was not recommended based on the fact that; (1) no damage would result to equipment located inside of the primary containment should the main steam lines become flooded, and (2) the motor-driven pumps are used in the HPCI system. In this same response, NMPC stated that for operational reasons, it may be advantageous to trip the shaft-driven pump (#13) on high level. In a letter to the NRC on April 13, 1978, NMPC committed to install the high level trip on the shaft-driven pump by automatically disengaging the clutch between the pump and the turbine. By letter dated

December 15, 1978, the NRC provided their safety evaluation on NMPC's position. They agreed with NMPC that the high level trip for the motor-driven pumps was not necessary and that the trip for the shaft-driven pump was advantageous. See Modification N1-7807 for details.

### 4.2.2 NUREG 0737 ITEM II.D-1

The question was again raised regarding the adequacy of vessel overfill protection at Nine Mile Point Unit. By letter dated April 1, 1982, NMPC committed to the following modifications;

1. Provide a reactor vessel high level trip of the motor-driven feedwater pumps, and;

2. Improve the reliability of the HPCI flow control system. The commitment was fulfilled by Modification N1-82-69.

### 4.3.2 NUREG 0619

By letter dated November 13, 1980, the NRC issued NUREG 0619 "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking." This NUREG outlined several inspection requirements and intervals, as well as identified possible system modifications that should be performed. By letter dated December 29, 1980, Niagara Mohawk outlined their feedwater nozzle inspection program. The NRC agreed with Niagara Mohawk's approach by letter dated July 10, 1981. Niagara Mohawk also committed in a letter dated September 8, 1981 to modify the feedwater low flow control system and revised procedures where necessary. The low flow control system was installed as part of modification N1-8269.

## 5.0 DESIGN CODES

- Original Codes

| Equipment | Design Code |
|---|---|
| Piping | ASME Sec. I-1962 and ASA B31.1-1955 |

## 6.0 OPERATIONAL ASPECTS

After ensuring necessary support systems are operating and the system is filled and vented, one feedwater booster pump is started. One condensate pump and one booster pump will be able to supply sufficient water during initial reactor startup. At approximately 400 psig reactor pressure, a motor-driven feedwater pump must be placed in service. The selected pump is vented; its associated flow control valve is closed and its associated manual recirculation block valve is open. Placing the control switch in the "start" position, starts the feedwater pump's auxiliary oil pump. When oil to the pump bearings reaches 8 psig, the feedwater pump starts. The auxiliary oil pump stops when the service oil pump increases bearing oil pressure above 15 psig. The recirculation valve for the pump that has started will open to provide a flow path until the low flow control valve is operated.

While closely monitoring reactor water level, the low flow control valve associated with the selected feedwater pump is opened to allow feedwater flow to the vessel.

The operator will have the flow control on automatic using the low flow control system. Upon reaching 50% to 75% open position on the low flow control valve, the operator will transfer control over to the main flow control valve.

One condensate pump, one booster pump and one motor-driven feedwater pump can provide the feedwater requirements during synchronization and initial loading of the turbine generator.

As the load is increased, generally the second motor-driven feedwater pump is started.

When the station load has reached approximately 200-230 MWe (approximately 2.5-3.0 x $10^6$ lbs/hr flow), the shaft-driven feedwater pump is placed in service. Normally the shaft-driven pump and one motor-driven feedwater pump are operated in parallel as station load is increased above 50 percent.

During reactor shutdown, the motor-driven pump is placed in manual control, backed down to zero flow, and taken out of service when reactor power is approximately 500 MWe. At this time, the shaft-driven pump is supplying feedwater demand. At approximately 200 MWe (2.5 x $10^6$ lbs/hr flow), both motor-driven pumps are placed in service, the flow from the shaft-driven pumps is reduced to zero, and the shaft-driven pump is removed from service.

The HPCI system would normally be operated in the event of a small reactor coolant line break which exceeds the capability of the control rod drive pumps (.003 ft.$^2$) but not large enough to allow the Core Spray System to be effective (greater than .13 ft.$^2$ at less than 365 psig). The HPCI system is normally in standby with the system ready and capable of "START" immediately upon initiation. The condensate system and the feedwater system will be in operation with the HPCI system ready to support automatic operations. There is no special valving required in HPCI operation since it is really the feedwater and condensate systems. However; the AC operated discharge valves for the feedwater pumps should be in the open position if that pump is not locked out, since with limited off-site power, there would be no power to open these valves if HPCI were required.

## 7.0 MODIFICATION HISTORY

### 7.1 Modification N1-7543

A. Description:

The spectacle flanges, originally installed on the recirculation line from the feedwater system to the main condenser (downstream of the 5th feedwater heaters), were removed and replaced with a piece of pipe welded in the line.

B. Reason/Justification:

The flanges were in the original design to allow the recirculation line to be blocked for feedwater system testing during initial startup. Replacing the flange with welded pipe eliminated leakage that occurred from the flanges.

### 7.2 Modification N1-7711

A. Description:

Instrument valve pneumatic controllers (i.e. E/P) for feedwater pump #13 were relocated from the pump itself to a floor mounted frame and flexible tubing installed to eliminate vibration damage.

B. Reason/Justification:

The excessive vibration that resulted from being located on the pump reduced considerably the effective life of the instruments.

## 7.3 Modification N1-7712

A. Description:

Instrumentation was added to monitor the flow and pressure to the mechanical seals of feedwater pump #13. In addition, at a later date, a section of one inch piping in the flow line to the mechanical seals was replaced with a 2" line.

B. Reason/Justification:

The instrumentation was added to monitor flow and pressure to feedwater pump #13 mechanical seals to increase the overall reliability of the pump by determining the cause of premature seal failure. By monitoring, it was determined that inadequate flow was the cause of the premature seal failures. Therefore, the one inch line was replaced with a two inch line to provide a higher flow rate to the mechanical seals.

## 7.4 Modification N1-7807

A. Description:

Installed a high reactor water level trip on the shaft-driven feedwater pump. This was accomplished by automatically disengaging the clutch between the pump and the turbine.

B. Reason/Justification:

In response to an NRC letter dated February 1, 1978, regarding possible flooding of main steam lines with resultant damage to relief valves, Niagara Mohawk proposed this modification to reduce the possibility of damage occurring.

## 7.5 Modification N1-8032

A. Description:

Replacement of #125 high pressure feedwater heater with state-of-the-art equipment. Relief valves and level instrumentation from the replaced heater were re-installed on the new heater.

B. Reason/Justification:

Failure of some of the tubes in the old heater had rendered the reliability of the heater in question. Circumferential tube cracks had been detected just inside the tube welds. The suspected mechanism of failure was stress corrosion cracking.

## 7.6 Modification N1-8049

A. Description:

Replaced a 2-3 foot section of the inlet cooling water pipe (turbine building closed loop cooling system) to the #13 feedwater pump seals and jacket with high pressure flexible rubber hose.

B. Reason/Justification:

The original connection between the TBCLC system and the #13 feedwater pump consisted of 1 inch schedule 40 carbon steel pipes bringing cooling water to the pump seals and the cooling water jacket. The pipes were connected to the cooling water jacket by a bolted flange. During operation, the pumps vibration tended to loosen the connections between the pipes and the pump, causing water leakage.

A section of the pipes was replaced with flexible hose since the hose "gives" with pump motion. In this manner the strain is taken off the flanged connectors. This essentially eliminated leakage at those joints.

7.7 Modification N1-8111

A. Description:

A single expansion connector from 2" to 8" and a new straight section of eight inch pipe were added to the feedwater pump recirculation lines back to the condenser, where the lines connect with the condenser.

B. Reason/Justification:

The original 4 inch section of pipe and connector had experienced wear effects of corrosion-erosion to a degree where turbine efficiency could have been affected.

7.8 Modification N1-8201

A. Description:

The original motor-operated feedwater isolation valves were replaced with state-of-the-art (flexible double wedge gate) motor-operated isolation valves.

B. Reason/Justification:

The motor-operated isolation valves were replaced due to unacceptable leakage that occurred during containment integrated leak rate testing.

## 7.9 Modification N1-8269

A. Description:

This modification was divided into the following three parts:

1. Instrumentation and control equipment was installed to provide a high reactor level trip of the motor-driven pumps.

2. The low flow control valves on the discharge of the motor-driven pumps were replaced. In addition, a new six inch recirculation line back to the condenser was installed for each motor-driven pump.

3. The HPCI control system was modified by; (1) installing a power transfer.circuit to provide an alternate power supply; (2) providing each HPCI controller with its own level signal from respective sensing channels; (3) removing feedwater temperature input into the control system; (4) adding annunciator alarms for loss of HPCI failure signal when in standby mode, (5) converting HPCI to single element level control with a maximum flow limit; (6) replacing flow transmitters, and (7) separating the K-relay circuit into two distinct circuits.

B. Reason/Justification:

1. This modification was part of a commitment made in response to NUREG 0737 Action Item II.D.1. By tripping the motor-driven pumps on high reactor water level, inadvertent flooding of the main steam lines and subsequent damage to the relief valves can be prevented.

2. This modification was part of a commitment made in response to NUREG 0619. Prior to this modification, the net feedwater flow to the reactor vessel was determined by the relative positions of the main feedwater control valve and the feedwater flushing valve. The net feedwater flow to the reactor vessel during low flow conditions was equal to the total flow through the main feedwater control valve less the flow back to the condenser through the feedwater flushing valve. This made control of flow difficult. As a result of limited feedwater control capability at low flow, thermal cycling occurred. By installing new low flow control valves (the original were locked close because they did not function) and a larger recirculation line, a more continued flow of feedwater at low flow conditions is possible. In this manner the potential detrimental effects of on-off feedwater flow functions can be avoided.

3. These modifications were made as part of a commitment in response to NUREG 0737 Action Item II.D.1 to increase the overall reliability of the HPCI control system. For details, see Safety Evaluations 84-20 and 83-28.

7.10 Modification N1-8277

A. Description:

Same as Modification N1-8032, Section 7.5 (except replaced #115 heater).

B. Reason/Justification:

Same as Modification N1-8032, Section 7.5 (expected replaced #115 heater).

## 7.11 Modification N1-8377

A. Description:

The feedwater heaters are equipped with a shell side level control system. This modification replaced the level controllers and transmitters.

B. Reason/Justification:

Replacement parts for the old feedwater heater shell side level instruments were no longer available from the manufacturer(s).

## 7.12 Modification N1-8430

A. Description:

Replacement of a section of the high pressure feedwater piping and relocation and redesign of a feedwater pipe restraint.

B. Reason/Justification:

During the 1984 outage, a crack was discovered in a section of high pressure feedwater piping. In addition, a pipe restraint was discovered to be faulty.

# 8.0 REFERENCES

## 8.1 Technical Documents


- FSAR (Updated), Steam to Power Conversion, Volume I, Chapter XI, Revision 2, June 1984.
- Functional Specifications and Design Criteria, Condensate and Feedwater Systems, Number 20, November 1, 1965.
- GE Design Criteria, Feedwater Control System, July 1, 1964.

- Operations Technology, High Pressure Coolant Injection, Module IV, Part 9, Revision 1, July 1982.

- Operations Technology, Feedwater and Feedwater Heating Systems, Module 5, Part 5, Revision 1, July 1982.

- Operations Technology, Feedwater Control System, Module 5, Part 6, Revision 1, July 1982.

- Functional Specification, Feedwater/HPCI Modifications - High Level Trip, March 12, 1984.

- Functional Specification, Feedwater/HPCI Modifications - Increase HPCI Reliability, September 20, 1983.

- Final Condensate, Booster and Feedwater Pump Heads and Pipe Sizing, November 10, 1964, Microfilm Location 040173720.

- Feedwater Heater Drain Size, Velocity and Pressure Loss Calculations, January 13, 1965, Microfilm Location 040173794.

## 8.2 Drawings

| | | |
|---|---|---|
| P & IDs: | C-18002-C | (S11) |
| | C-18003-C | (S12) |
| | C-18004-C | (S12) |
| | C-18005-C | (S12) |
| | C-18024-C | (S13.1) |
| Construction: | C-18156-C | (S12) |
| | C-18107-C | (S12) |
| | C-18108-C | (S12) |
| | C-18116-C | (S12) |
| | C-18121-C | (S12) |
| | C-18106-C | (S12) |
| | C-23291-C | (S12) |

| | | |
|---|---|---|
| Isometric: | C-26837-C | (S12) |
| | C-26838-C | (S12) |
| | C-26839-C | (S12) |
| | C-26840-C | (S12) |
| | C-26841-C | (S12) |
| | C-26842-C | (S12) |

Electrical:

- Elementary Wiring Diagrams (E21)

| | |
|---|---|
| C-19853-C | Clutch Control - #13 FWP |
| C-22453-C | Feedwater Heater Control Circuits |
| C-23077-C | Feedwater Control System |

- Interconnection Wiring Diagrams (E21)

| | |
|---|---|
| C-22004-C | Feedwater |
| C-23205-C | Feedwater Heaters |

- Connection Diagrams

| | |
|---|---|
| C-22454-C | FDWTR Heaters #111, 112, 113 |
| C-22455-C | FDWTR Heaters #114, #115 |
| C-22456-C | FDWTR Heaters #121, 122, 123 |
| C-22457-C | FDWTR Heaters #124, #125 |
| C-22458-C | FDWTR Heaters #131, 132, 133 |
| C-22459-C | FDWTR Heaters #134, #135 |

- One Line Diagrams

| | |
|---|---|
| C-23076-C | Feedwater Control System |

- Plans and Details

| | |
|---|---|
| C-26956-C | FDWTR Pump #13 Clutch |
| C-26957-C | |

8.3 Procedures

- Operating Procedures

| | |
|---|---|
| N1-OP-16 | Feedwater System Booster Pump to Reactor |
| N1-OP-43 | Startup and Shutdown |
| N1-OP-46 | High Pressure Coolant Injection |

- Surveillance Procedures

N1-ISP-25.7
N1-ISP-25.8
N1-ST-IC5
N1-ST-Q3
N1-ST-V4
N1-ICP-HPCI

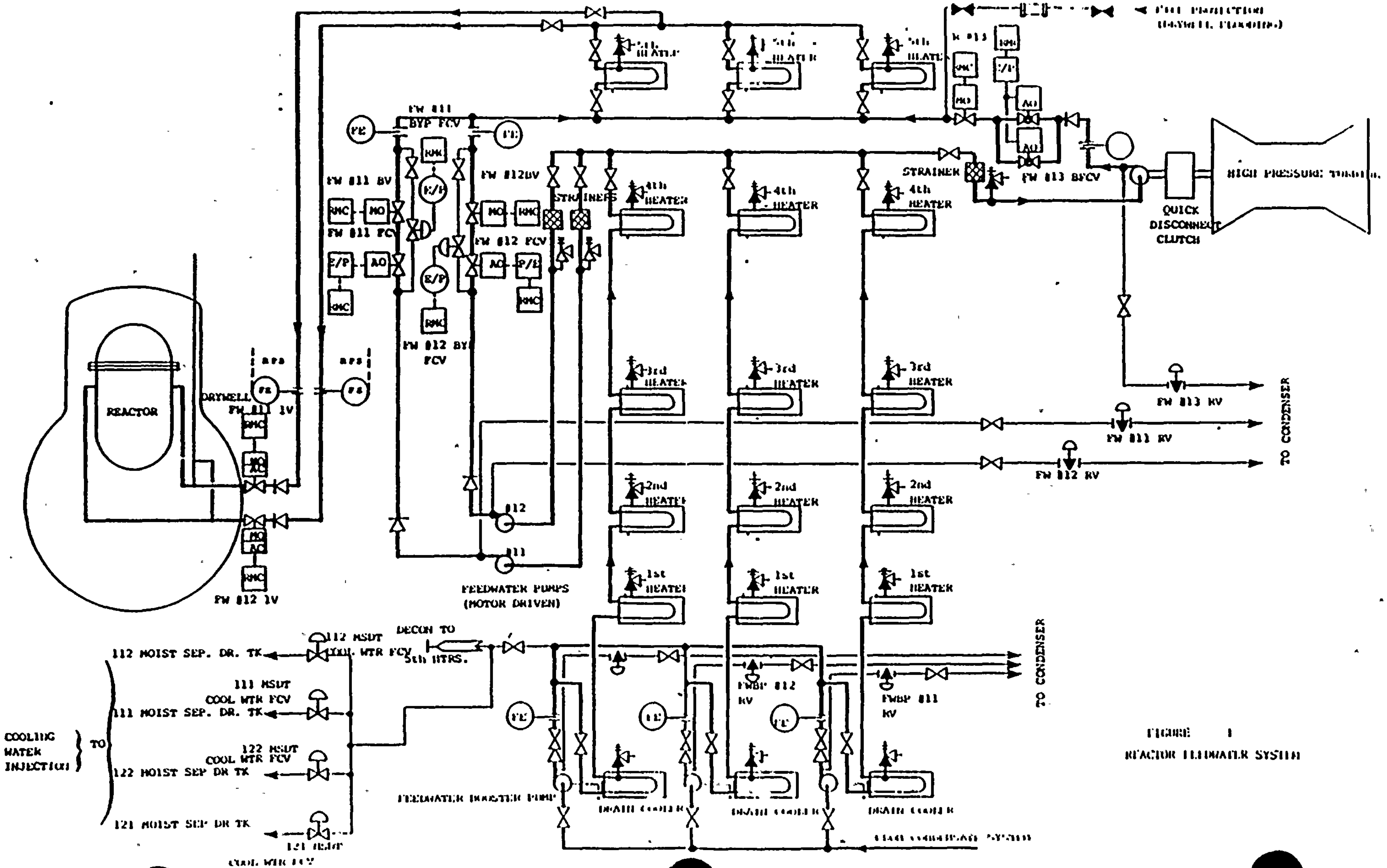
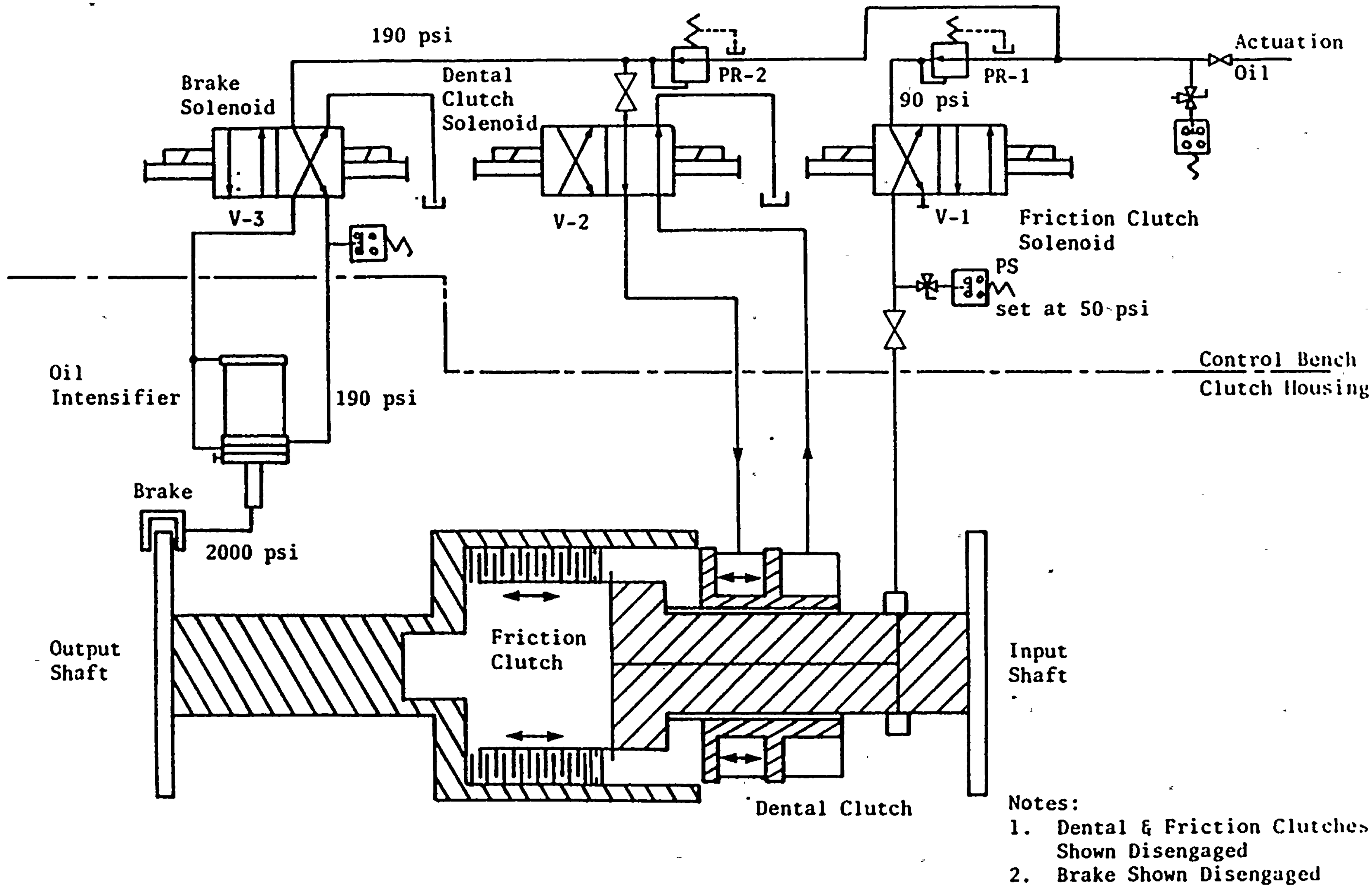
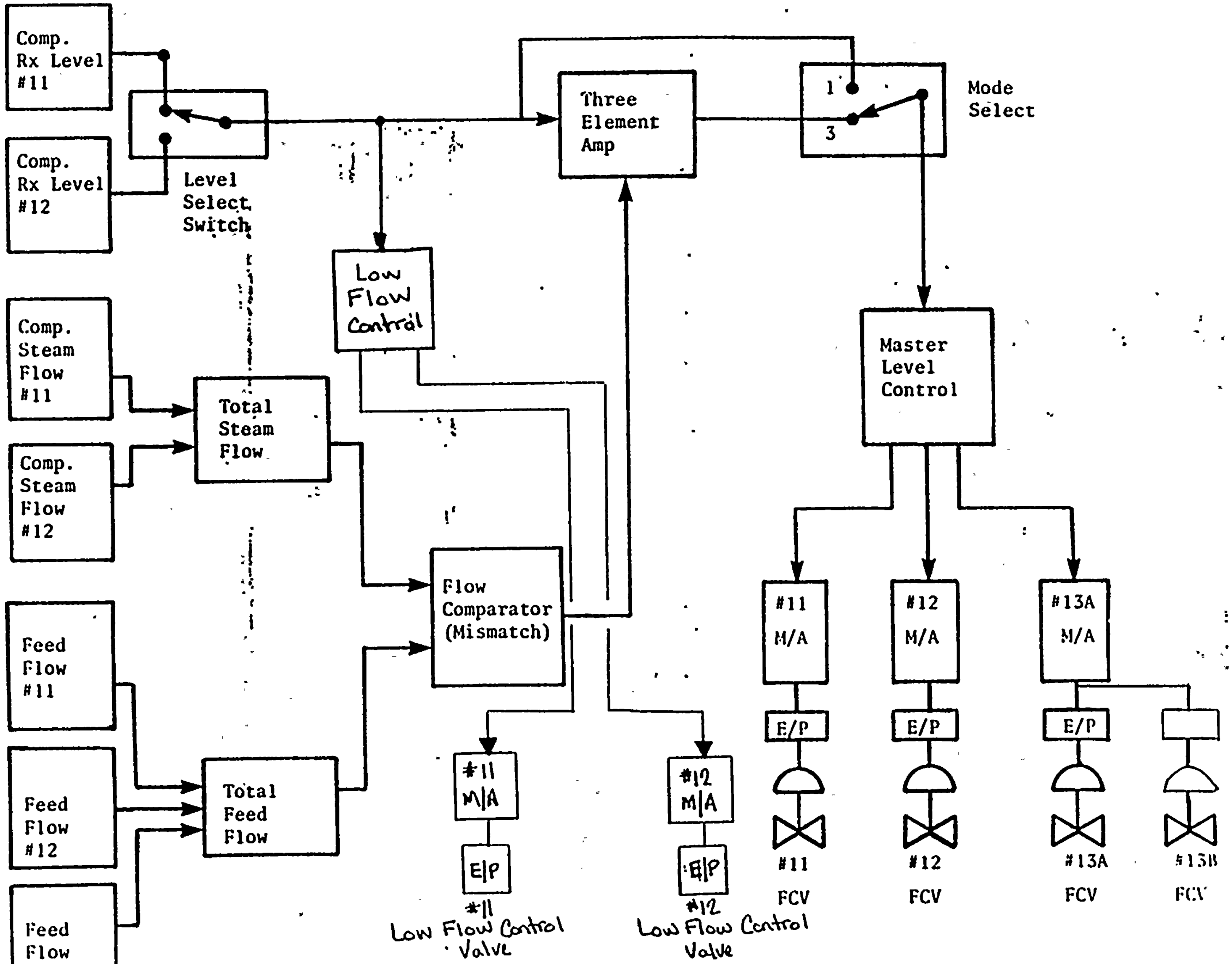



FIGURE 1
REACTOR FEEDWATER SYSTEM



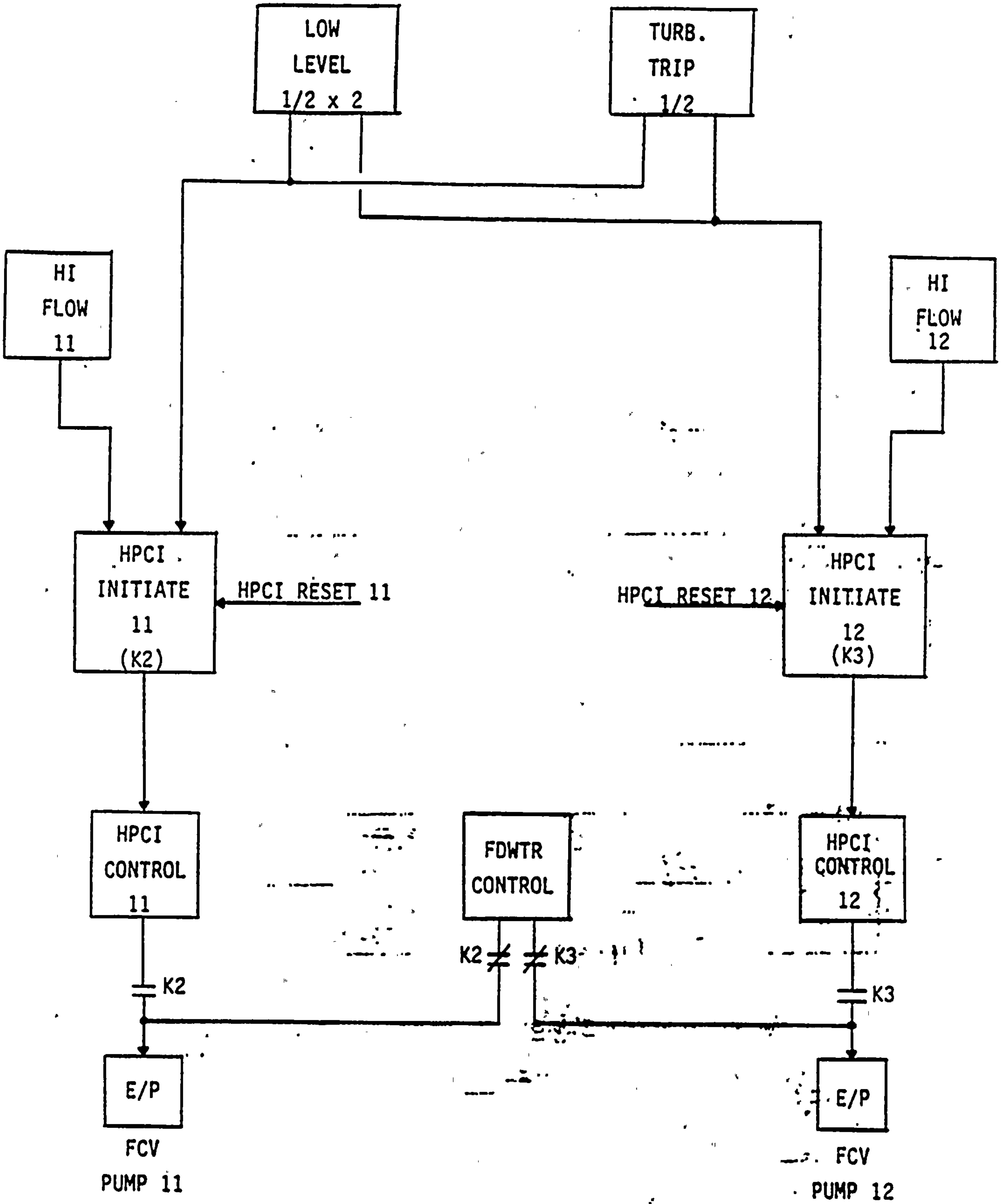

Feed Pump Clutch Assembly

FIGURE 2



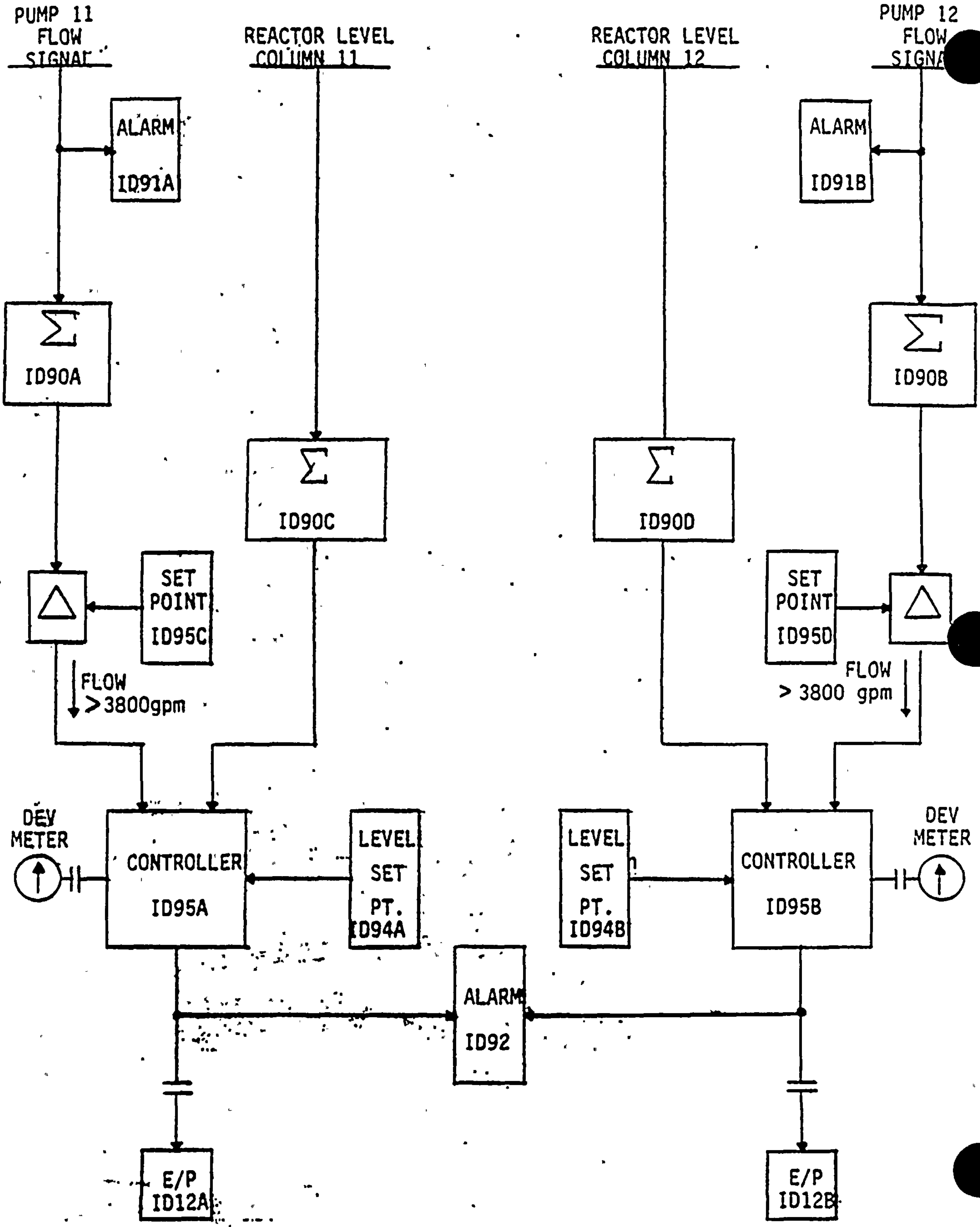

FEEDWATER C OL SYSTEM

Figw 3




HPCI INITIATION LOGIC

FIGURE 4




HPCI CONTROL LOGIC

FIGURE 5