CHAPTER 5: BOILER LEVEL CONTROL

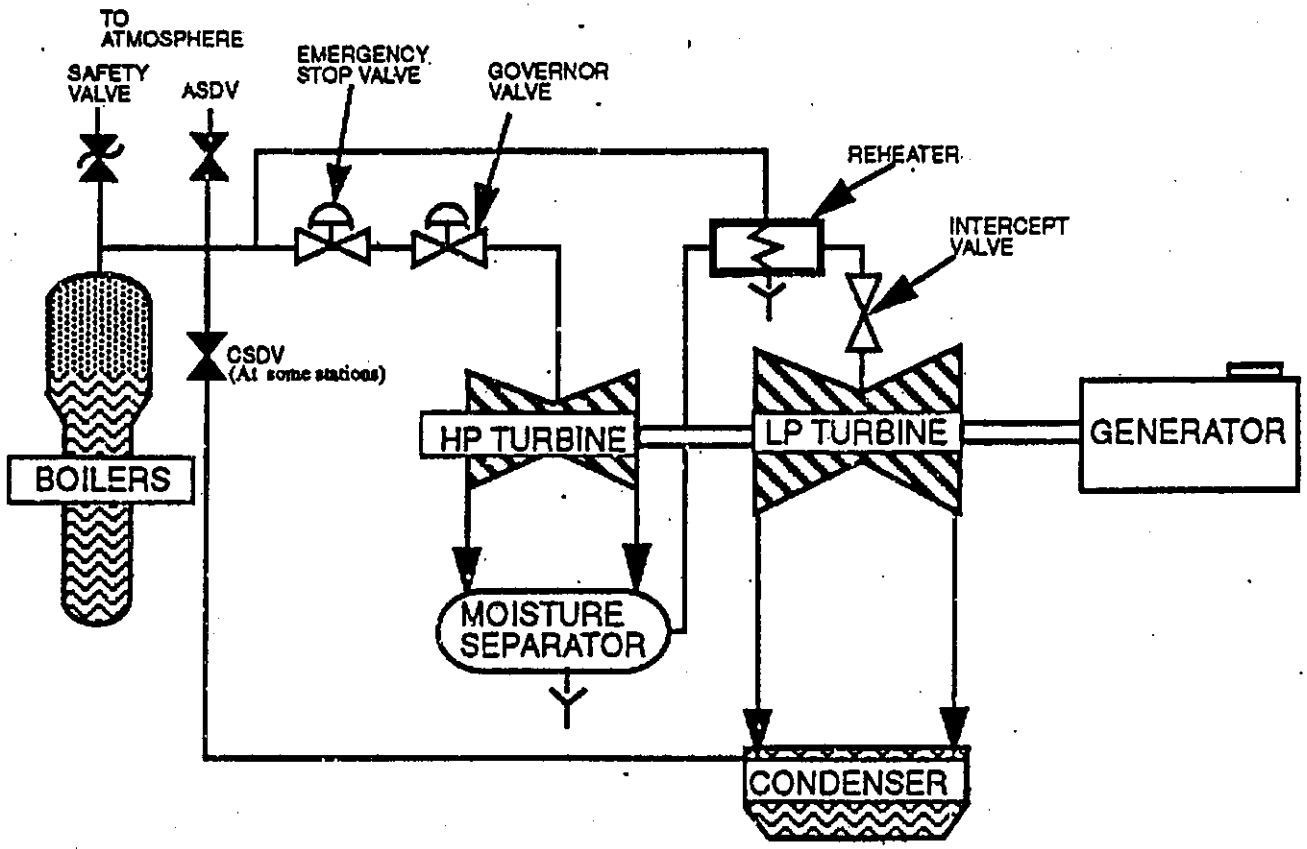
MODULE A: THE PROCESS TO BE CONTROLLED

MAIN FUNCTIONS OF THE STEAM, TURBINE & FEEDWATER SYSTEMS

- Provide the means for the transfer of heat energy from the primary heat transport system, and for the production of steam.
- Convey the steam produced in the steam generators to the high pressure turbine and other balance of plant loads.
- Provide for overpressure protection of the steam generator secondary side.
- Provide instrumentation for steam generator level and pressure control.
- Provide for a crash cool of the steam generators on a loss-of-coolant.
- Enable testing of one turbine stop valve at a time without interruption to the unit and without causing problems in control of steam generator water levels.
- Provide feedwater to each steam generator and maintains steam generator secondary side water levels.
- Provide for cooldown of the heat transport system following a design basis earthquake.
- Provide for a remote manual isolation of each pair of steam generators from the steam system (as may be required in the event of a tube leak).

STEAM SYSTEM

- Safety valves installed on top of the boiler protect the steam system from over pressure.
- The pressure from the boilers drives the steam to the high pressure (HP) turbine through the following valves:
  - ⇒ the emergency stop valves which are to quickly stop the steam flow to the turbine to prevent damage to the turbine
  - ⇒ the governor valves, which control the quantity of steam flowing to the turbine, and therefore the speed of the turbine when not connected to the grid, and the electrical output of the unit when the generator is synchronized to the grid.



- From the governor valve the steam passes through the HP turbine.
- Steam leaves the high pressure turbine at approximately 900 kPa and 170°C at 10% moisture
- It passes to the moisture separator which removes the moisture in the steam. Steam leaving the moisture separator has the same temperature and pressure as that at the turbine outlet but without moisture.
- The steam next passes through a reheater, which uses steam directly from the boiler to heat the steam from the moisture separator to a superheated condition at about 230°C and 900 kPa. Since the Reheater drains are at saturation temperature, they are returned directly to the boilers.

- Before entering the LP turbine, the steam passes through intercept valves. In a fashion similar to the emergency stop valves, these valves shut off steam to the LP turbine in an emergency.
- The steam finally passes through the low pressure turbine and is then exhausted to the condenser at approximately 5 kPa(a), 35°C and 10% moisture.

TURBINE BYPASS

- Condenser Steam Discharge Valves are installed to allow the steam to bypass the turbine and flow directly to the condenser on loss of turbine so that the reactor can continue to operate at the power required to prevent a 'poison-out'. They are also used to discharge steam on a loss of line, or on a turbine trip, so that the main steam safety valves do not lift.
- Atmospheric Steam Discharge Valves are low capacity valves used to control steam generator pressure via the steam pressure control program. They are opened in proportion to the pressure error, normally with an offset in the steam pressure setpoint. These valves may also be used to provide a heat sink during shutdown for decay heat removal when the main condenser is unavailable.

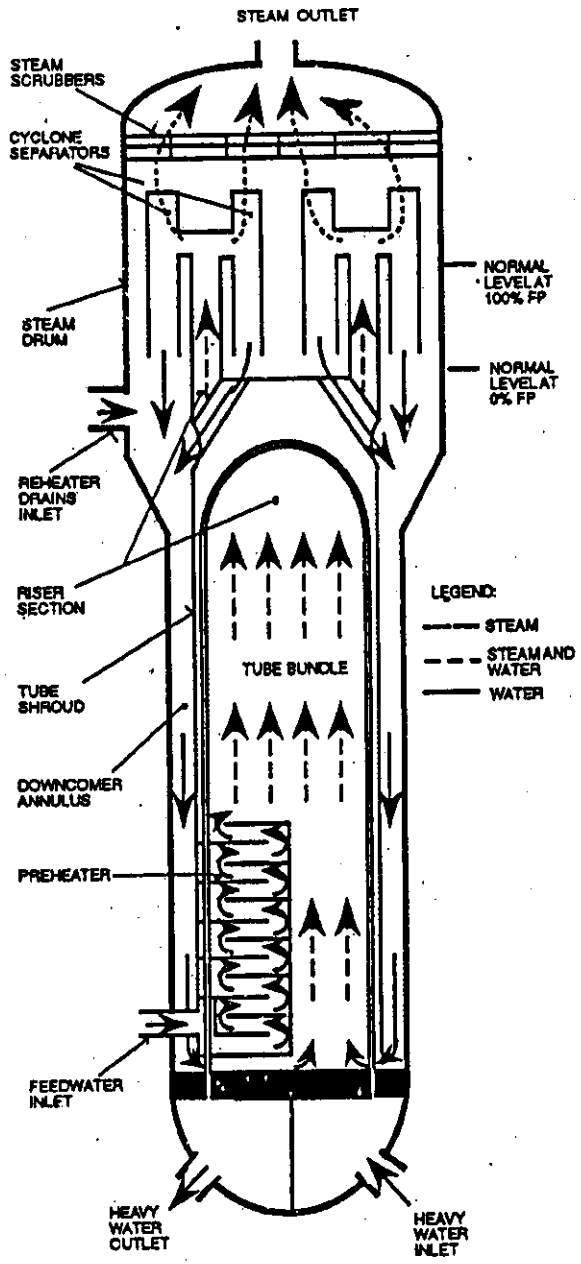
EXTRACTION STEAM

The efficiency of the thermodynamics of the steam and feedwater cycle can be optimized by taking some of the energy of the steam at various points between the main steam header and the low pressure turbine and using it to heat the feedwater. Extraction steam is supplied to the following:

- low pressure heaters
- deaerator
- high pressure heaters

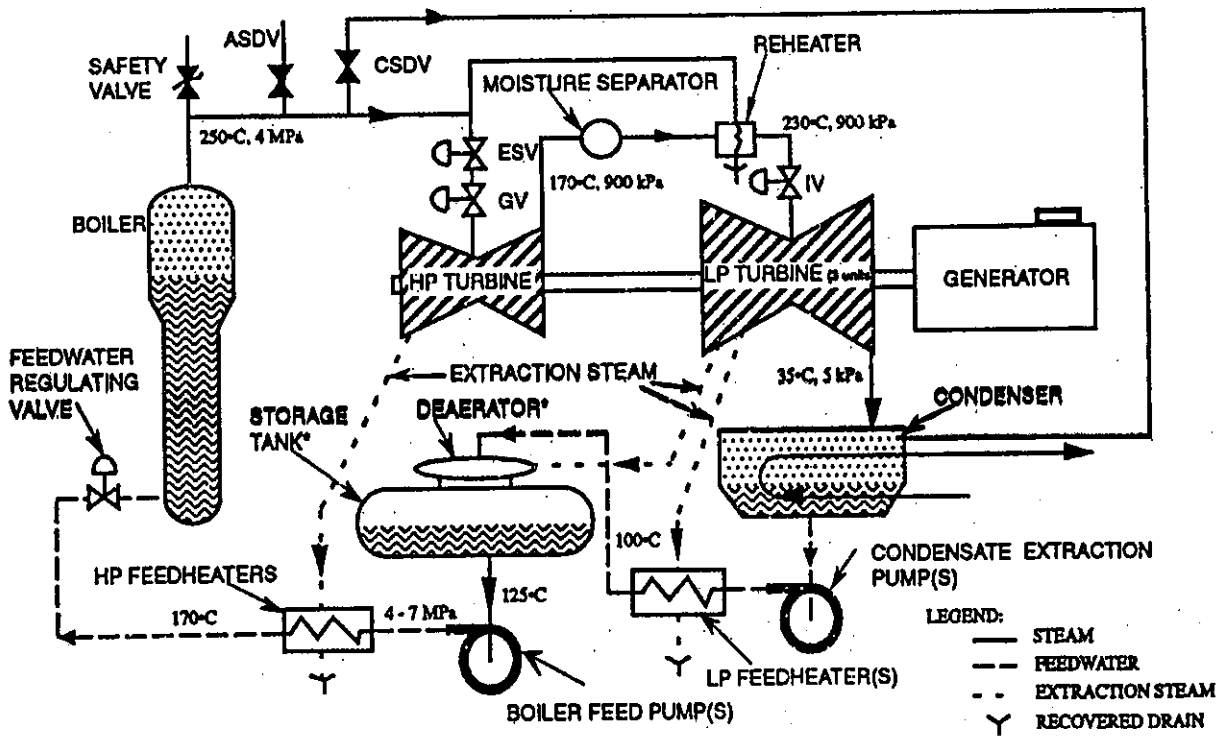
BOILER

- Hot pressurized heat transport heavy water enters the boiler and passes through the tube bundle. Heat transfers from the heavy water to the feedwater, causing the feedwater to boil.
- The steam leaving the top of the tube bundle is about 90% water. To prevent damage to the turbine, only dry steam must leave the boiler.
- Cyclone separators, located above the tube bundle, dry the steam by giving the steam/water mixture a swirling centrifugal motion. The water, being denser than steam, moves to the outside area of the separator and is drained off.
- The steam scrubbers, located above the cyclone separators, remove the last traces of moisture.
- Water separated from the steam in the cyclone separator and steam scrubber drains to the outside of the boiler's tube shroud. The amount of water cycling through the tube bundle, through the downcomer, is typically ten times as much as feedwater entering the boiler.
- The water in the boiler moves through natural circulation without the use of pumps. The water and steam in the tube bundle move upward because of the decrease in density due to the addition of heat. The water that comes out from the cyclone separators is relatively dense, and falls down the downcomer to begin the cycle again.
- The feedwater flow in the boiler starts from the preheater. The preheater heats the feedwater to near saturation temperature. Inside the boiler the feedwater circulates up around the tube bundle and down the downcomer many times while acquiring the latent heat of vaporization, and finally leaves the boiler as nearly saturated steam.



FEEDWATER SYSTEM

- The water leaving the condenser is at relatively low temperature and pressure.
- A series of heat exchangers raises the condensate temperature to about 170°C.
- The preheater increase the temperature to almost saturation temperature in the boiler.
- A set of pumps, known as boiler feed pumps (BFP), force the feedwater into the boilers.



* Physically the highest vessel in the system

LOW PRESSURE FEEDHEAT SYSTEM

- The first stage in the boiler feedwater heating is through the LP feedheating system.
- The condensate extraction pump (CEP) delivers the condensate from the condenser hotwell to the LP feedheaters.
- The low pressure feedheating system gets its name from the low pressure condition of the feedwater, at about 1400 kPa.
- The LP feedheaters use extraction from the LP turbines as their heating medium. The extraction steam condenses in the shell of the heater. A separate pump recovers this condensate by pumping it to the condenser hotwell. The feedwater leaves the last LP feedheater at approximately 80°C to 100°C.

DEAERATOR AND STORAGE TANK

- The deaerator is the next stage in the feedwater heating process. This is the highest vessel in the feedheating system. The deaerator adds heat to and removes non-condensable gases from the feedwater.
- The incoming feedwater enters the deaerator near the top and sprays downward over cascade trays. Extraction steam from the LP turbine enters the deaerator near the bottom and passes upward. As a result the feedwater heats up to about 125°C. The deaerated feedwater and condensed steam drain from the deaerator into a storage tank. The storage tank supplies water for boiler operation.

HIGH PRESSURE FEEDHEATING SYSTEM

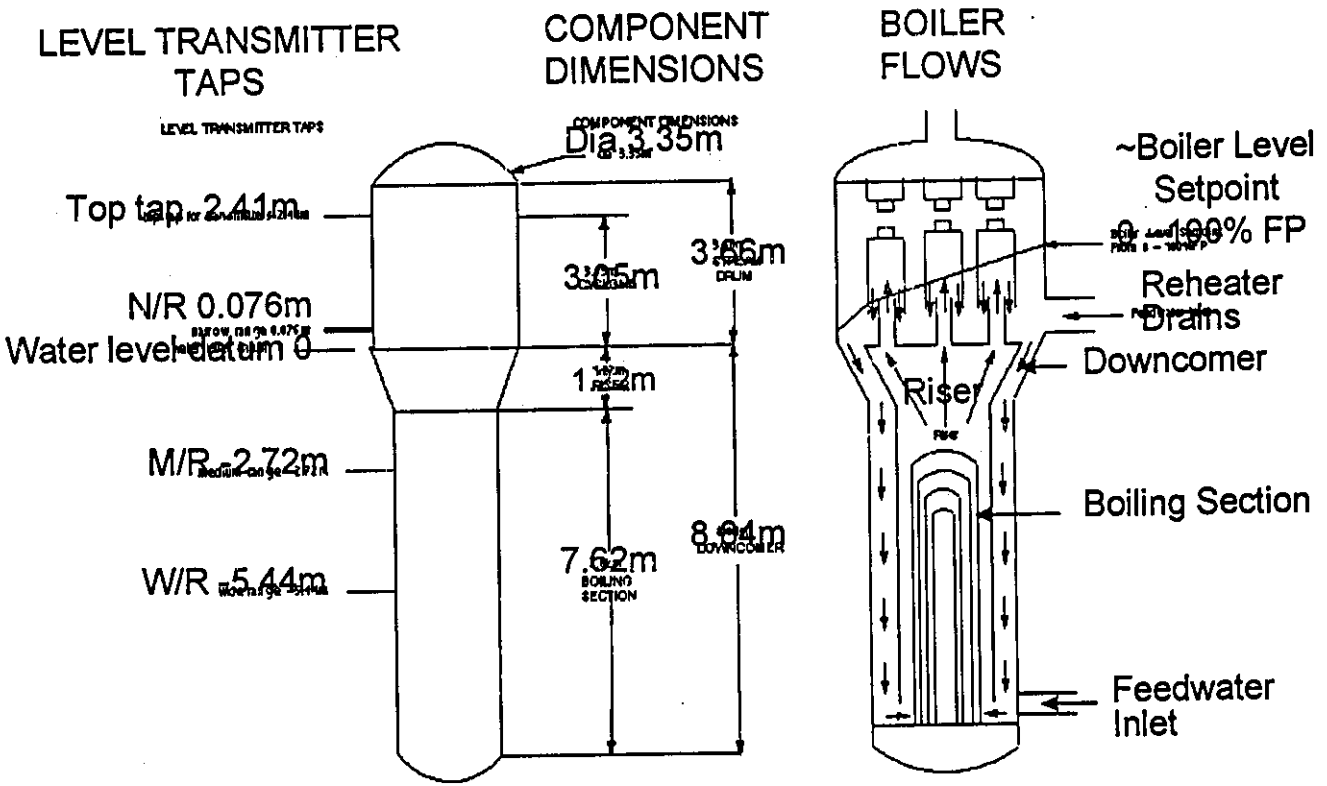
- From the deaerator storage tank, the feedwater undergoes one more stage of having its temperature and pressure raised.
- The boiler feed pumps (BFP) take suction from the deaerator storage tank and raise the feedwater pressure to between 4 and 7 MPa. The pump discharges the high pressure feedwater to the high pressure (HP) feedheaters.
- The HP feedheaters heat the feedwater to about 170°C. HP feedheater operation and construction are similar to that of the LP feedheaters. Extraction steam from the HP turbine normally supplies the heating medium.

CANDU BOILER FEED PUMPS AND LEVEL CONTROL

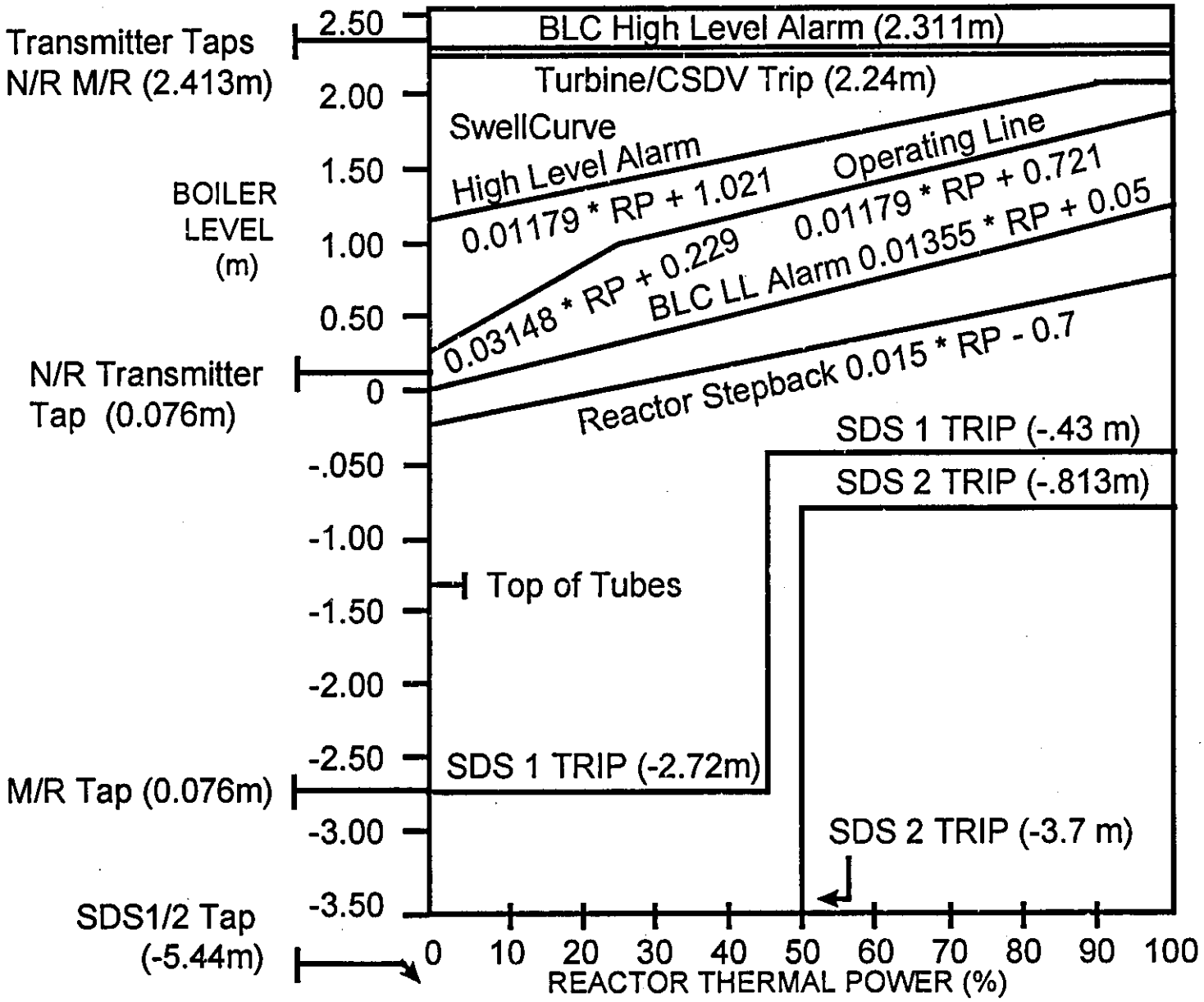
- Two main boiler feed pumps are required to supply the necessary flow, and one additional pump is on standby.
- One auxiliary pumps is also provided, it is sized so that it can supply the flow to remove decay heat in case of a loss of class IV supply to the main pumps.
- Connections to the Condensate system allow for recirculating flow when the pumps are operating but the level control valves are closed.
- The level in each steam generator is controlled individually.
- Since the measured level in a boiler is higher for a given mass of inventory as the power level increases due to the expansion of the water with increased boiling, the level setpoint as well as alarm and trip settings are increased automatically as a function of reactor power.
- Because of safety, range of control and maintenance considerations, each steam generator has a set of three control valves for feedwater control connected in parallel: one small valve to control feedwater during shutdown, startup, and low power operation, and two larger valves to control feedwater for on-power conditions. Each of the two large valves can handle the full power flow requirements. Isolating valves are provided for each control valve.
- The steam generator level control system balances feedwater to steam flow for all operating conditions: fast reactor runup, reactor setback, turbine trip and 'poison-prevent' mode.

1.0 INTRODUCTION

- the Boiler Level Control program executes in both computers and has the following main functions:
  - determine validity of level, steam and feedwater flow readings
  - compute reactor power
  - compute the level setpoint as a function of reactor power
  - compute high and low level alarms
  - initiate transfer of control from in-service valve to standby valve
  - compute error signal from level, steam and feedflow measurements
  - verify control action



2.0 BOILER LEVEL CONTROL LINES



3.0 INPUT SIGNALS TO BLC

3.1 Boiler Level Measurements

Boiler #	64323 - LT #1A (N/R Level) 64323 - LT #2B (N/R Level) 64323 - LT #3C (N/R Level) 64323 - LT #4 (M/R Level)

Input Signal Selection/Alarm Logic

Boiler Level	None IRR	1 IRR	2 IRR	3 IRR	Comments Alarm Logic
Narrow Range	Use Median	Use Higher of 2 Good	Use Good	Use Medium Range	If level < 0.25m phase in M/R < 0.2m use M/R Alarm > 0.08m drift N/R from selected N/R
Medium Range		If no N/R fail BLC If level < N/R range substitute 0			Alarm > 0.2m drift M/R from selected N/R

3.2 Boiler Steam Flow Measurements (two per boiler)

Boiler 1	63611 - FT 3
Boiler 2	63611 - FT 4
Boiler 3	63611 - FT 1
Boiler 4	63611 - FT 2

Input Signal Selection/Alarm Logic

None IRR	1 IRR	2 IRR	3 IRR	4 IRR
Use respective pair flow	Use average of Good flows for affected pair	Use average of Good flows for affected pair	Do not use flow terms	Do not use flow terms

Spread alarm if any value $\pm$ 10% from average flow and flow > 15%

Alarmed values are considered irrational for signal selection

3.3 Boiler Feed Flow Measurements (two per boiler)

Boiler 1	64323 - FT 6
Boiler 2	64323 - FT 7
Boiler 3	64323 - FT 8
Boiler 4	64323 - FT 9

Input Signal Selection/Alarm Logic

None IRR	1 IRR	2 IRR	3 IRR	4 IRR
Use respective pair flow	Use average of Good flows for affected pair	Use average of Good flows for affected pair	Do not use flow terms	Do not use flow terms

All irrational inputs are alarmed

3.4 Boiler Steam Pressure Measurements (two per boiler)

Boiler 1	63611 - PT 4
Boiler 2	63611 - PT 3
Boiler 3	63611 - PT 1
Boiler 4	63611 - PT 5

Input Signal Selection/Alarm Logic

None IRR	1 IRR	2 IRR	3 IRR	4 IRR
Use 2nd highest	Use median of 3 Good values	Use higher of 2 Good values	Do not use pressure rate term	Do not use pressure rate term

All irrational inputs are alarmed by BLC and BPC

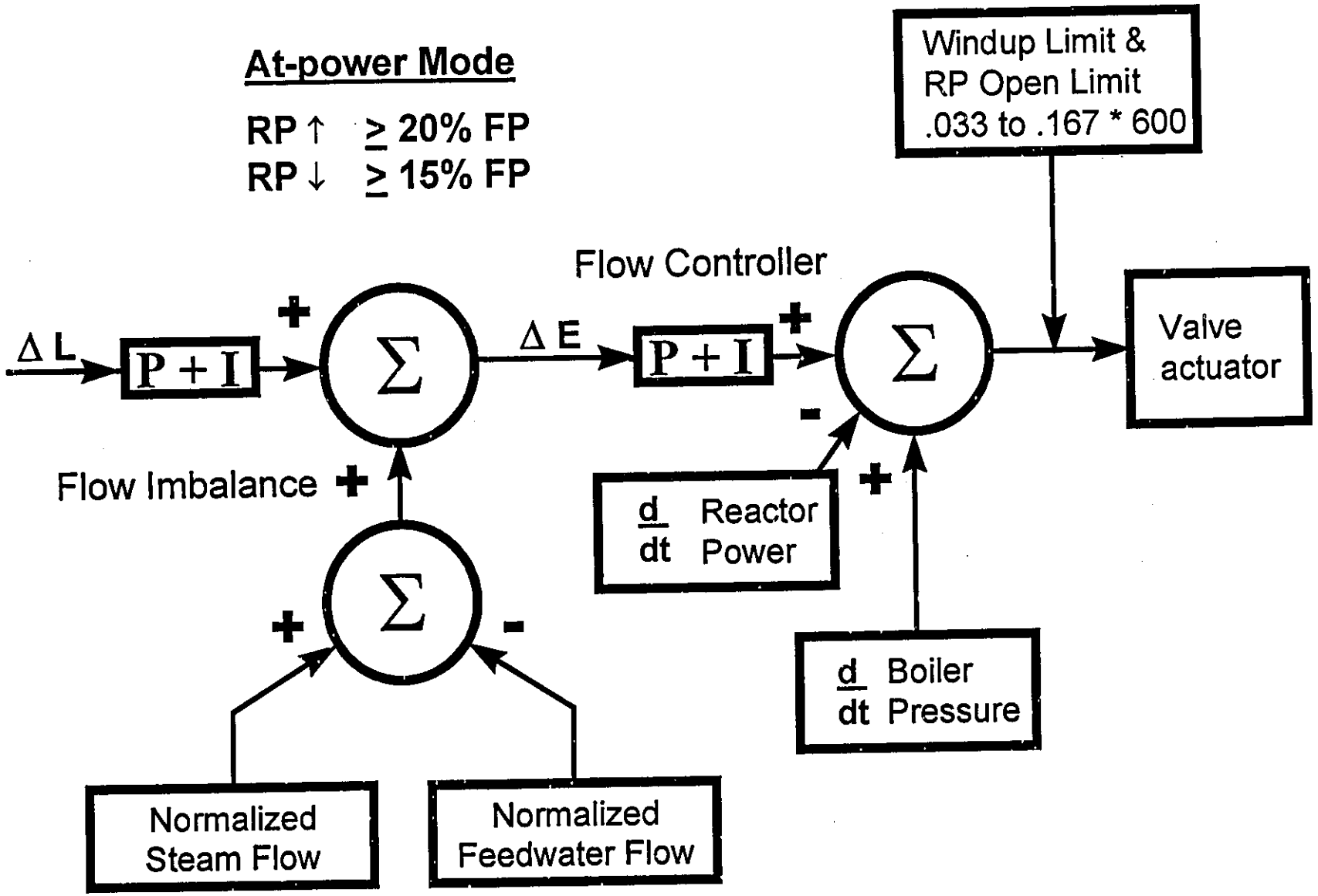
3.5 Reactor Power Measurements

- Ion chambers < 1%FP
- In core Detectors > 1% FP
- If both of above Irrational, BLC assumes 0 %FP
- RRS Calibration factors applied with 20 sec time constant corresponding to RP change to boiler heat input time lag i.e. essentially thermal power
- If RRS not running in the same DCC, use the last good calibration factors

BLC calculates reactor power for 2 uses:

- Mode determination
- Setpoint calculation

4.0 BLC AT-POWER OPERATION



5.0 DCC BLC PROGRAM FAILURES

- BLC fails if the following are <u>not</u> met:
  - at least 1 good level measurement per boiler (N/R or M/R)
  - at least 1 good D/A level measurement
  - All A/I feedback signals within 10% of signal output
  - Executive sees no software problems
- BLC <u>Master</u> fails
  - BLC slave tracks
  - Alarms failure
- BLC <u>Slave</u> fails
  - Alarms failure
  - Reduced redundancy
- Dual BLC Program Failure
  - 100% LCVs fail closed (SV vents air from actuator)
  - Trim LCVs fail to controller's last position
  - all MVs stay in last position

CHAPTER 5: STEAM, TURBINE AND FEEDWATER SYSTEM

MODULE B: SIMULATOR EXERCISES

MODULE OBJECTIVES:

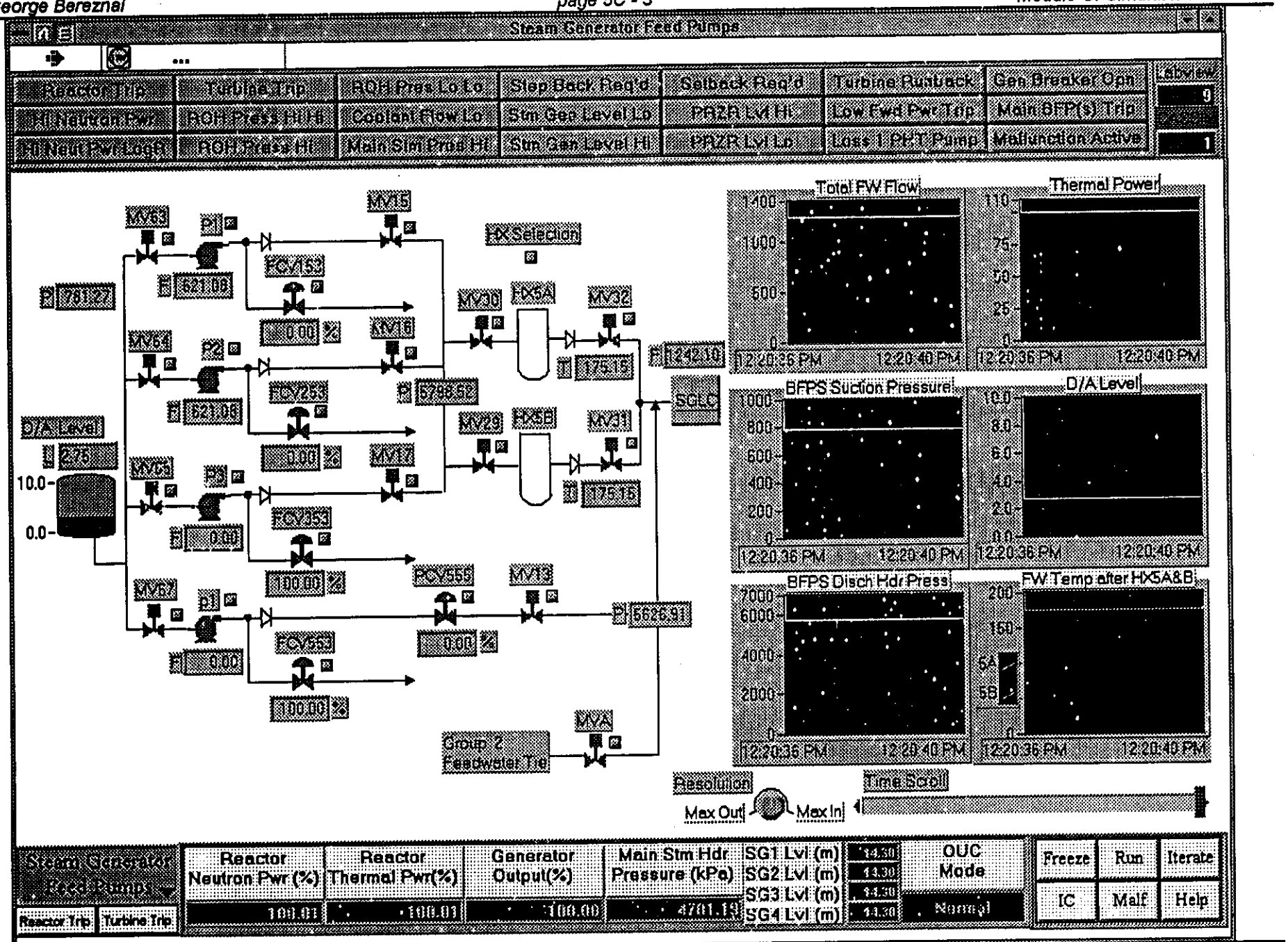
At the end of this module, you will be able to:

1. **Identify the parameters associated with the Bolier Level Control;**
2. **Respond correctly to the following events:**
   - **Fail Closed all Feedwater LCVs & MVs**
   - **Turbine Spurious Trip**
   - **Feedwater LCV101 Fails Open**
   - **Feedwater LCV101 Fails Closed**
   - **All Main BFPs Trip**
   - **Throttle PT Fails Low**

STEAM GENERATOR FEED PUMPS PAGE

Screen shows the portion of the feedwater system that includes the Deaerator, the boiler feed pumps, the high pressure heaters and associated valves, with the output of the HP heaters going to the Steam Generator Level Control Valves. The following parameters are displayed:

- Deaerator Level (m)
- Boiler Feedpump Suction Header Pressure (kPa)
- Boiler Feed Pump inlet valves (MV63 to MV68), outlet valves (MV13 to MV18) and associated popup menus allowing them to be opened or closed
- Main Boiler Feed Pumps (P1 to P4) and Auxiliary Boiler Feed Pumps p1 and p2 with associated popup menus for control selections
- Recirculating flow control valves FCV153, 253, 353, 453, 553, 653; pressure control valves PCV555, 565; and associated popup menus for AUTO/MANUAL selection and controller parameter tuning
- High Pressure Heaters HX5A and HX5B and popup menus to select either or both heaters to be in-service
- HP Heater isolation valves MV29 to MV32 and popup menus for open and close control
- Pressure at inlet and outlet of HP heaters (kPa)
- Flow at inlet header to Steam Generator Level Control Valves (kg/sec)

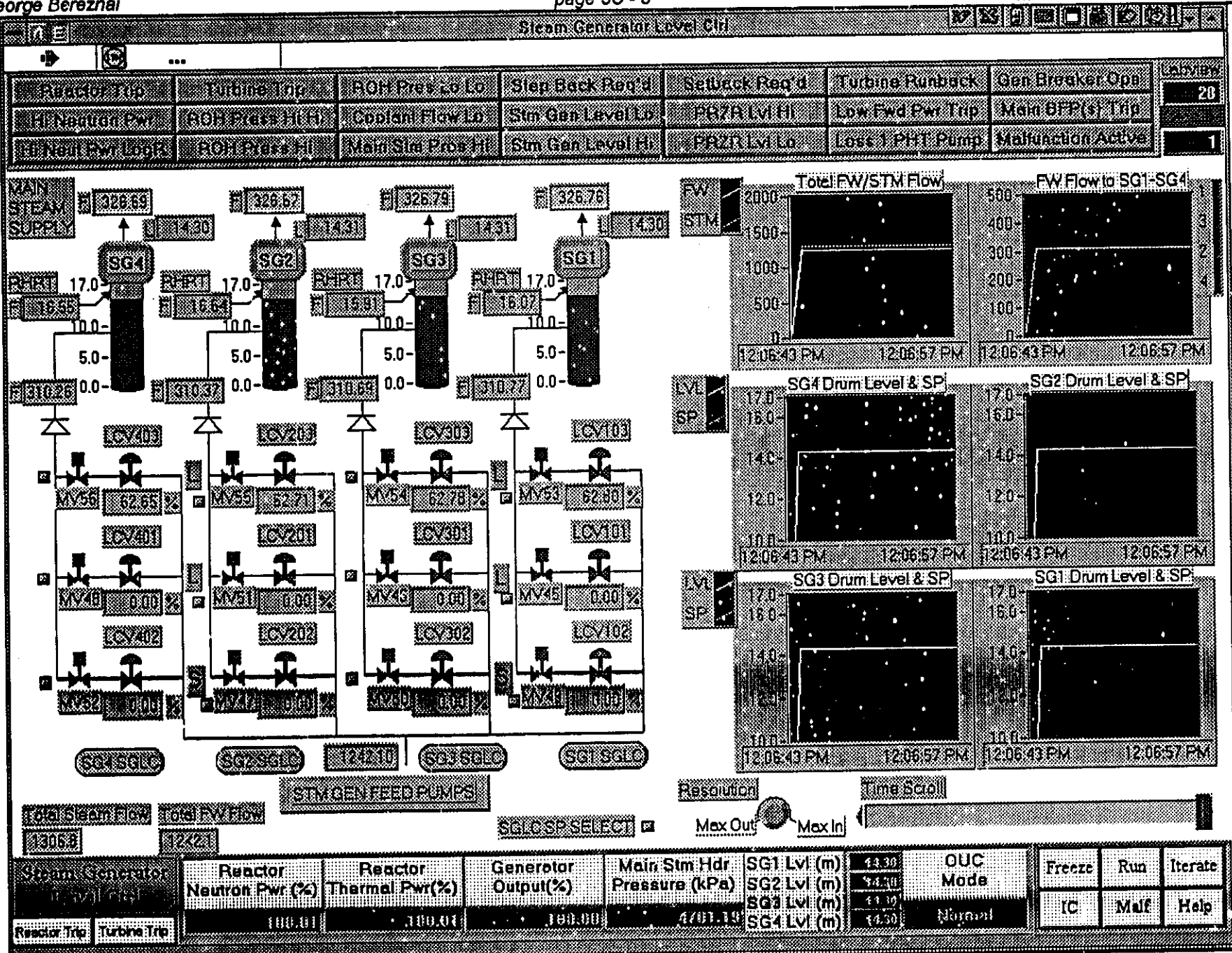

Steam Generator Feed Pumps
Reactor Trip
Turbine Trip
RCH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
RCH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr Log
RCH Press Hi
Main Stm Press Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
Labview
MV63
MV15
HX Selection
FCV153
MV30
HX5A
MV32
MV64
MV16
MV29
HX5B
MV31
MV65
MV17
FCV353
MV67
FCV555
MV13
FCV553
MV4
Group 2 Feedwater Trip
D/A Level
Total FW Flow
Thermal Power
BFPS Suction Pressure
D/A Level
BFPS Disch Hdr Press
FW Temp after HX5A&B
Resolution
Max Out
Max In
Time Scroll
Steam Generator Feed Pumps
Reactor Trip
Turbine Trip
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
Normal
Freeze
Run
Iterate
IC
Malf
Help

STEAM GENERATOR LEVEL CONTROL PAGE

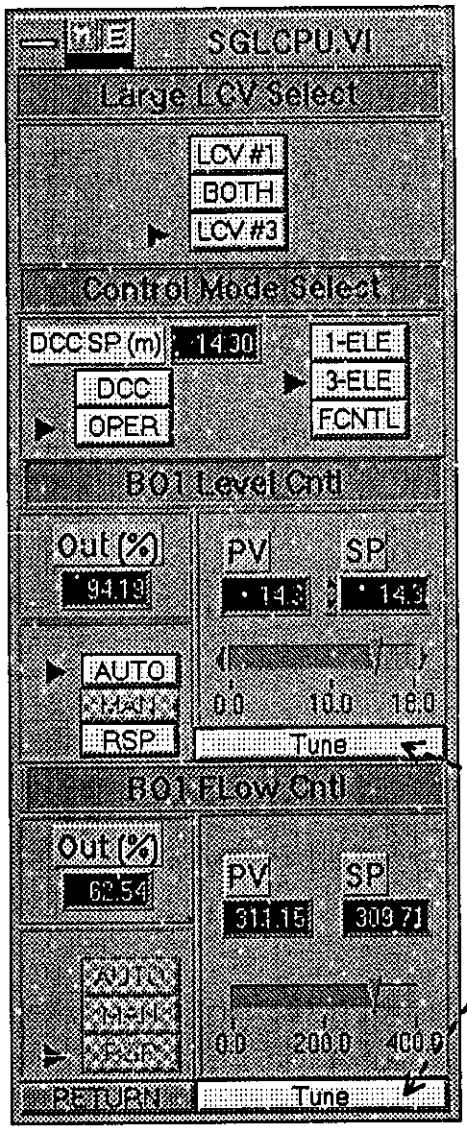
Screen shows each of the four boilers and associated level control valves. The following parameters are described (starting near the top of the screen) for Steam Generator 1, the same applies to SG 2, 3 and 4.

- Steam Generator Flow (kg/sec)
- Steam Generator Level (m)
- Reheater Flow (kg/sec)
- Feedwater Flow (kg/sec)
- Large Level Control Valve (LCV103) Status and Opening (%)
- Large Level Control Isolation Motorized Valve (MV53) Status and AUTO/MANUAL Controller Popup Menu
- Large Level Control Valve (LCV101) Status and Opening (%)
- Large Level Control Isolation Motorized Valve (MV45) Status and AUTO/MANUAL Controller Popup Menu
- Small Level Control Valve (LCV102) Status and Opening (%)
- Small Level Control Isolation Motorized Valve (MV49) Status and AUTO/MANUAL Controller Popup Menu
- Steam Generator 1 Level Control (SG1 SGLC) Popup Menu
- Steam Generator Level Control Setpoint (SGLC SP) Select Popup Menu

Total Steam Flow (kg/sec) and Total feedwater Flow (kg/sec) to all four Boilers is shown at the bottom left hand corner


Steam Generator Level Ctrl
Reactor Trip
Turbine Trip
ROH Press 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 Log R
ROH Press Hi
Main Stm Press Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
Annunc
20
1
MAIN STEAM SUPPLY
SG4
SG2
SG3
SG1
RHRT
17.0
10.0
5.0
0.0
LCV403
LCV203
LCV303
LCV103
LCV401
LCV201
LCV301
LCV101
LCV402
LCV202
LCV302
LCV102
SG4 SGLC
SG2 SGLC
SG3 SGLC
SG1 SGLC
STM GEN FEED PUMPS
Total Steam Flow
Total FW Flow
SGLC SP SELECT
Max Out
Max In
Resolution
Time Scroll
Total FW/STM Flow
FW Flow to SG1-SG4
SG4 Drum Level & SP
SG2 Drum Level & SP
SG3 Drum Level & SP
SG1 Drum Level & SP
12:06:43 PM
12:06:57 PM
Steam Generator
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
Normal
Freeze
Run
Iterate
IC
Malf
Help
Reactor Trip
Turbine Trip

Steam Generator Level Controller Popup Menu with OPERator Control Mode Selected



Operator can select 1 Element, 3 Element or Flow Control; DCC setpoint is displayed for reference only

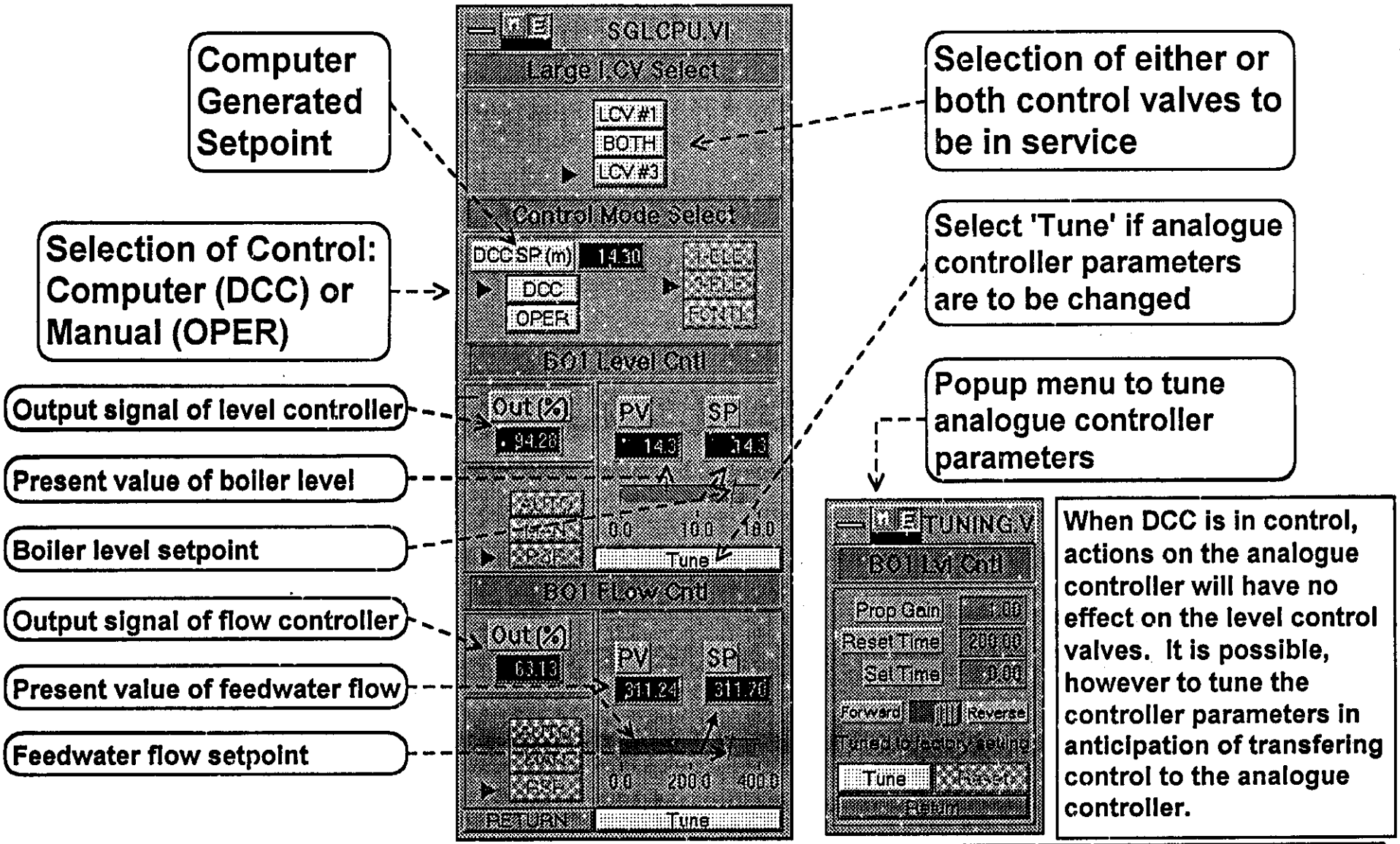
Under 3 Element Control the Output of the level controller is an input to the flow controller's setpoint

Operator can manually select the value of the level control setpoint

The Output signal of the flow controller determines the opening of the flow control valve

Tuning the parameters of the level and/or flow controller will alter the response of the boiler level control system

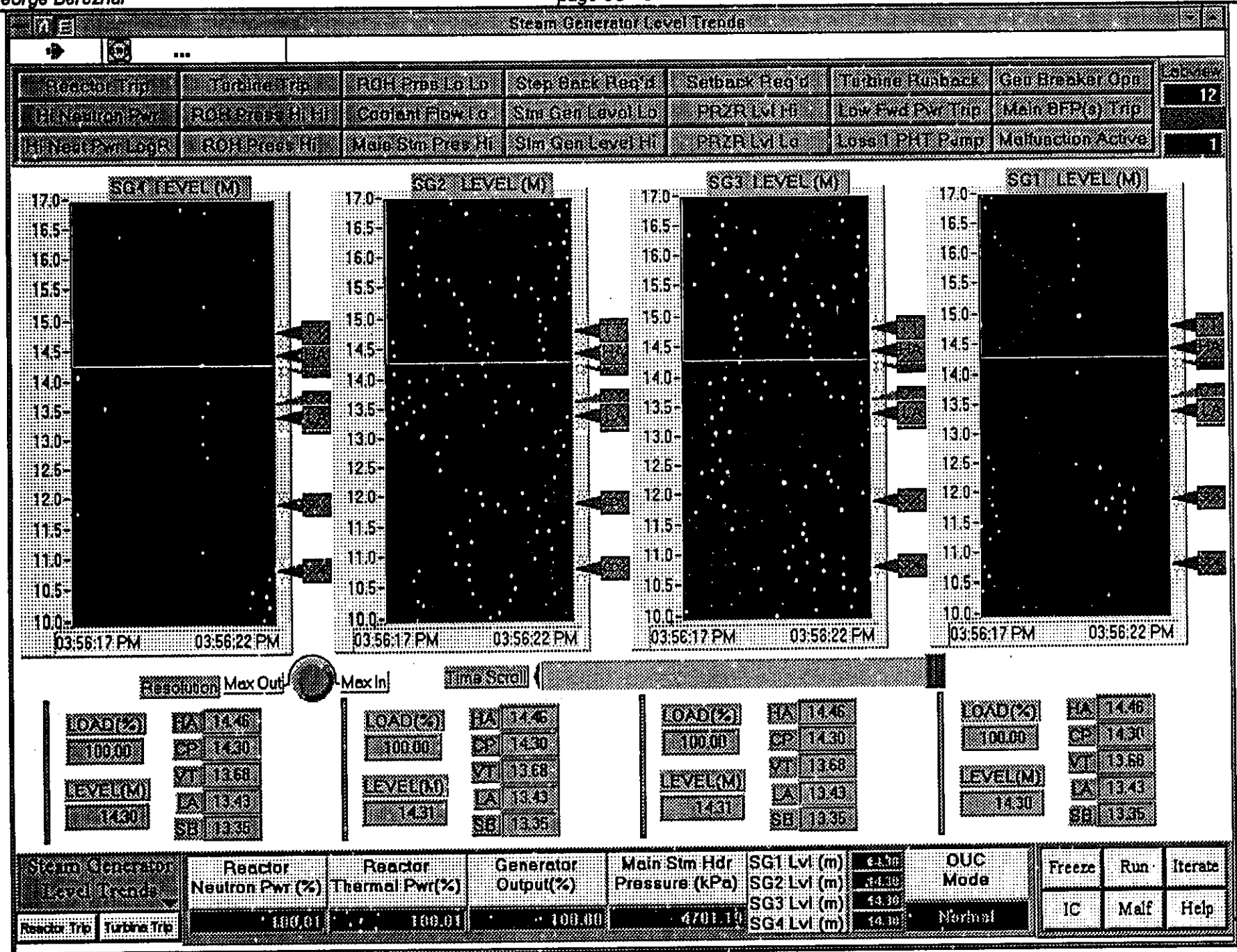
Steam Generator Level Control 'SG1 SGLC' Popup Menu



STEAM GENERATOR LEVEL TRENDS PAGE

Screen shows the steam generator level displays, including the actual level, the alarm, control and trip points. These points are identified as follows:

- **TT - Turbine Trip**
- **HA - High steam generator level Alarm**
- **CP - Control (or set) Point**
- **VT - Valve Transfer Point**
- **LA - Low Steam generator level Alarm**
- **SB - SetBack reactor**
- **SDS1 - ShutDown System 1 trip**
- **SDS2 - ShutDown System 2 trip**


Steam Generator Level Trends
Reactor Trip
Turbine Trip
RCH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Opn
Hi Neutron Pwr
RCH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Main BFP(s) Trip
Hi Neut Pwr Log R
RCH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
Latched
12
1
SG4 LEVEL (M)
SG2 LEVEL (M)
SG3 LEVEL (M)
SG1 LEVEL (M)
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
03:56:17 PM
03:56:22 PM
Resolution
Max Out
Max In
Time Scroll
LOAD(%)
100.00
LEVEL(M)
14.30
14.31
HA 14.46
CP 14.30
VT 13.68
LA 13.43
SB 13.35
Steam Generator Level Trends
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)
14.30
14.31
14.30
14.30
OUC Mode
Normal
Freeze
Run
Iterate
IC
Malf
Help

STEAM GENERATOR LEVEL MANUAL CONTROL

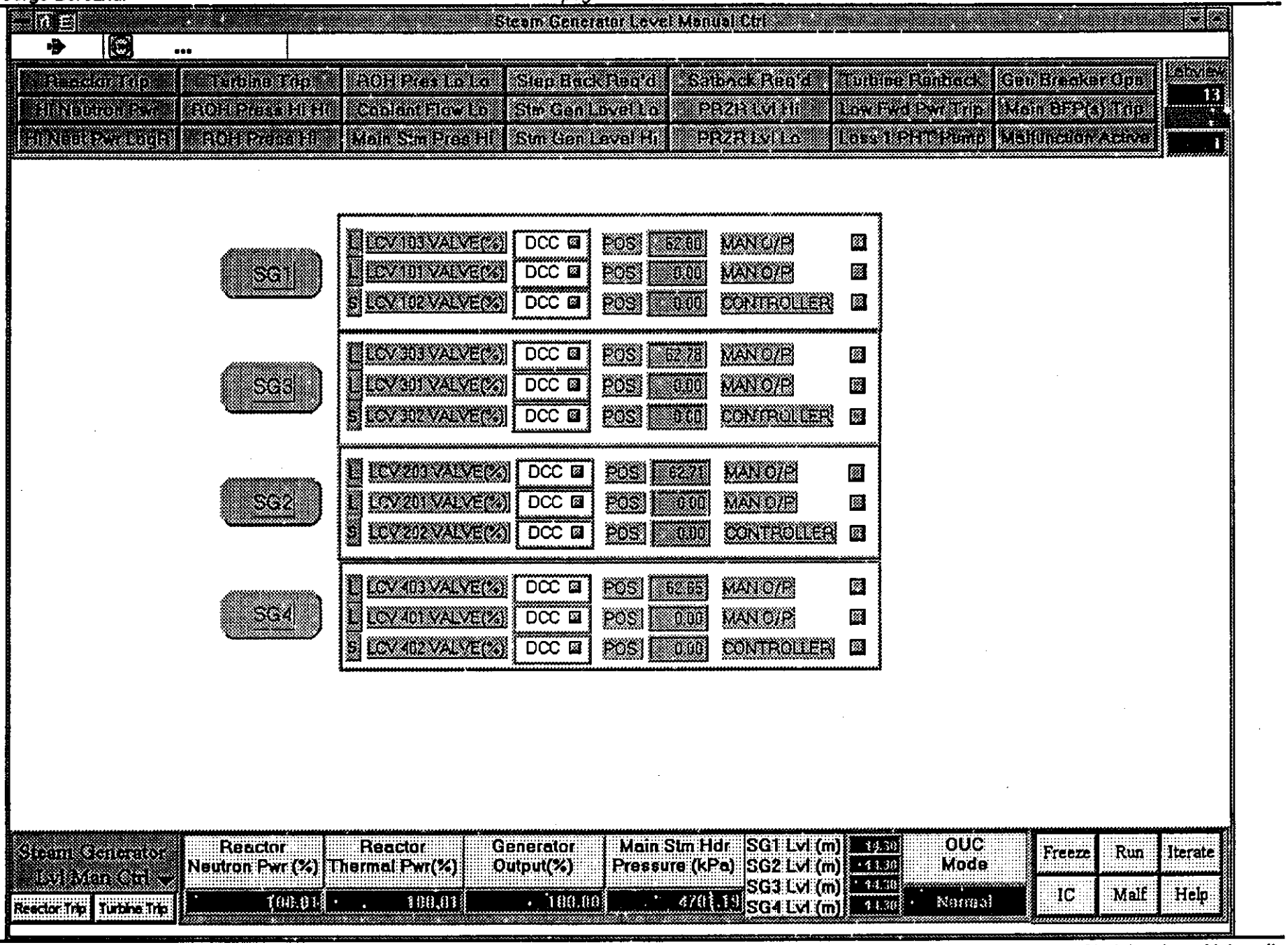
This screen allows the manual control of the level in each of the four steam generators. Since the actions are the same for any one steam generator, SG1 is the only one described here.

Under normal operating conditions all level control valves are under DCC Control. At full power normally one large valve (LCV103 for SG1 at the 100%FP Initial Condition) is in control, the other large valve and the small valve are closed.

While under DCC control the MAN O/P (Manual Output) station tracks the DCC signal.

Transferring control from DCC to MANUAL allows direct control of the valve's position by the operator.

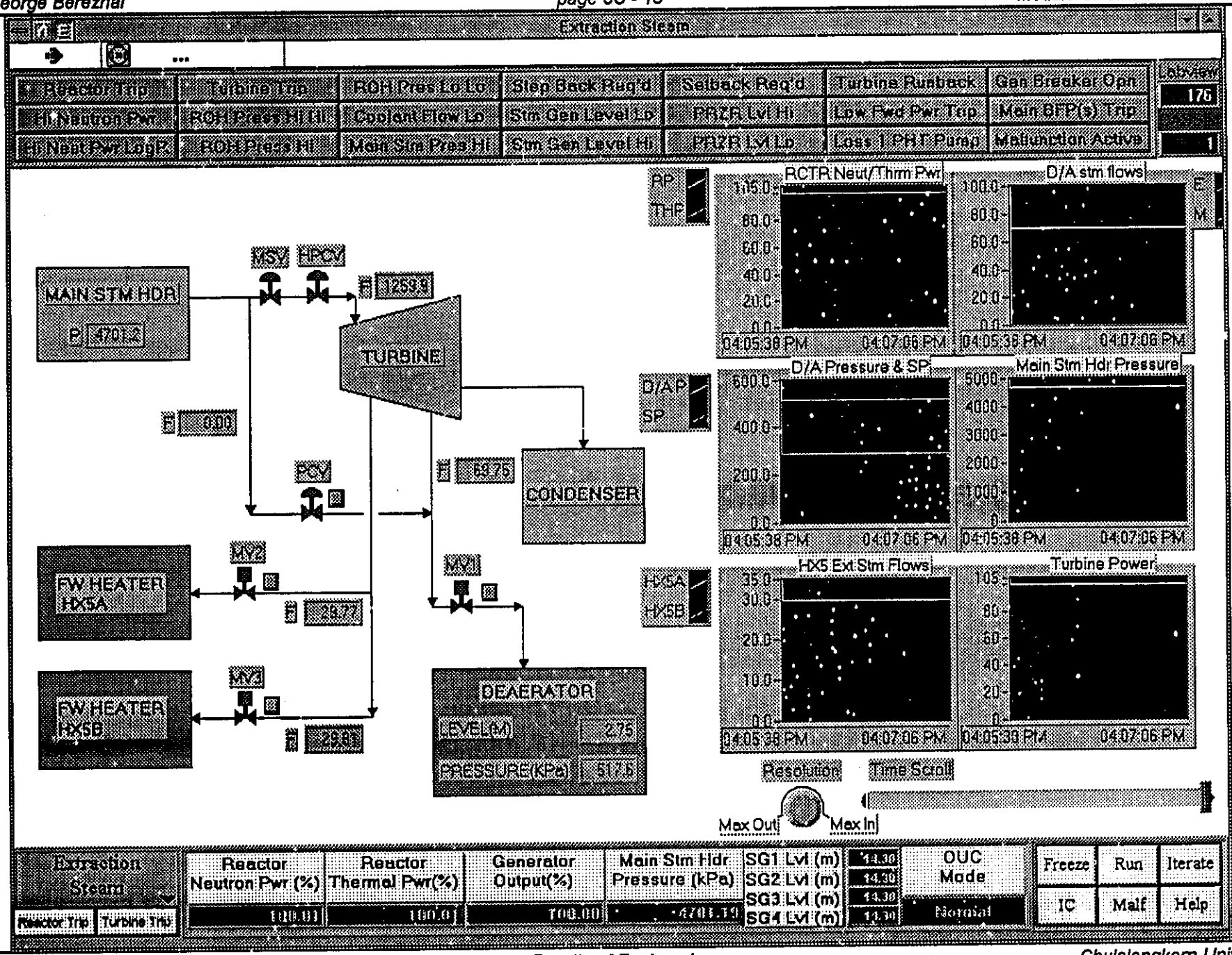
For the small valves, transfer from DCC to AUTO allows for tuning of the controller, and valve control to be transferred from the DCC to either AUTO or MANUAL control.


Steam Generator Level Manual Ctrl
Reactor Trip
Turbine Trip
ROH Pres Lo Lo
Step Back Req'd
Setback Req'd
Turbine Runback
Gen Breaker Ops
Hi Neutron Pwr
ROH Press Hi Hi
Coolant Flow Lo
Stm Gen Level Lo
PRZR Lvl Hi
Low Fwd Pwr Trip
Hi Neut Pwr Log Hi
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
SG1
SG3
SG2
SG4
LCV 103 VALVE(%)
LCV 101 VALVE(%)
LCV 102 VALVE(%)
LCV 303 VALVE(%)
LCV 301 VALVE(%)
LCV 302 VALVE(%)
LCV 203 VALVE(%)
LCV 201 VALVE(%)
LCV 202 VALVE(%)
LCV 403 VALVE(%)
LCV 401 VALVE(%)
LCV 402 VALVE(%)
DCC
POS
62.80
0.00
MAN O/P
CONTROLLER
62.78
62.71
62.85
Steam Generator Lvl Man Ctrl
Reactor Trip
Turbine Trip
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
Normal
Freeze
Run
Iterate
IC
Malf
Help

EXTRACTION STEAM PAGE

Screen shows the extraction steam flows from the Main Steam system to the Deaerator and the High Pressure Heaters in addition to the steam flow to the Turbine. The following parameters are displayed:

- **Main Steam Header Pressure (MPa)**
- **Steam Flow to the Turbine (kg/sec)**
- **Steam flow to the Deaerator from the Main Steam Header (kg/sec)**
- **Extraction Steam flow to the Deaerator (kg/sec)**
- **Extraction Steam flow to the High Pressure Heaters (kg/sec)**
- **Deaerator Level (m)**
- **Deaerator Pressure (kPa)**
- **Valve Status for MSV (Motorized or Emergency Stop Valve) and HPCV (High Pressure Turbine Control or Governor Valve)**
- **Valve status and popup menus to provide for manual control of motorized valves MV1, 2 and 3**
- **Valve status and popup menu for AUTO/MANUAL selection and controller parameter tuning**


Extraction Steam
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 Log/K
ROH Press Hi
Main Stm Pres Hi
Stm Gen Level Hi
PRZR Lvl Lo
Loss 1 PHT Pump
Malfunction Active
Labview
176
1
RP
THP
RCTR Neut/Thrm Pwr
D/A stm flows
MSV
HPCV
MAIN STM HDR
P 4701.2
TURBINE
F 1253.9
F 0.00
F 69.75
CONDENSER
PCV
MV2
FW HEATER HX5A
F 29.77
MV1
MV3
FW HEATER HX6B
F 29.81
DEAERATOR
LEVEL(M) 2.75
PRESSURE(KPa) 517.5
D/A P
SP
D/A Pressure & SP
Main Stm Hdr Pressure
HX5A
HX6B
HX5 Ext Stm Flows
Turbine Power
04:05:38 PM
04:07:06 PM
Resolution
Time Scroll
Max Out
Max In
Extraction Steam
Reactor Trip
Turbine Trip
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
Normal
Freeze
Run
Iterate
IC
Malf
Help

SIMULATOR EXERCISE 5.1

1. From a Simulator Initial state of 100% full power, insert malfunction "FW LCV101 FAILS OPEN"

   Observe unit response on "Steam Generator Level Control" and "Steam Generator Level Trend" displays.

   - What are the main system responses?
   - What would the Operator need to do to maintain power production?

2. Repeat the above but view only the "Plant Overview" page until the alarm "Stm Gen Level Hi" is received.

   - Take the appropriate Operator actions to maintain power production.

SIMULATOR EXERCISE 5.2

1. From 100 %FP Initialization state:
   a. change 'Control Mode Select' to OPERator and select 3-ELEment control for SG1 and SG3;
   b. for SG1 change selection of LCV from #3 to #1;
   c. after feedwater and boiler level transients are over, insert malfunction 'FW LCV101 fails closed';
   d. observe the responses of feedwater flow, steam flow and pressure, and boiler level on all four steam generators.

2. From 100 %FP Initialization state:
   a. change 'Control Mode Select' to OPERator and select 1-ELEment control for SG1 and SG3;
   b. for SG1 change selection of LCV from #3 to #1;
   c. after feedwater and boiler level transients are over, insert malfunction 'FW LCV101 fails open';
   d. observe the responses of feedwater flow, steam flow and pressure, and boiler level on all four steam generators.

3. Explain the main differences in response between 1 and 2.

SIMULATOR EXERCISE 5.3

1. From 100 %FP Initialization state:

   a. insert malfunction "Steam Generator #1 FW FT irrational"

   b. observe the responses of feedwater flow, steam flow and pressure, and boiler level on all four steam generators;

   c. what would be the correct operator action?

2. From 100 %FP Initialization state:

   a. insert malfunction "Steam Generator #1 FW FT irrational"

   b. observe the responses of feedwater flow, steam flow and pressure, and boiler level on all four steam generators;

   c. perform the correct operator action;

   d. describe the system's response.

SIMULATOR EXERCISE 6.1

From a Simulator Initial state of 100% full power, insert malfunction "TURBINE SPURIOUS TRIP"

- What is reactor power when turbine speed settles at 5 rpm?
- Remove malfunction, reset turbine trip, select 'TRU ENABLE', synchronize the generator and load to about 10 %FP;
- Select NORMAL OUC mode and raise unit output to 60%

SIMULATOR EXERCISE 6.2

1. From 100 %FP Initialization state:

   a. Manually Trip the Reactor

   b. Confirm Reactor Trip (neutron power decreasing rapidly, all shutdown rods in the core).

2. Once Neutron Power is below 0.01 %FP and Turbine speed is at 5 RPM, begin power recovery operation:

   a. reset Reactor Trip;

   b. raise Reactor Power to 10 %FP;

   c. reset Turbine Trip, select 'TRU ENABLE', synchronize the generator and load to about 10 %FP;

3. In ALTERNATE mode raise Reactor Power and Generator Power to a level determined by the number of Adjuster Rod banks not fully in the core:

   100% - (5 x number of rod banks not fully in core)%

   Record the reactor (%FP) and generator power level (%FP and MW) reached when power recovery has been completed.

   Ensure that for the allowed reactor power the generator is producing the maximum power.