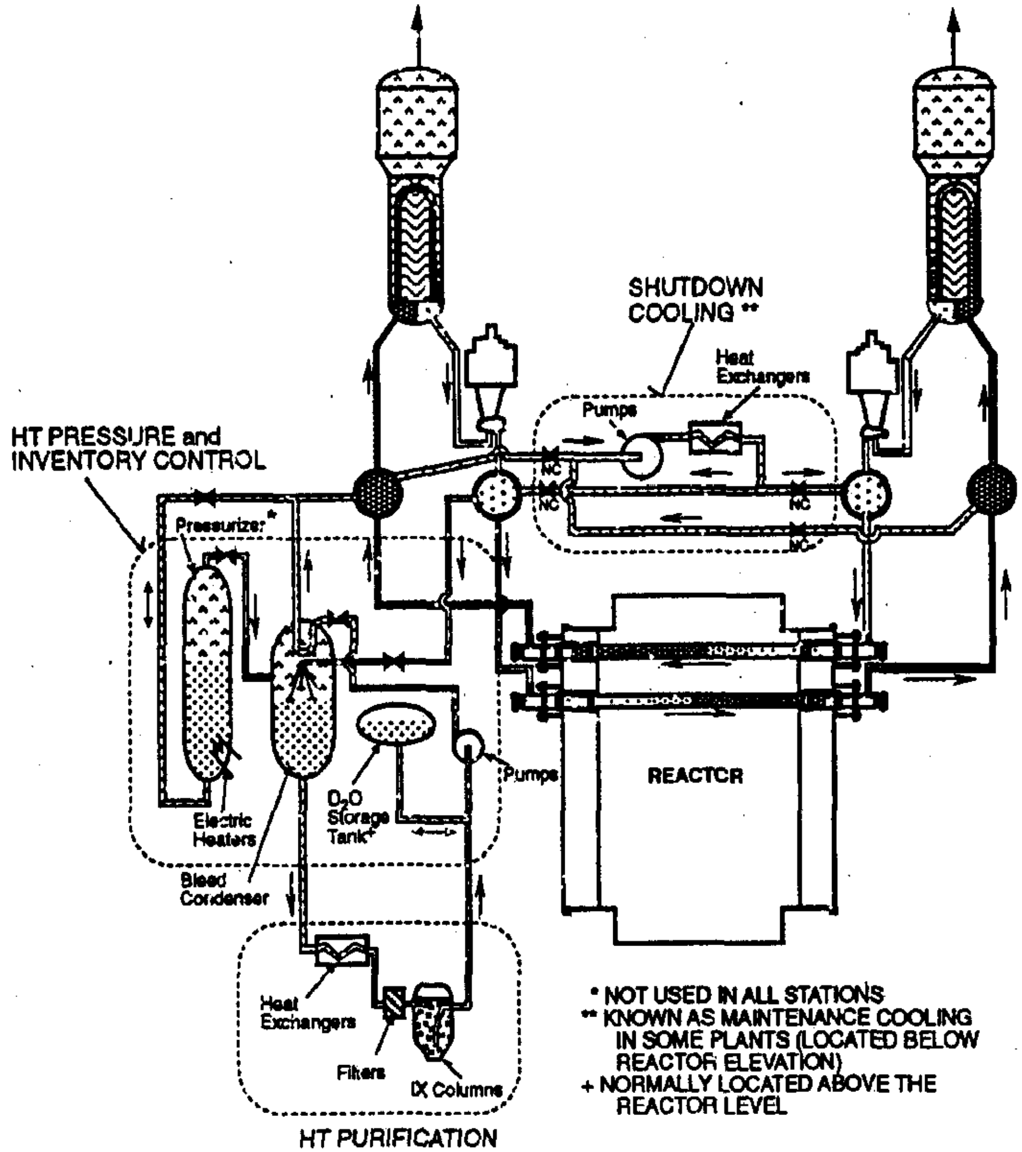
CHAPTER 4:

HEAT TRANSPORT SYSTEM

The Heat Transport System consists of the following sub-systems:

- **the main circuit: transports heat produced by the reactor to the steam generators;**
- **the pressure and inventory system: maintains the required pressure in the main circuit and provides make-up water to and holds the excess inventory for the system;**
- **shutdown cooling system: removes reactor decay heat following shutdown;**
- **purification system: controls the chemistry of the reactor coolant.**



MODULE A: MAIN CIRCUIT

MODULE OBJECTIVES:

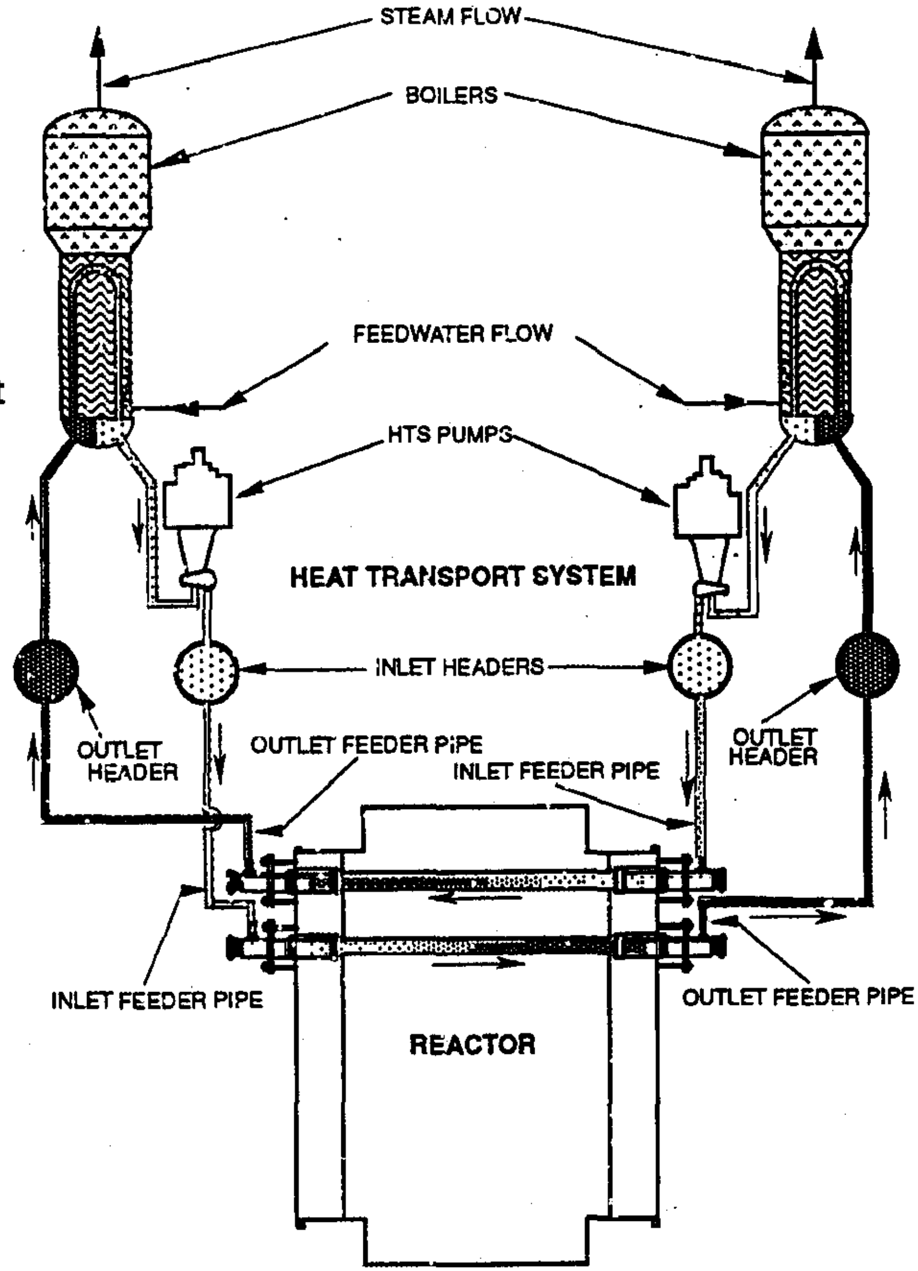
At the end of this module, you will be able to describe the following features of a CANDU reactor:

1. **The functions of the main or primary heat transport system;**
2. **The layout and major components of the main circuit;**
3. **The main features of the circulating pumps.**

1. INTRODUCTION

The functions of the Main Heat Transport Circuit are:

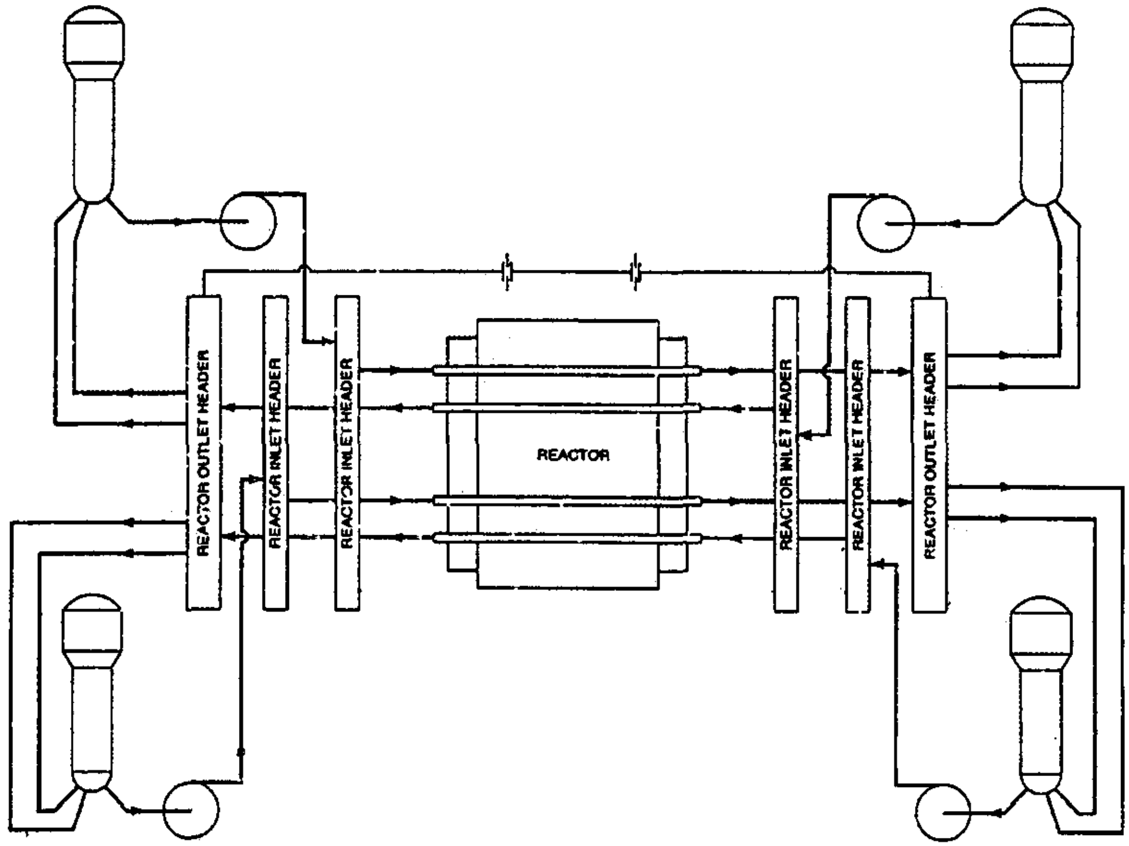
- transports heat produced by the fission of natural uranium fuel in the reactor fuel channels to the steam generators, where the heat is transferred to light water to produce steam;
- provides COOLING of the reactor fuel at all times during reactor operation and provides for the coolant to remove decay heat when the reactor is shut down;
- each heat transport pump has sufficient rotational inertia so that the rate of coolant flow reduction matches the rate of power reduction following the reactor trip if power to the pump motor is lost;
- allows decay heat removal by natural circulation under total loss of pumping power;
- limits the effect of postulated loss-of-coolant accidents to within the capability of the safety systems and provides a path for emergency coolant flow to the reactor fuel in the event of such an accident.
- provides CONTAINMENT for fission products that may be released from defected fuel during normal operating conditions;
- the heat transport system is seismically qualified to the design basis earthquake.



2. MAIN CIRCUIT EQUIPMENT

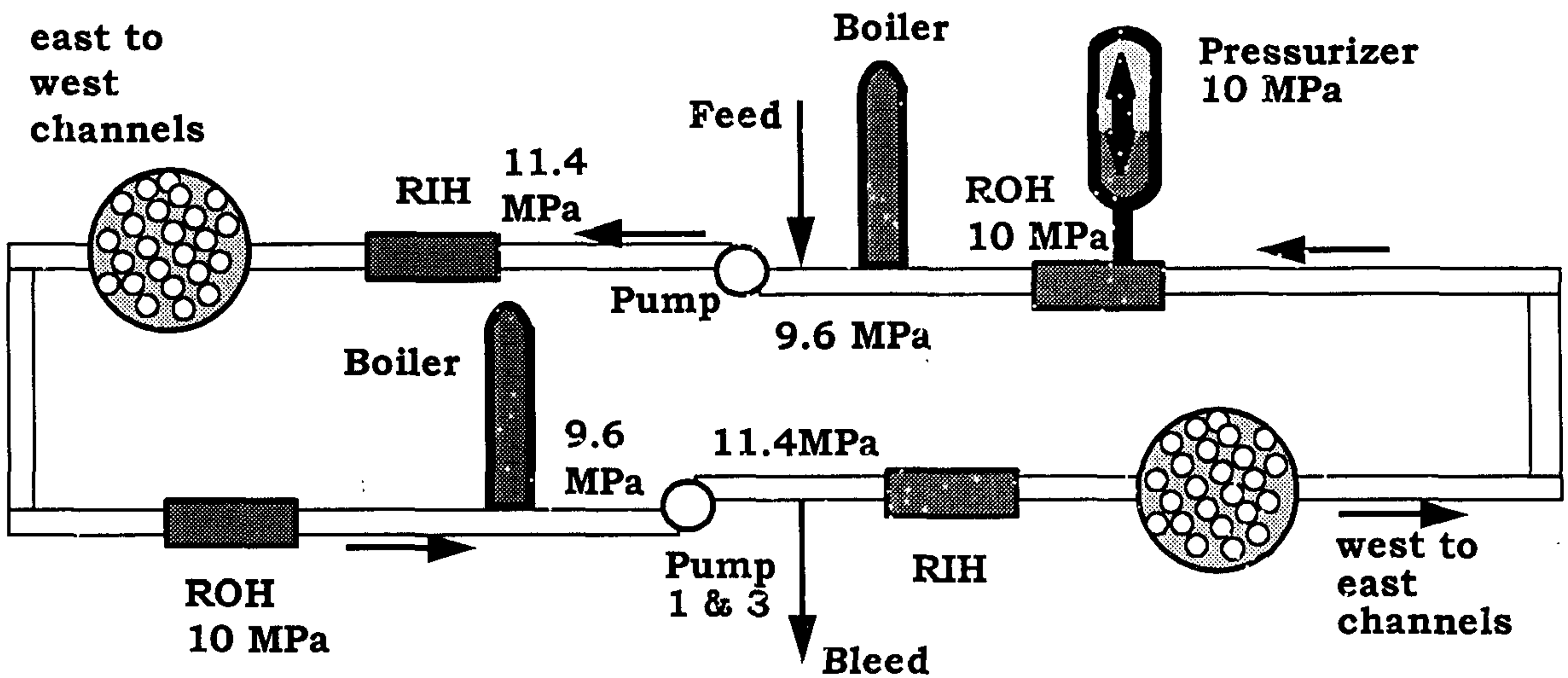
The Main Heat Transport circuit consists of:

- **two cross-connected figure-of-eight loops;**
- **480 pressure tubes with individual inlet and outlet feeder pipes;**
- **four reactor inlet headers;**
- **two or four reactor outlet headers;**
- **four motor driven pumps;**
- **four steam generators;**
- **interconnecting piping;**
- **valve connections to the pressure and inventory control system.**



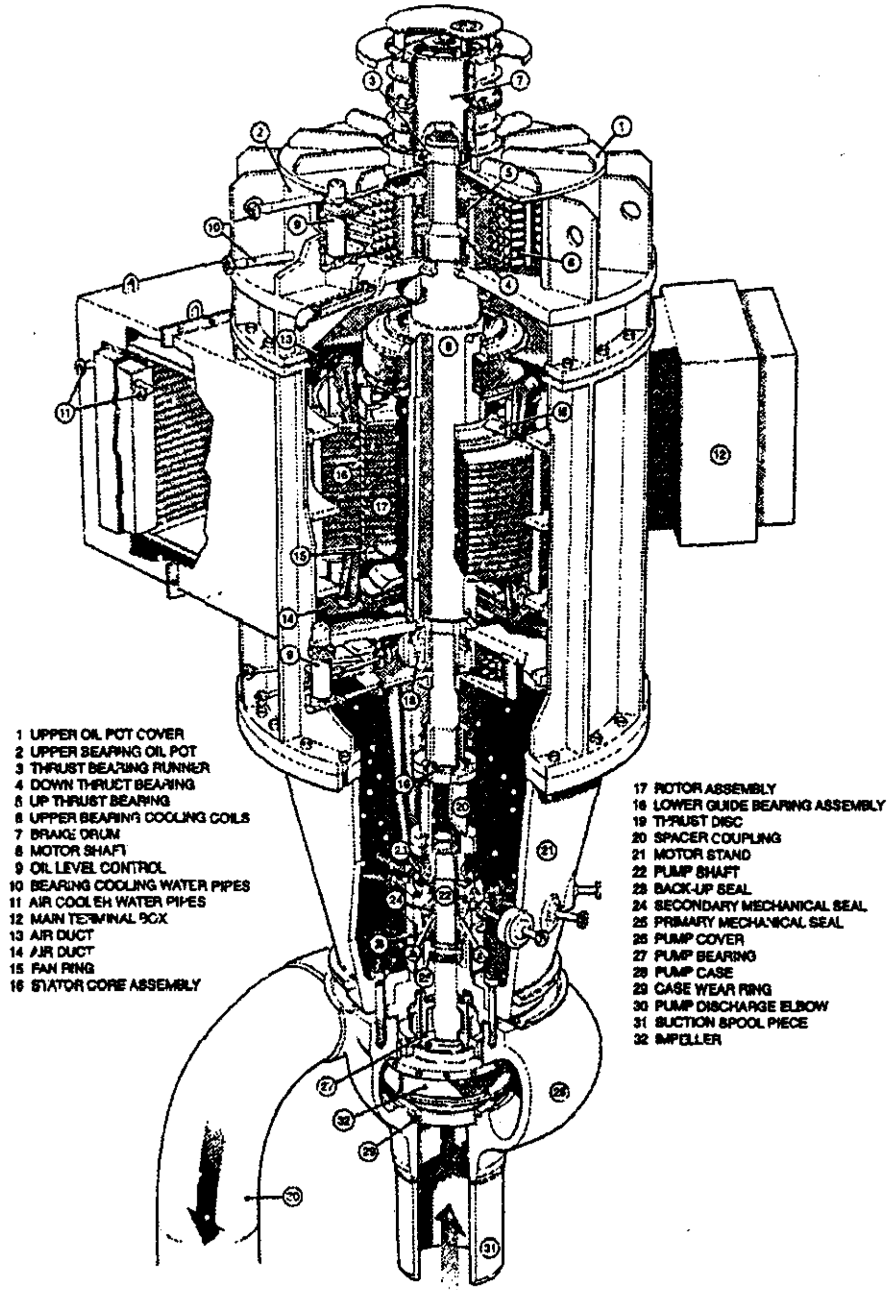
3. MAIN CIRCUIT FLOWS AND PRESSURES

- main circuit pressure must be maintained so that:
  - ⇒ there is adequate saturation margin in the reactor outlet headers
  - ⇒ the required net positive suction head for the circulation pumps is provided
- the main circuit must be filled, except under specific shutdown conditions;
- continuous flow to provide cooling of the fuel is required.



4. CIRCULATING PUMPS

- The four heat transport pumps are vertical, single-stage, single-suction, single-discharge centrifugal pumps.
- The pump bearing is located above the impeller. The shaft sealing arrangement, above the bearing, consists of three mechanical seals and one backup seal in series.
- The pump seal cooling system supplies cooled, filtered, and purified heavy water for lubricating and cooling the mechanical seals.
- A leakage recovery cavity, located between the uppermost mechanical seal and the backup seal, routes the normal seal leakage and leakage from a failure of all three mechanical seals, to the leakage collection system.
- Each pump is driven by a vertical, totally enclosed, air/water-cooled squirrel cage induction motor.
- The pump/motor unit has sufficient rotational inertia, supplemented by inertia packets in the motor so that, on loss of power, the rate of coolant flow reduction matches the power rundown following the reactor trip.
- Natural circulation maintains adequate cooling of the fuel after the pumps stop.



CHAPTER 4: HEAT TRANSPORT SYSTEM

MODULE B: PRESSURE AND INVENTORY CONTROL SYSTEM

MODULE OBJECTIVES:

At the end of this module, you will be able to describe the following features of a CANDU reactor:

1. **The functions of the pressure and inventory control system;**
2. **The major components and operation of the pressure and inventory control system;**
3. **The difference between "normal" and "solid" mode of operation.**

1. SYSTEM REQUIREMENTS

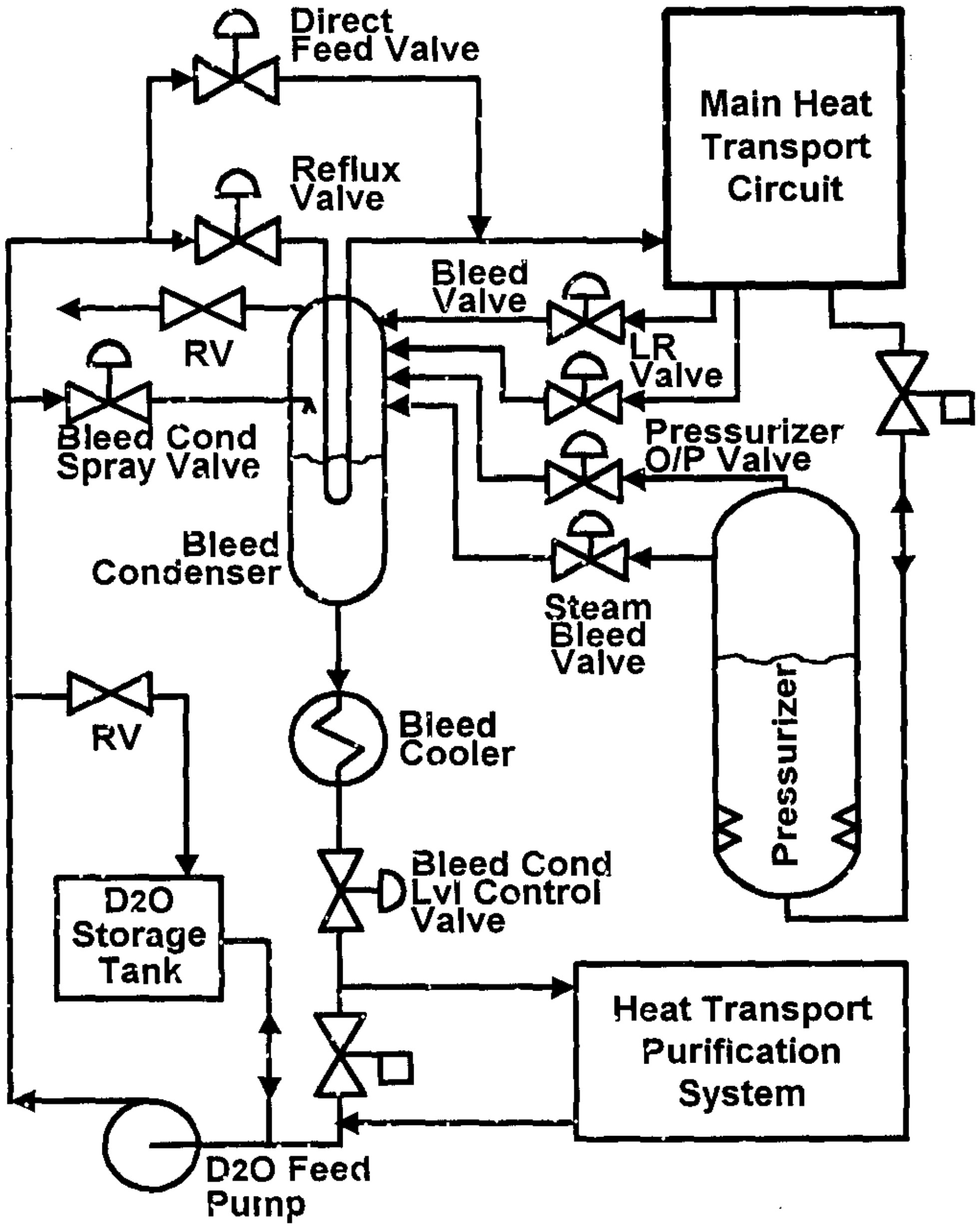
The heat transport pressure and inventory control system performs the following functions:

- Controls the pressure and heavy water inventory in the heat transport system for all normal operating conditions.
  - ⇒ Limits pressure increases and decreases due to various operating transients to acceptable values.
  - ⇒ Accommodates heat transport system coolant swell and shrinkage associated with warmup, cooldown, power maneuvering and other unit disturbances.
  - ⇒ Provides for suitable heat transport system pressure recovery following sudden pressure reduction due to power reduction, such as a trip or a stepback.
  - ⇒ Limits pressure reduction in the heat transport system due to sudden depressurization of the secondary side of the steam generators.
  - ⇒ Provides overpressure protection for the heat transport system for all modes of operation and a means of containing any relief from the heat transport system in the short term.
- Provides adequate net positive suction head for the heat transport heavy water feedpumps during normal reactor operation.
- Minimizes outflow of heat transport coolant due to the failure of associated valves.
- Provides the heat transport purification system with a cool heavy water flow.
- Provides for the storage of adequate amounts of heavy water for normal operating conditions.
- Provides a means of degassing the heat transport system coolant.

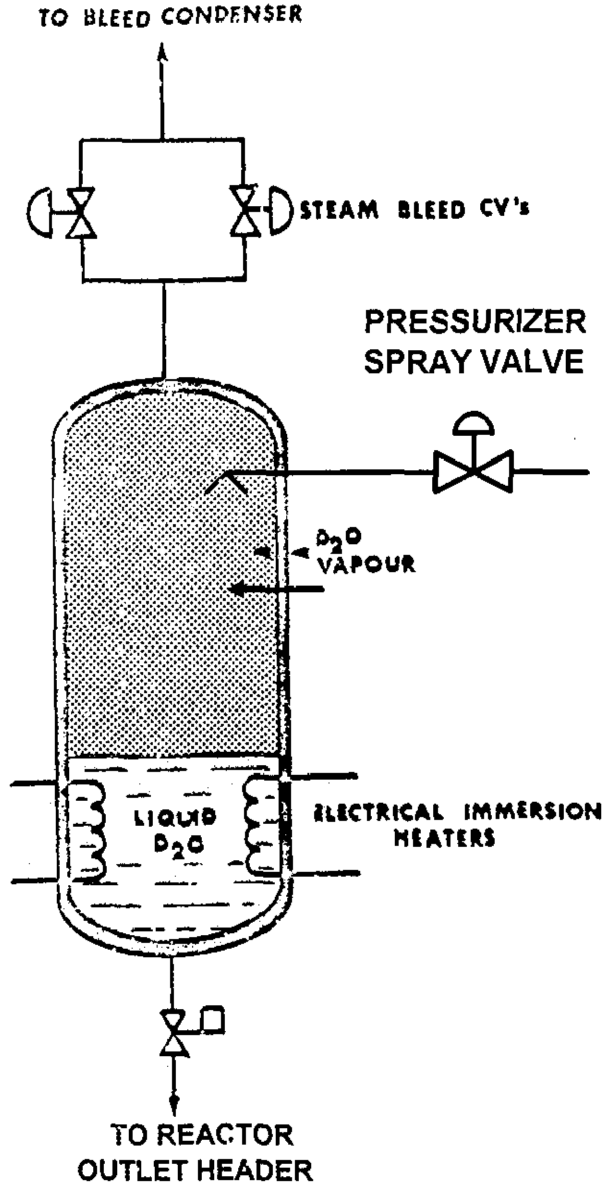
2. SYSTEM COMPONENTS

The main components of the pressure and inventory control system are:

- **pressurizer**
- **bleed condenser**
- **bleed cooler**
- **storage tank**
- **purification circuit**
- **pressurizing pumps**
- **feed, bleed and relief valves**
- **connections to the main circuit**
- **pressure, level and temperature control circuits**



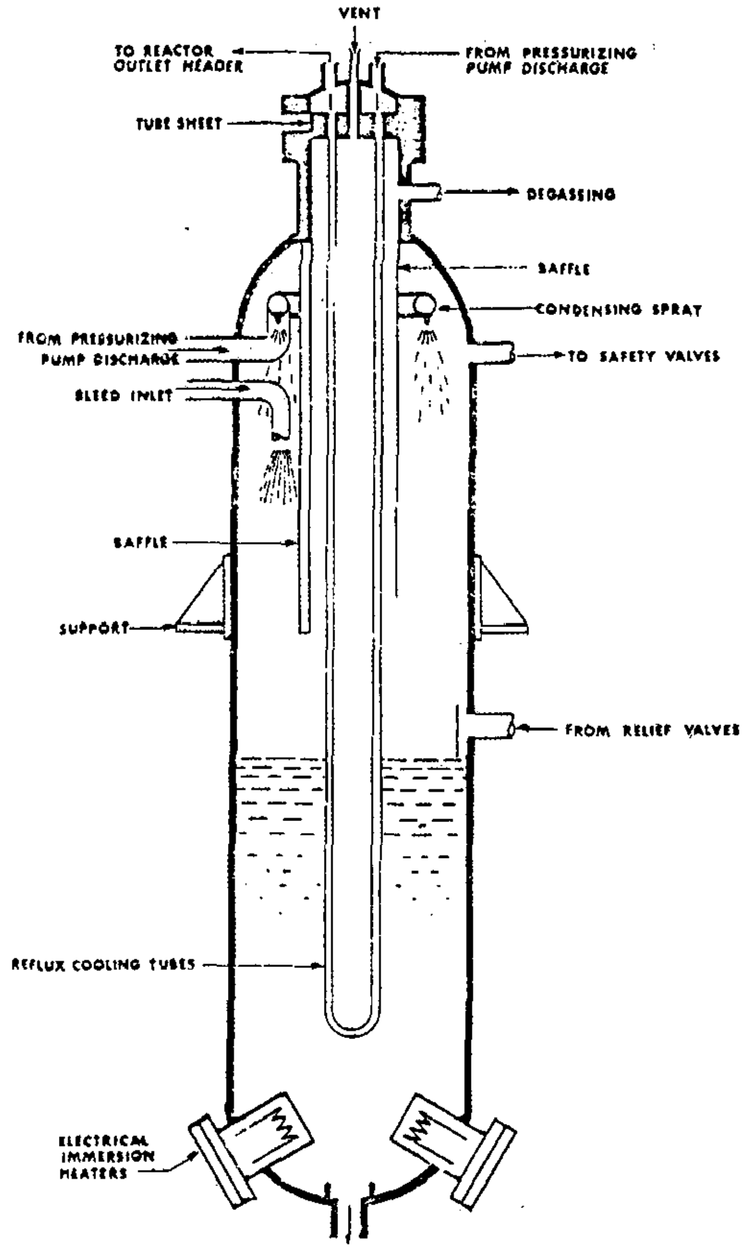
3. PRESSURIZER



- The pressurizer is connected to the main heat transport system at one of the steam generator inlet lines by the pressurizer connection line. A valve is provided to isolate the pressurizer from the heat transport system during maintenance shutdowns.
- The pressurizer's liquid and steam are kept at saturation, and at a pressure that is slightly higher than the saturation conditions in the reactor outlet header at 100%FP.
- Pressurizer (and hence heat transport) pressure can be raised by adding heat to the liquid via electric heaters, and the pressure can be reduced by bleeding steam out of the pressurizer.
- The variable heater is used under normal steady state conditions. The on-off heaters come on if the pressure drops below the range of the variable heater.
- If the pressure increases beyond the range of pressurizer pressure control valves, two steam relief valves discharge steam to the bleed condenser until the pressure is reduced to the normal control range. To achieve cooldown of the pressurizer, cool heavy water is sprayed into the steam space to condense some of the steam.
- During a reactor power increase the outlet header pressure rises as a result of the swell in the system. The level setpoint in the pressurizer increases automatically so that all the swell resulting from power increases is stored in the pressurizer.
- The level in the pressurizer (and hence the heat transport system inventory) is normally controlled via the main circuit feed and bleed valves.

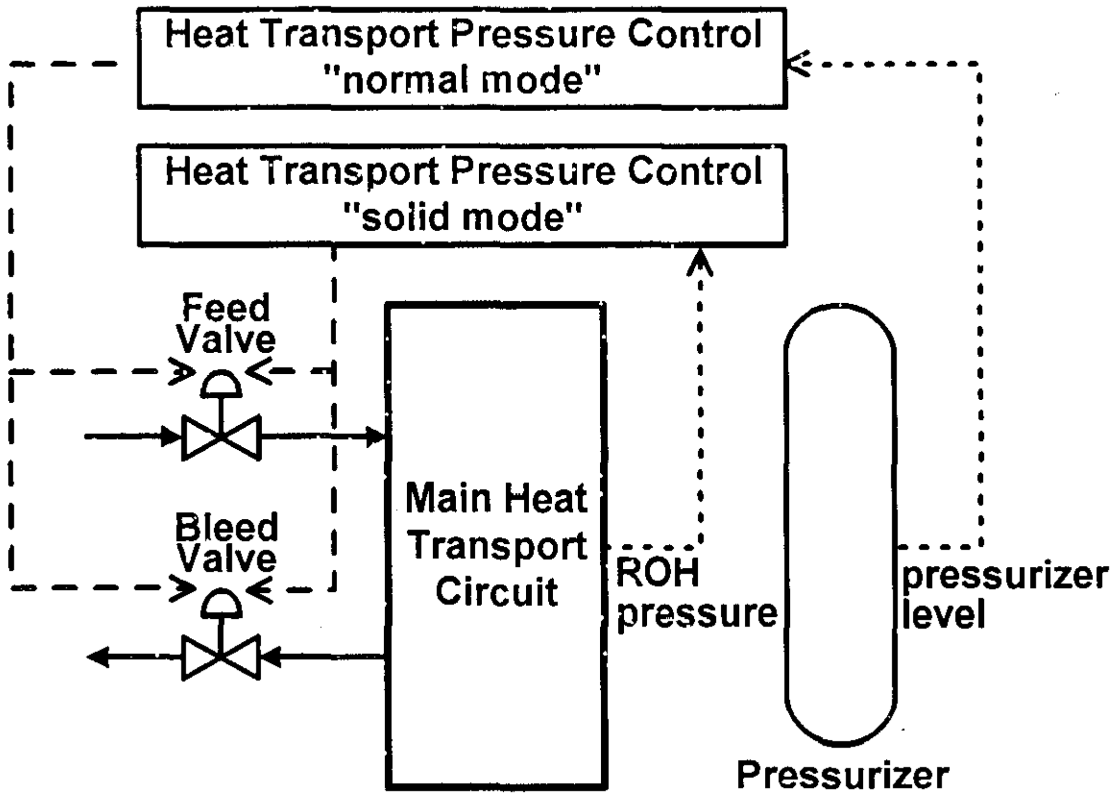
4. BLEED CONDENSER

- Under high pressure conditions in the pressurizer and/or the main heat transport circuit, pressure relief is via flow into the bleed condenser (also known as the degasser condenser).
- Pressure in the bleed condenser is regulated by condensing the heavy water steam with cooling flow through a reflux tube bundle and a spray flow.
- The reflux bundle flow and the spray flow are regulated by control valves as demanded by the bleed condenser pressure controllers.
- There is normally a constant bleed flow into the Bleed Condenser. The level is controlled by the valves that regulate the outflow from the bleed condenser via the bleed cooler.



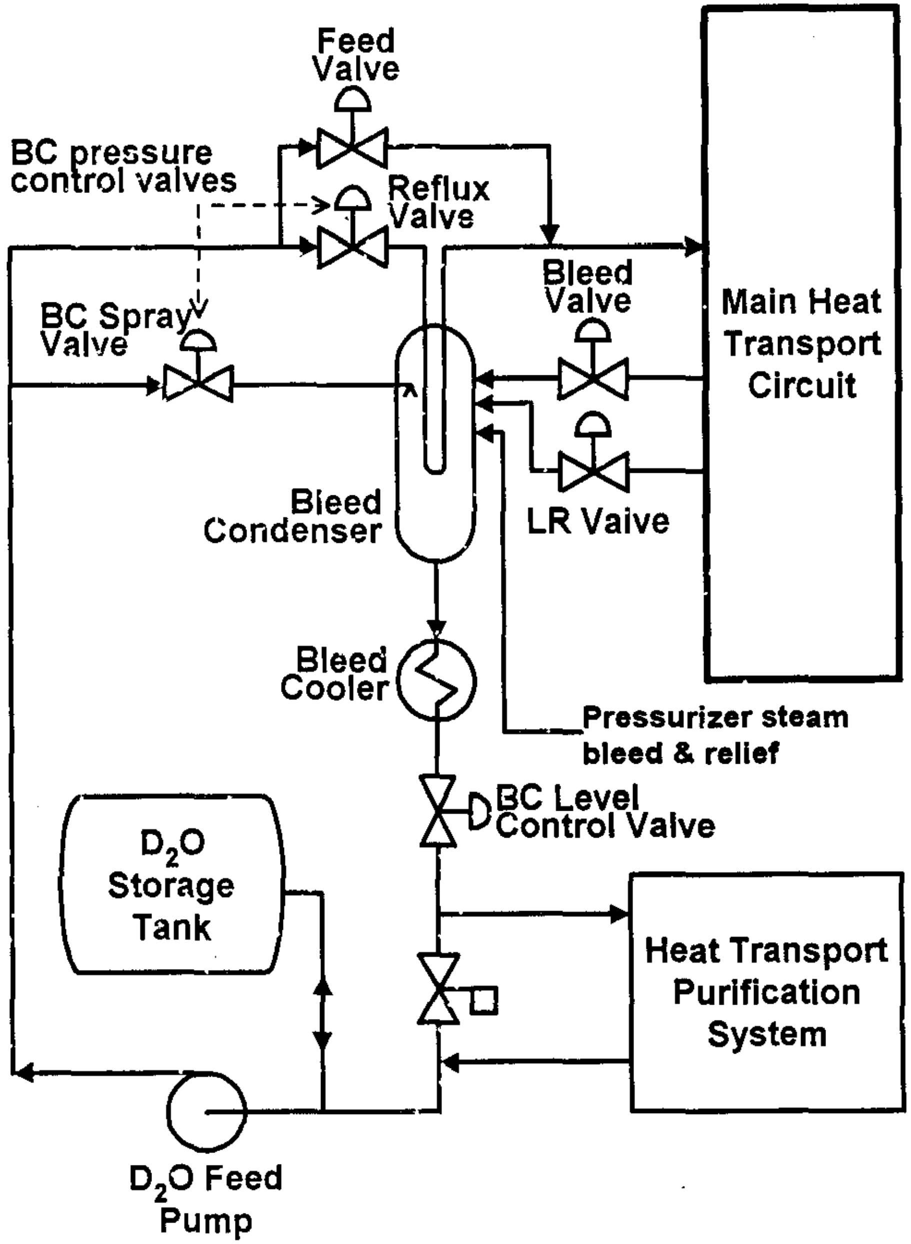
5. INVENTORY CONTROL

- **Inventory control for the heat transport system is achieved by feed and bleed, with the excess inventory being supplied from or stored in the D_2O Storage tank.**
- **In "normal mode", i.e. under pressurizer control, feed and bleed flows are controlled by the pressurizer level controller;**
- **When the Pressurizer is isolated from the main circuit, typically under warm-up and cool-down conditions, heat transport pressure control is performed by the feed and bleed circuit. This condition is referred to as the "solid mode". Compressibility of the heat transport system at 250°C is in the order of 4 MPa/m^3.**
- **In the "solid mode" feed and bleed flows are controlled by the heat transport reactor outlet header pressure controller;**



6. FEED AND BLEED CIRCUIT

- **Bleed flow is taken from the suction of one of the heat transport pumps and discharged into the bleed condenser via the bleed valves as two phase flow.**
- **The steam is condensed in the bleed condenser. Note that under normal operating conditions the cooling is provided by a reflux cooling tube bundle carrying feed flow, hence the tube bundle recovers part of the heat from the bleed flow.**
- **The bleed flow is further cooled by the bleed cooler before entering the heat transport purification system.**
- **The bleed condenser level control valves maintain the heavy water level in the bleed condenser at the setpoint.**
- **One heavy water feedpump is normally operating and takes water from the heavy water storage tank and/or the heat transport purification system. It supplies the required flow through feed control valves to the heat transport system via the heat transport pump suction line.**

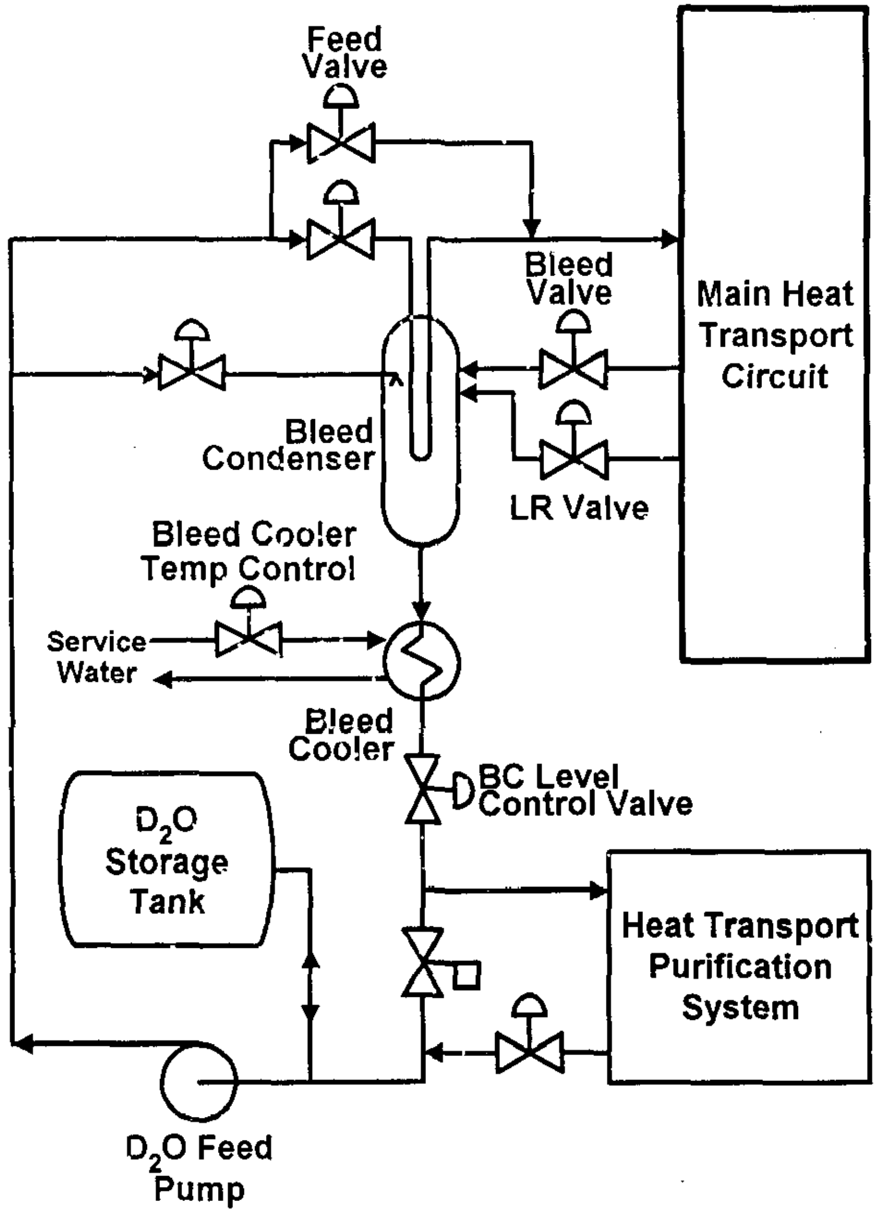


7. BLEED COOLER TEMPERATURE CONTROL

- The downstream heavy water temperature must be sufficiently low to ensure feedpump net positive suction head and to avoid damage to the ion exchange resin in the purification circuit.
- Over-temperature protection is provided by override controls, which close the bleed condenser level control valves on high temperature at the cooler outlet.

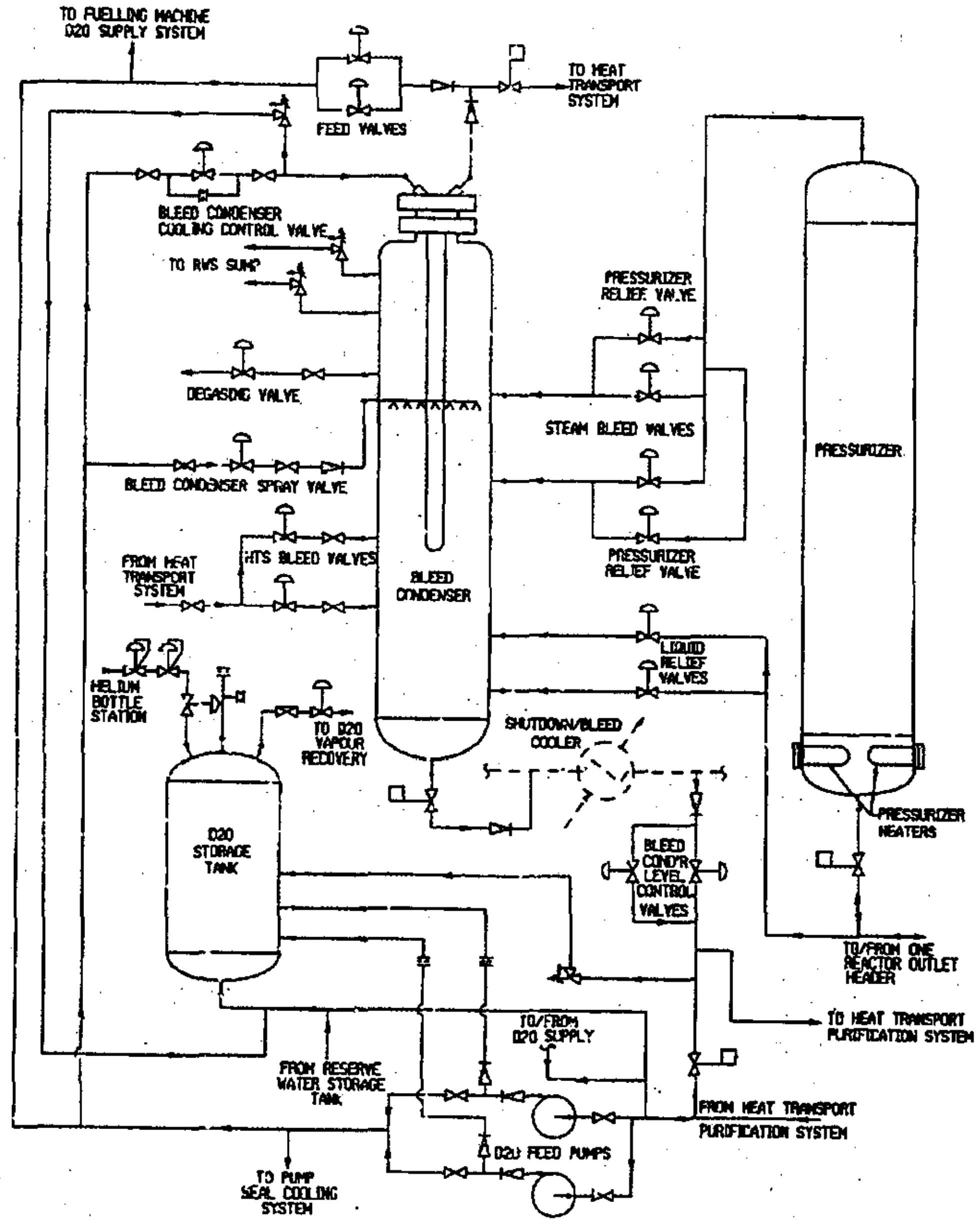
8. STORAGE AND TRANSFER CIRCUIT

- The heavy water storage tank serves as the head tank for the feedpumps. During initial warmup to 100°C, the heavy water swell from the heat transport system is accommodated in the heavy water storage tank.



9. TYPICAL CANDU PRESSURE AND INVENTORY CONTROL SYSTEM

- Pressurizer
- Bleed Condenser
- Bleed Cooler
- Storage Tank
- Bleed Valves
- Feed Valves
- Pressurizer Spray Valves
- Bleed Condenser Spray Valves
- Degassing Valves
- Liquid Relief Valves
- Pressurizer Relief Valves
- Bleed Condenser Level Control Valves
- Feedpumps



CHAPTER 4: HEAT TRANSPORT SYSTEM

MODULE C: WARM-UP AND COOLDOWN

MODULE OBJECTIVES:

At the end of this module, you will be able to describe the following features of a CANDU reactor:

1. The functions of the system;
2. The equipment and operation of the shutdown cooling system;
3. The main steps in warming up and cooling down the heat transport system.

SHUTDOWN COOLING SYSTEM

- Cools the heat transport system after a reactor shutdown and following an initial cooldown by steam rejection, to a temperature suitable for maintenance.
- Maintains the heat transport system temperature at the maintenance level for any desired length of time.
- Provides a means of draining, refilling and level control of the heat transport system to allow maintenance of the heat transport pumps or steam generators.
- Cools down the heat transport system from the zero power hot temperature under abnormal conditions.
- Provides a long term heat sink after a design basis earthquake, following depletion of Group 2 feedwater to the steam generators.

The system consists of two circuits, one located at each end of the reactor. Each circuit consists of one pump, one heat exchanger, valves and piping. The system is normally full of heavy water and isolated from the heat transport system by the header isolation valves.

One of the coolers, called the shutdown/bleed cooler, carries out the dual functions of shutdown cooling and bleed cooling. A small isolation valve, called the warmup valve, is located in parallel with one of the inlet header isolation valves. This valve is used for warming the shutdown cooling system.

Cooling water to both heat exchangers is provided by the recirculated cooling water system.

There are two bypass lines; one bypassing the pump/heat exchanger and another bypassing the pumps only. Both lines have a motorized valve for isolation. The pump/heat exchanger bypass line is used to moderate the cooling efficiency of the heat exchangers. The pump bypass allows the shutdown coolers to be used with the heat transport pumps when the shutdown cooling pumps are unavailable.

For normal heat transport system cooldown, steam from the steam generators bypasses the turbine and flows into the turbine condenser to reduce the heat transport system temperature from the hot shutdown temperature to 177°C in approximately 30 minutes.

HEAT TRANSPORT SYSTEM COOLDOWN

- Cooldown of the main circuit from zero power hot to 177°C is achieved by discharging steam from the steam generator secondary side through the condenser steam discharge valves to the condenser or, in case of loss of condenser vacuum, to the atmosphere via the atmospheric steam discharge valves.
- Below 177°C the shutdown cooling heat exchanger becomes the heat sink and circulation is provided by the shutdown cooling pumps. Heat transport pumps can be used for circulation if the shutdown cooling pumps are not available. The bleed condenser is isolated and the bleed condenser level control valves take over the function of the bleed valves.
- Under abnormal conditions, the shutdown cooling system can achieve cooldown from zero power hot conditions.
- The system is depressurized in steps as the system temperature decreases. The system is under 'normal' mode pressure control until the heat transport pumps are shut down, to minimize the chance of pump cavitation due to a sudden depressurization. Once the heat transport pumps are shut down, the operator has the option to continue cooldown in 'normal' mode or switch to 'solid' mode control.
- When the heat transport system temperature falls to 54°C, the heat transport system may be depressurized and the coolant level lowered to near the header level. The coolant is removed via the shutdown cooling system and transferred to the heavy water storage tank.
- If a short shutdown is expected it is desirable to isolate the pressurizer and maintain it pressurized, since heating the pressurizer takes much longer than heating the heat transport system. If an extended shutdown is planned, the pressurizer will usually be isolated from the heat transport system and depressurized with the pressurizer heaters switched off. Heat transport system pressure control is under 'solid' mode.

HEAT TRANSPORT SYSTEM SHUTDOWN

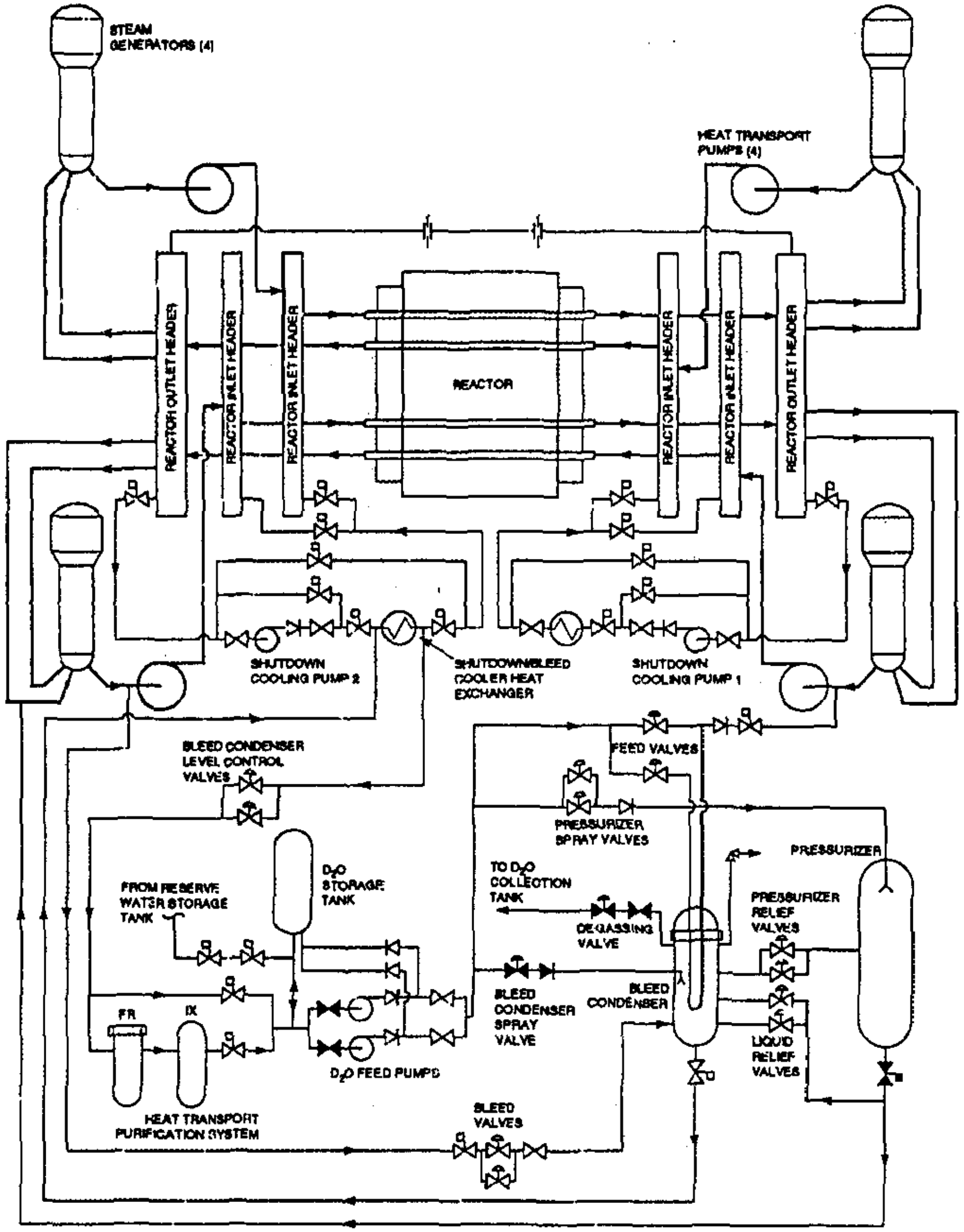
- Cooldown from 177°C to 54°C or below is achieved using the shutdown cooling system. Initially all motorized valves in the system are closed. The bleed condenser is isolated before switching from steam generator to shutdown cooling for cooldown. The outlet header isolation valves are opened to pressurize the system and ensure adequate NPSH. The heat transport pumps are shut down and the shutdown cooling pumps are started. The isolation valves to both heat exchangers and the pump/heat exchanger bypass valve are opened. The warmup valves are opened to allow warmup of the shutdown cooling piping. The inlet header isolation valves are then gradually opened. Both coolers are valved in for cooldown and the pump/heat exchanger bypass valve is maintained in a partially open position to prevent the cooldown rate from exceeding the design rate of 2.8°C per minute.
- When the shutdown cooling system is in the long-term cooldown mode with both shutdown cooling pumps operating and with the heat transport system full, part of the shutdown cooling flow bypasses the core through the steam generators and pumps. In the event of failure of one of the shutdown cooling pumps, the reactor outlet header temperature increases slightly but does not result in boiling in any of the fuel channels.
- For steam generator or pump maintenance, or inspection requiring the opening of the pressure boundary, the heat transport system coolant is drained to near the header level. Under this operating condition, all the shutdown cooling system flow goes through the core. Manual feed and bleed is used to control the heavy water level in the heat transport system.
- With recirculated cooling water available, the shutdown cooling system can be used to cool the heat transport system from 260°C for a limited number of cycles.
- Under abnormal conditions, such as loss of both shutdown cooling pumps, the shutdown cooling system can operate under the heat transport pump mode. In this mode, the shutdown cooling system pumps are off, the pump bypass valve is opened and coolant flow is driven through the shutdown coolers by the heat transport pump, from the inlet header to the outlet header.

HEAT TRANSPORT SYSTEM WARMUP

- Following a prolonged shutdown, the heat transport system could be at atmospheric pressure and at ambient temperature. The heat transport system coolant may be drained to near the header level or it may be completely filled. The heat transport pumps are stopped and cooling is provided by the shutdown cooling system. The pressurizer is partially filled with heavy water and is isolated from the heat transport system.
- In preparation for system warmup, the heat transport system must be refilled if it has been partially drained and then put on 'solid mode' pressure control. The main circuit can be pressurized by the heavy water feedpumps.
- The initial stage of warmup involves activating the pressurizer heaters which results in a gradual increase in pressurizer temperature and pressure. The pressurizer isolation valve is opened and heat transport pressure control is transferred to the normal mode prior to startup of the heat transport circulating pumps.
- The next step of warmup involves stopping both shutdown cooling pumps and closing the shutdown cooling/reactor outlet header isolation valves. The heat transport pumps are started. The system is warmed up by pump heat and low reactor heat.
- The shutdown cooling/reactor inlet header isolation valves are closed when the heat transport temperature reaches 177°C and normal bleed is established via the bleed condenser and bleed valves. System swell up to 100°C is stored in the heavy water storage tank. The swell during the remaining warmup period is accommodated in the pressurizer. The heat transport system is pressurized in steps as the system temperature increases.
- After warmup, the heat transport system coolant temperature and pressure at the outlet header are the zero power hot values. The pressurizer is hot and pressurized and is connected to the main heat transport circuit. Raising of reactor power can now begin.

HEAT TRANSPORT SYSTEM

- **Main Circuit**
- **Pressure and Inventory Control System**
- **Purification System**
- **Shutdown Cooling System**



CHAPTER 4: HEAT TRANSPORT SYSTEM

MODULE D: SIMULATOR EXERCISES

MODULE OBJECTIVES:

At the end of this module, you will be able to:

1. **Identify the parameters associated with the Heat Transport Main Circuit, Pressure and Inventory Control systems;**
2. **Respond correctly to the following events:**
   - **PHT Liquid Relief Valve (CV20) Fails Open**
   - **PHT Steam Bleed Valve (CV22) Fails Open**
   - **PHT Feed Valve (CV12) Fails Open**
   - **Pressurizer Surge Valve (MV1) Fails Close**
   - **PHT Bleed Valve (CV5) Fails Open**

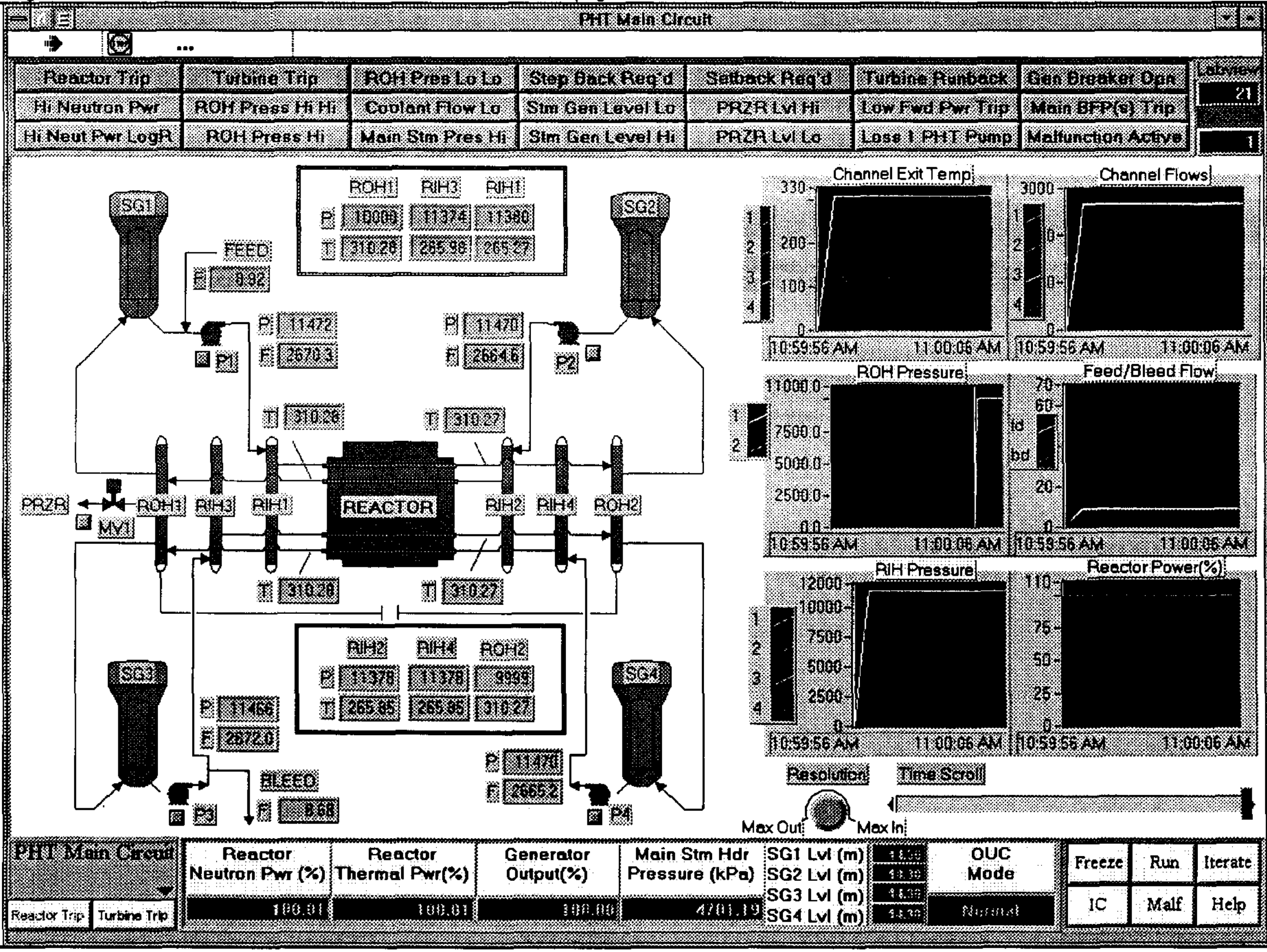
PHT MAIN CIRCUIT

This screen shows a simplified layout of the main heat transport system: the 480 coolant channels are represented by only four channels, two per loop showing the opposite directions of flow in the figure of eight configuration of each loop.

Starting from fuel channel number 1 at the reactor and following the direction of coolant flow, the system components and parameters shown are:

- average channel exit temperature (°C)
- ROH2 (note that ROH2 pressure and temperature are shown in the box below the reactor)
- SG2
- P2 (selection allows 'START', 'STOP' and 'RESET' operations)
- Pressure (kPa) and temperature (°C) at the outlet of P2
- RIH2 (note that RIH2 pressure and temperature are shown in the box below the reactor)
- fuel channel number 2
- average channel exit temperature (°C)
- ROH1 (note that ROH1 pressure and temperature are shown in the box above the reactor)
- SG1
- Feed flow into main loop (kg/sec)
- P1 (selection allows 'START', 'STOP' and 'RESET' operations)
- Pressure (kPa) and temperature (°C) at the outlet of P1
- RIH1 (note that RIH1 pressure and temperature are shown in the box above the reactor)
- flow returns to fuel channel number 1

The same equipment and parameters are shown in the lower loop, except that instead of feed flow into this loop there is bleed flow out (kg/sec).


PHT Main Circuit
Reactor Trip
Turbine Trip
ROH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
ROH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr LogR
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Lose 1 PHT Pump
Malfunction Active
SG1
SG2
SG3
SG4
FEED
BLEED
REACTOR
PRZR
MV1
P1
P2
P3
P4
ROH1
RIH3
RIH1
RIH2
RIH4
ROH2
Channel Exit Temp
Channel Flows
ROH Pressure
Feed/Bleed Flow
RIH Pressure
Reactor Power(%)
Resolution
Time Scroll
Max Out
Max In
Reactor Neutron Pwr (%)
Reactor Thermal Pwr(%)
Generator Output(%)
Main Stm Hdr Pressure (kPa)
SG1 Lvl (m)
SG2 Lvl (m)
SG3 Lvl (m)
SG4 Lvl (m)
OUC Mode
Freeze
Run
Iterate
IC
Malf
Help

PHT FEED AND BLEED

This screen shows the Heat Transport pressure control system, including the pressurizer, bleed (or de-gasser) condenser, pressure relief, feed and bleed circuits and D2O storage tank.

Starting with the storage tank at the bottom left hand corner, it level is displayed in meters. The tank supplies the flow and suction pressure for the Feed (or Pressuring) pumps P1 and P2: normally one pump is running, the popup menu allows START, STOP and RESET operations.

The Flow (kg/sec) and Temperature (°C) of the feed flow are displayed. Part of the flow goes to the Bleed Condenser to provide spray cooling (via CV14, kg/sec) and reflux cooling (via CV11, kg/sec), with the reflux flow being returned to the feed line past the feed control valve CV12; the feed flow then passes through the feed isolation valve MV18 before entering the main circuit at the suction of the main circulating pump 1.

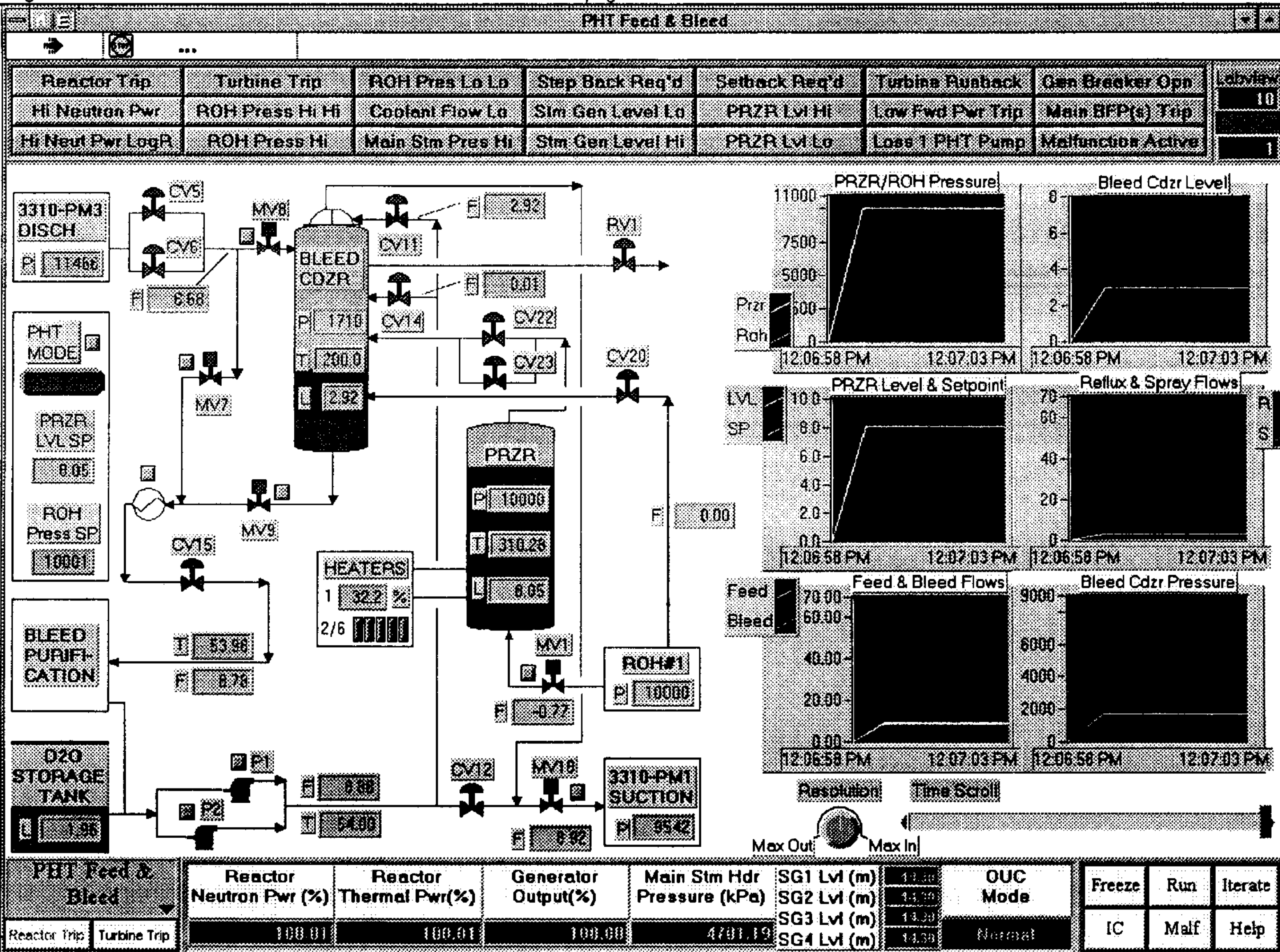
Proceeding in an anti-clockwise direction, the Pressure (kPa) and Temperature (°C) of ROH#1 are shown. Flow from the Outlet header is normally to and from the Pressurizer via MV1, a negative flow (kg/sec) indicating flow out of the pressurizer. In case of excessive heat transport header pressure, relief valve CV20 opens and discharges flow (kg/sec) to the Bleed Condenser. Pressurizer Pressure (kPa), Temperature(°C) and Level (m) are displayed.

Pressurizer pressure is maintained by heaters (in case the pressure falls) and by steam discharge valves CV22 and CV23 if the pressure is too high.

Bleed Condenser pressure relief is provided via RV1. Parameters displayed for the Bleed Condenser are: Pressure (kPa), Temperature(°C) and Level (m). Feed flow from main circuit pump 3 (header pressure in kPa) flows (kg/sec) via Bleed Control valves CV5, CV6 and MV8. Bleed Condenser by-pass is via MV7.

The outflow from the Bleed Condenser is via MV9, the Bleed Cooler and the Bleed Condenser Level Control valve CV15 to the Purification Circuit. The values of Temperature(°C) and Flow (kg/sec) into the Purification System are displayed.

Heat Transport pressure control in NORMAL mode is via the Pressurizer; via the PHT MODE popup menu SOLID mode can be selected. PRESSURIZER LEVEL SETPOINT and ROH PRESSURE SETPOINT are also shown.


PHT Feed & Bleed
Reactor Trip
Turbine Trip
ROH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
ROH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr LogR
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
Labview
10
1
3310-PM3
DISCH
P 11466
CV5
CV6
F 6.68
MV8
BLEED
CDZR
P 1710
T 200.0
L 2.92
CV11
F 2.92
CV14
F 0.01
CV22
CV23
RV1
CV20
PHT
MODE
PRZR
LVL SP
8.05
ROH
Press SP
10001
MV7
MV9
CV15
HEATERS
1 32.2 %
2/6
PRZR
P 10000
T 310.28
L 8.05
F 0.00
T 53.96
F 8.78
BLEED
PURIFI-
CATION
MV1
F -0.77
ROH#1
P 10000
D2O
STORAGE
TANK
L 1.96
P1
P2
F 8.68
T 54.00
CV12
MV18
F 8.92
3310-PM1
SUCTION
P 9542
PRZR/ROH Pressure
11000
7500
5000
Przr
Roh
12:06:58 PM
12:07:03 PM
Bleed Cdzr Level
PRZR Level & Setpoint
LVL
SP
10.0
8.0
6.0
4.0
2.0
0.0
Reflux & Spray Flows
R
S
70
60
40
20
0
Feed & Bleed Flows
Feed
Bleed
70.00
60.00
40.00
20.00
0.00
Bleed Cdzr Pressure
9000
6000
4000
2000
Resolution
Time Scroll
Max Out
Max In
PHT Feed & Bleed
Reactor Trip
Turbine Trip
Reactor
Neutron Pwr (%)
100.01
Reactor
Thermal Pwr(%)
100.01
Generator
Output(%)
100.00
Main Stm Hdr
Pressure (kPa)
4701.19
SG1 Lvl (m)
SG2 Lvl (m)
SG3 Lvl (m)
SG4 Lvl (m)
OUC
Mode
Freeze
Run
Iterate
IC
Malf
Help

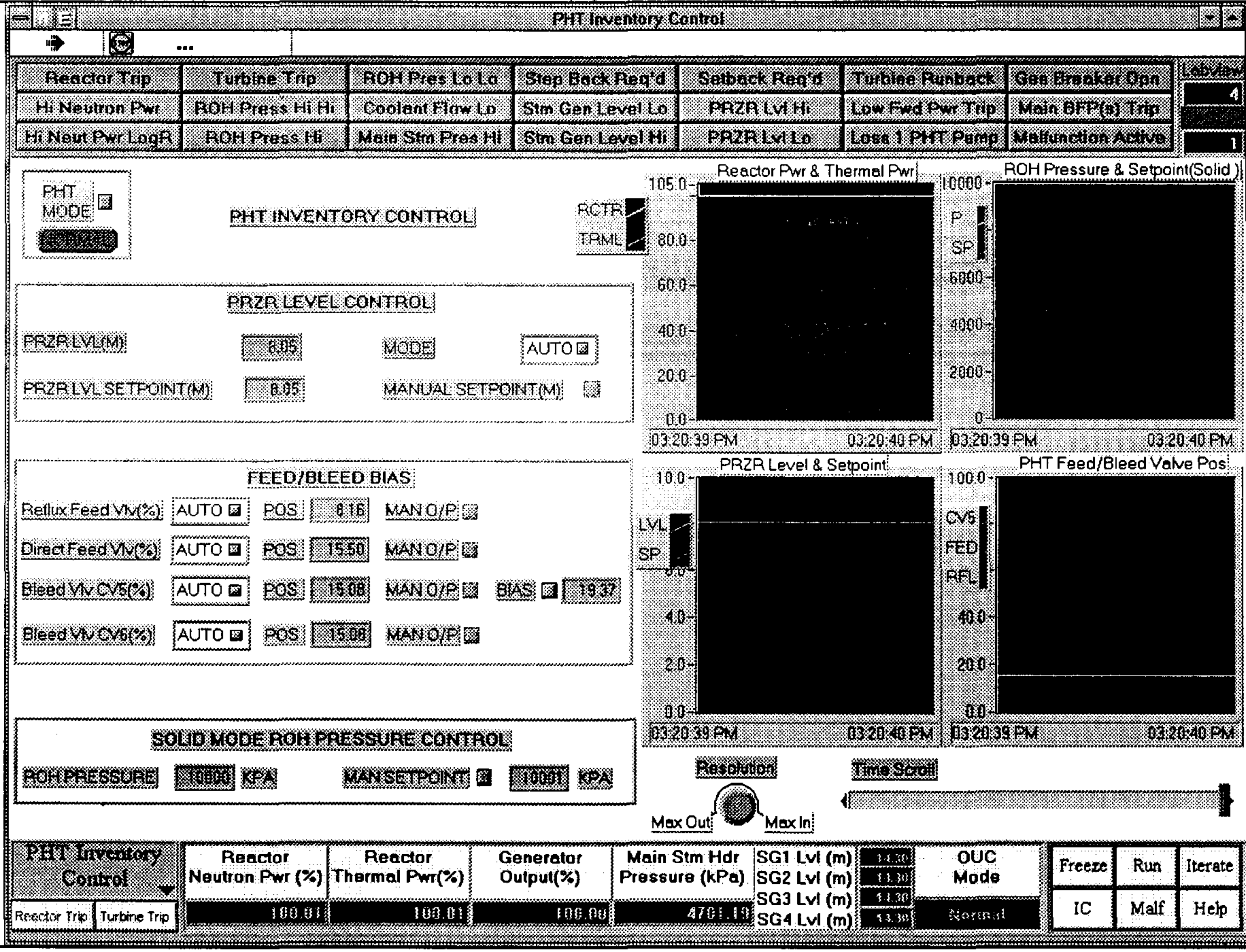
PHT INVENTORY CONTROL

The screen shows the parameters relevant to controlling the inventory in the main heat transport loop. Either NORMAL or SOLID modes of operation may be selected. Note that in NORMAL mode, inventory control is achieved by controlling Pressurizer Level, while in SOLID mode inventory control is by means of maintaining main heat transport pressure via the feed and bleed valves.

Pressurizer Level is normally under computer control, with the setpoint being ramped as a function of reactor power and the expected shrink and swell resulting from the corresponding temperature changes. Level control may be transferred to MANUAL and the SETPOINT can then be controlled manually.

The amount of feed and bleed is controlled about a bias value that is set to provide a steady flow of bleed to the Purification System. The amount of flow may be adjusted by changing the value of the BIAS. The positions of feed and bleed valves are normally under AUTO control, but may be changed to MANUAL using the popup menus.

In SOLID mode the ROH PRESSURE (kPa) may be controlled manually via the popup menu.

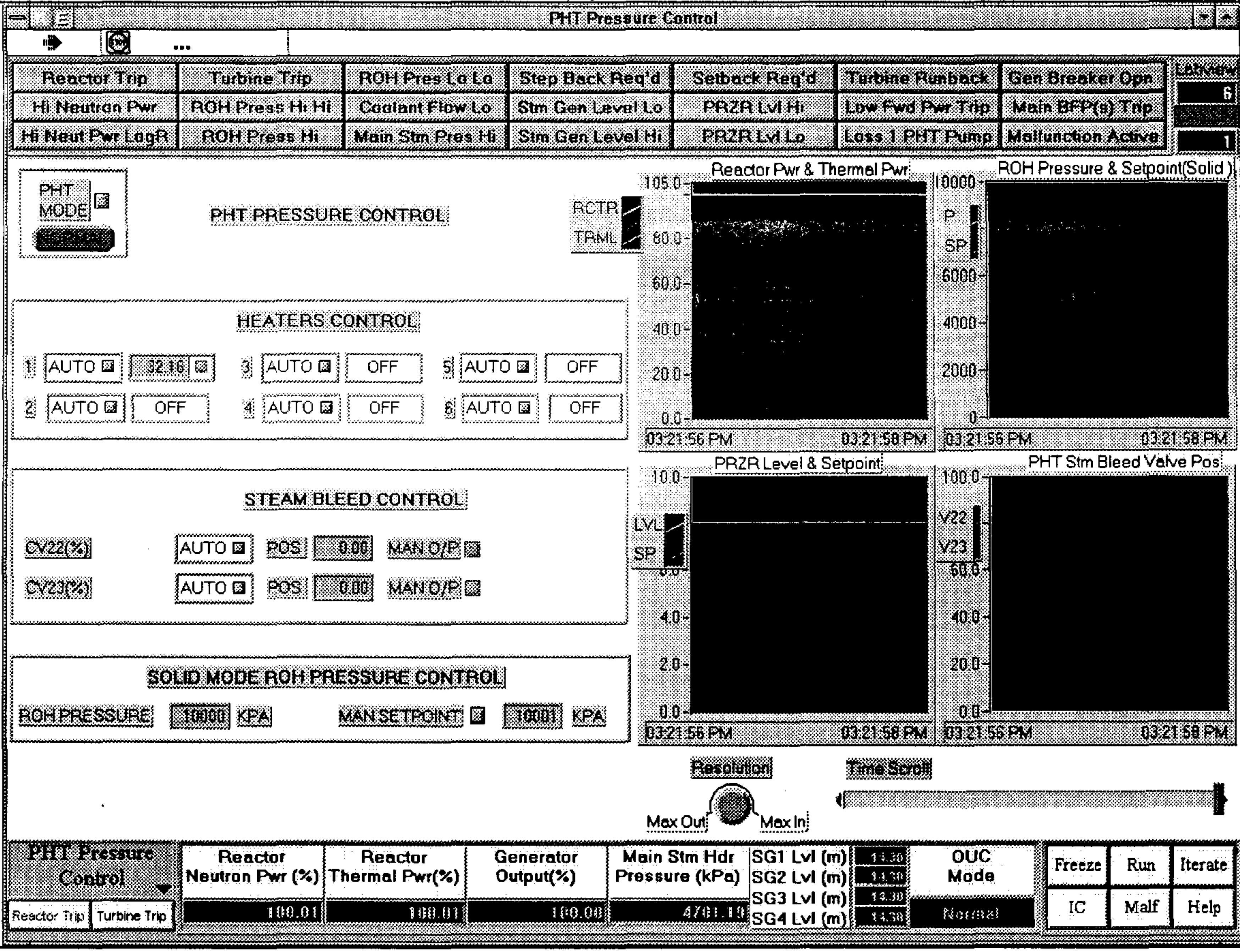

PHT Inventory Control
Reactor Trip
Turbine Trip
ROH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
ROH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr LogR
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
PHT MODE
PHT INVENTORY CONTROL
PRZR LEVEL CONTROL
PRZR LVL(M) 8.05
MODE AUTO
PRZR LVL SETPOINT(M) 8.05
MANUAL SETPOINT(M)
FEED/BLEED BIAS
Reflux Feed Vlv(%) AUTO POS 8.16 MAN O/P
Direct Feed Vlv(%) AUTO POS 15.50 MAN O/P
Bleed Vlv CV5(%) AUTO POS 15.08 MAN O/P BIAS 19.37
Bleed Vlv CV6(%) AUTO POS 15.08 MAN O/P
SOLID MODE ROH PRESSURE CONTROL
ROH PRESSURE 10000 KPA
MAN SETPOINT 10001 KPA
Reactor Pwr & Thermal Pwr
RCTR
TRML
ROH Pressure & Setpoint(Solid)
P
SP
PRZR Level & Setpoint
LVL
SP
PHT Feed/Bleed Valve Pos
CV5
FED
RFL
03:20:39 PM
03:20:40 PM
Resolution
Max Out
Max In
Time Scroll
PHT Inventory Control
Reactor Trip
Turbine Trip
Reactor Neutron Pwr (%) 100.01
Reactor Thermal Pwr(%) 100.01
Generator Output(%) 100.00
Main Stm Hdr Pressure (kPa) 4701.19
SG1 Lvl (m)
SG2 Lvl (m)
SG3 Lvl (m)
SG4 Lvl (m)
OUC Mode
Normal
Freeze
Run
Iterate
IC
Malf
Help

PHT PRESSURE CONTROL

This screen is similar to the previous one in terms of the ability to select PHT Pressure Control MODE and SOLID MODE ROH PRESSURE CONTROL. The difference arise in the control of Pressurizer pressure.

The six HEATERS are normally in AUTO, with the variable Heater (#1) modulating. The other five heaters are either ON or OFF, and under AUTO control. Via the popup menus MANUAL operation can be selected, and each heater may be selected to START, STOP or RESET.

STEAM BLEED CONTROL is via CV22 and CV23. These are normally in AUTO mode, but may be placed on MANUAL and the valve opening manually controlled via popup menus.


PHT Pressure Control
Reactor Trip
Turbine Trip
ROH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
ROH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr LogR
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
PHT MODE
PHT PRESSURE CONTROL
HEATERS CONTROL
AUTO
32.16
OFF
STEAM BLEED CONTROL
CV22(%)
CV23(%)
POS
0.00
MAN O/P
SOLID MODE ROH PRESSURE CONTROL
ROH PRESSURE
10000
KPA
MAN SETPOINT
10001
Reactor Pwr & Thermal Pwr
RCTR
TRML
ROH Pressure & Setpoint(Solid)
P
SP
PRZR Level & Setpoint
LVL
PHT Stm Bleed Valve Pos
V22
V23
03:21:56 PM
03:21:58 PM
Resolution
Max Out
Max In
Time Scroll
PHT Pressure Control
Reactor Trip
Turbine Trip
Reactor Neutron Pwr (%)
100.01
Reactor Thermal Pwr(%)
100.01
Generator Output(%)
100.00
Main Stm Hdr Pressure (kPa)
SG1 Lvl (m)
SG2 Lvl (m)
SG3 Lvl (m)
SG4 Lvl (m)
OUC Mode
Normal
Freeze
Run
Iterate
IC
Malf
Help

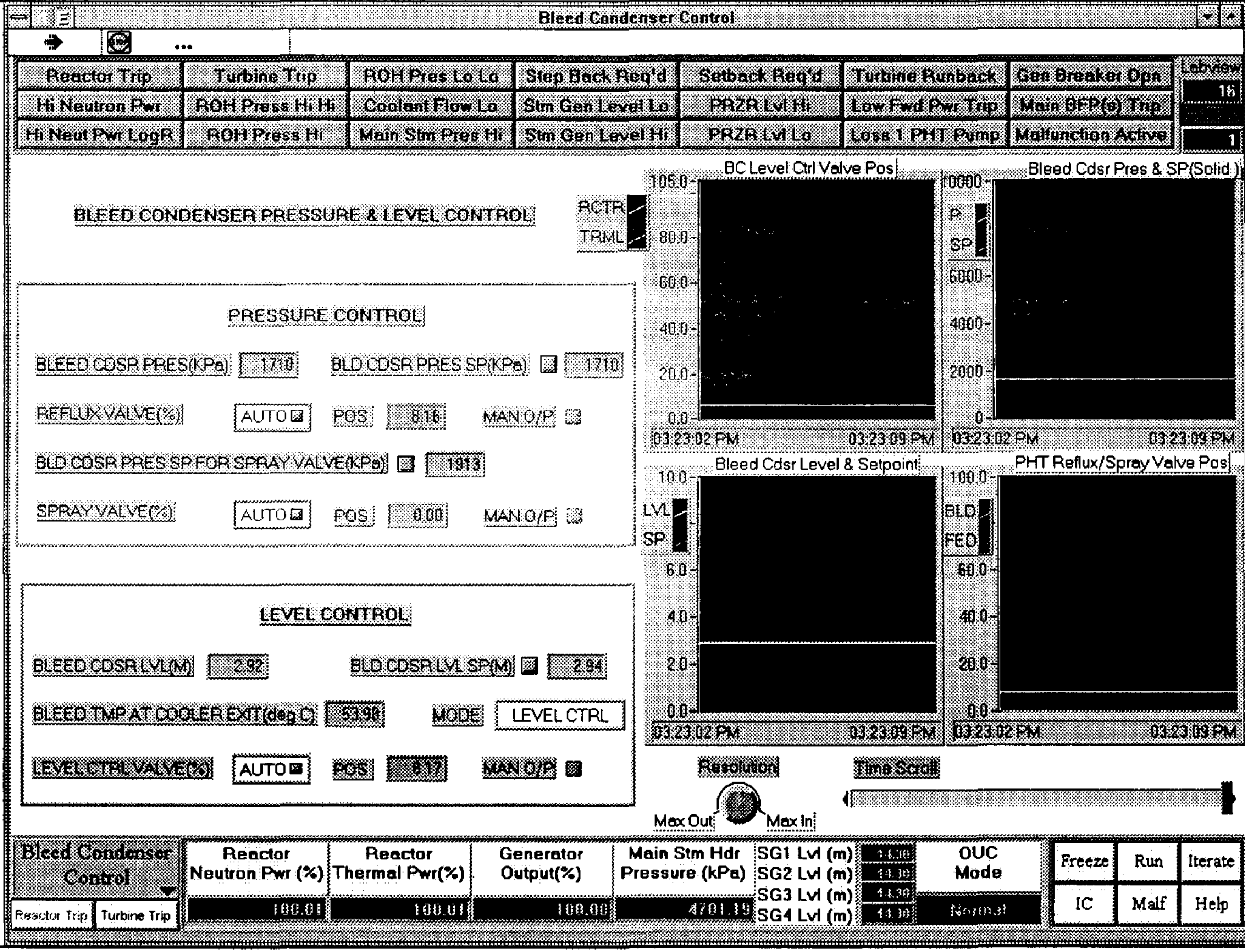
BLEED CONDENSER CONTROL

The parameters required to control Bleed Condenser Pressure and Level are shown on this screen.

PRESSURE CONTROL is normally achieved via altering the REFLUX flow, and SPRAY flow only takes place if REFLUX flow is unable to maintain pressure control. To achieve such a split mode of operation, the SETPOINT for the Reflux valve, denoted as BLEED CONDENSER PRESSURE SETPOINT (kPa) is set at a value lower than the BLEED CONDENSER PRESSURE SETPOINT FOR SPRAY VALVE (kPa). Both valves are normally on AUTO, but may be selected to MANUAL and the valve opening controlled directly via popup menus.

LEVEL CONTROL is normally in the AUTO mode about the specified SETPOINT. However if the BLEED TEMPERATURE AT COOLER EXIT exceeds a preset value (68°C), the control mode is switched to TEMPERATURE CONTROL mode, which restricts the valve opening so as to protect the ion exchanger resin.

The LEVEL CONTROL VALVE may be placed on MANUAL for direct control of the valve's position.


Bleed Condenser Control
Reactor Trip
Turbine Trip
ROH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
ROH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr LogR
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Lose 1 PHT Pump
Malfunction Active
Labview
16
1
BLEED CONDENSER PRESSURE & LEVEL CONTROL
RCTR
TRML
PRESSURE CONTROL
BLEED CDSR PRES(KPa)
1710
BLD CDSR PRES SP(KPa)
1710
REFLUX VALVE(%)
AUTO
POS
8.16
MAN O/P
BLD CDSR PRES SP FOR SPRAY VALVE(KPa)
1913
SPRAY VALVE(%)
AUTO
POS
0.00
MAN O/P
LEVEL CONTROL
BLEED CDSR LVL(M)
2.92
BLD CDSR LVL SP(M)
2.94
BLEED TMP AT COOLER EXIT(deg C)
53.98
MODE
LEVEL CTRL
LEVEL CTRL VALVE(%)
AUTO
POS
8.17
MAN O/P
BC Level Ctrl Valve Pos
Bleed Cdsr Pres & SP(Solid)
P
SP
Bleed Cdsr Level & Setpoint
LVL
SP
PHT Reflux/Spray Valve Pos
BLD
FED
03:23:02 PM
03:23:09 PM
Resolution
Time Scroll
Max Out
Max In
Bleed Condenser Control
Reactor Trip
Turbine Trip
Reactor Neutron Pwr (%)
100.01
Reactor Thermal Pwr(%)
100.01
Generator Output(%)
100.00
Main Stm Hdr Pressure (kPa)
4701.19
SG1 Lvl (m)
SG2 Lvl (m)
SG3 Lvl (m)
SG4 Lvl (m)
OUC Mode
Normal
Freeze
Run
Iterate
IC
Malf
Help