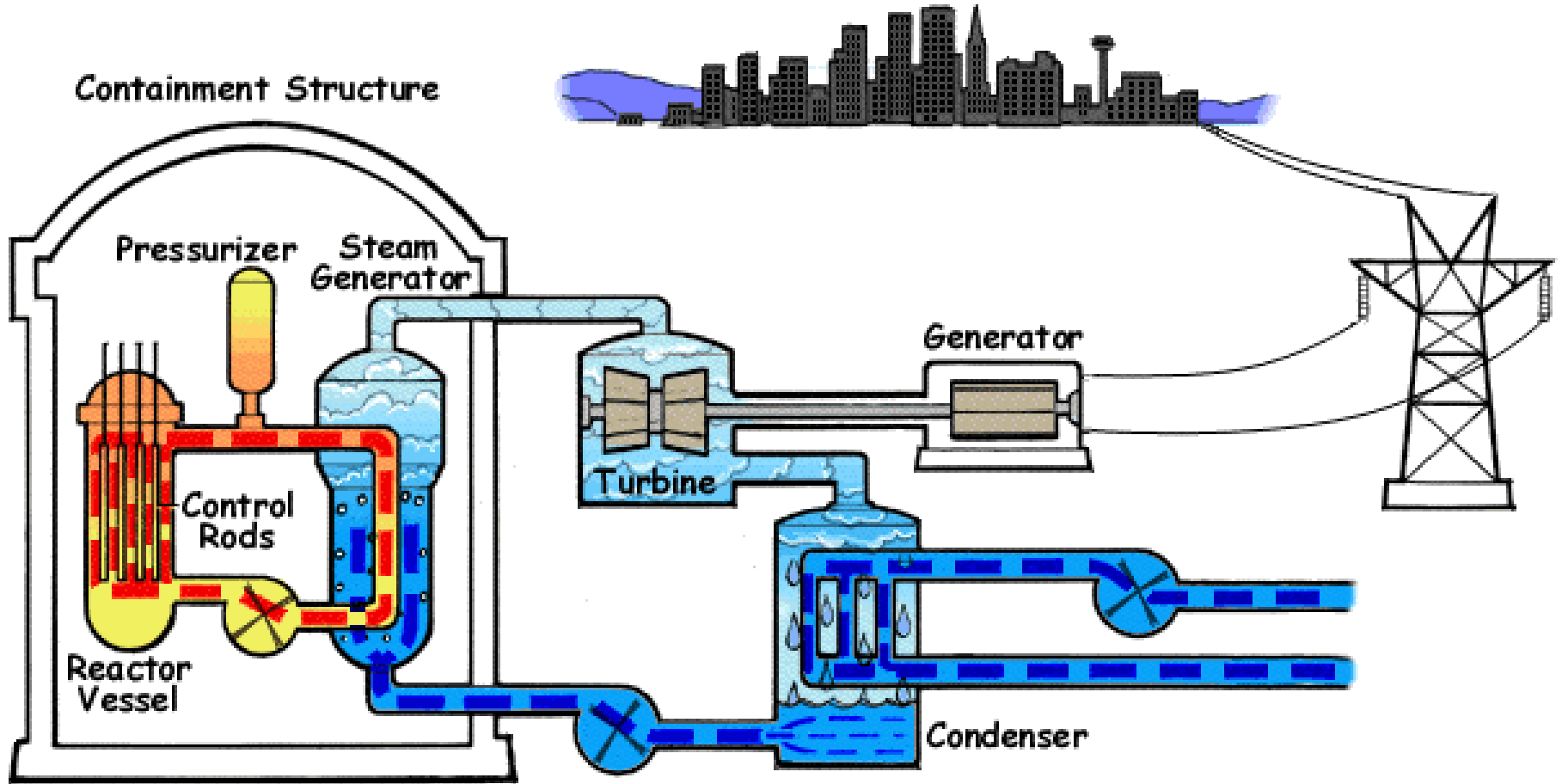


Simulation of Reactor Operation Exercise Using IAEA Advanced PWR-Simulator

Deswandri
PRTRN – OR TN
BRIN

Pressurized Water Reactor



<https://www.nrc.gov/reading-rm/basic-ref/students/animated-pwr.html>

IAEA Advanced PWR Simulator

IAEA Generic Pressurized Water Reactor Simulator



Click anywhere to continue
with the selected IC...

Select an IC to load:

Full Power

68% FP

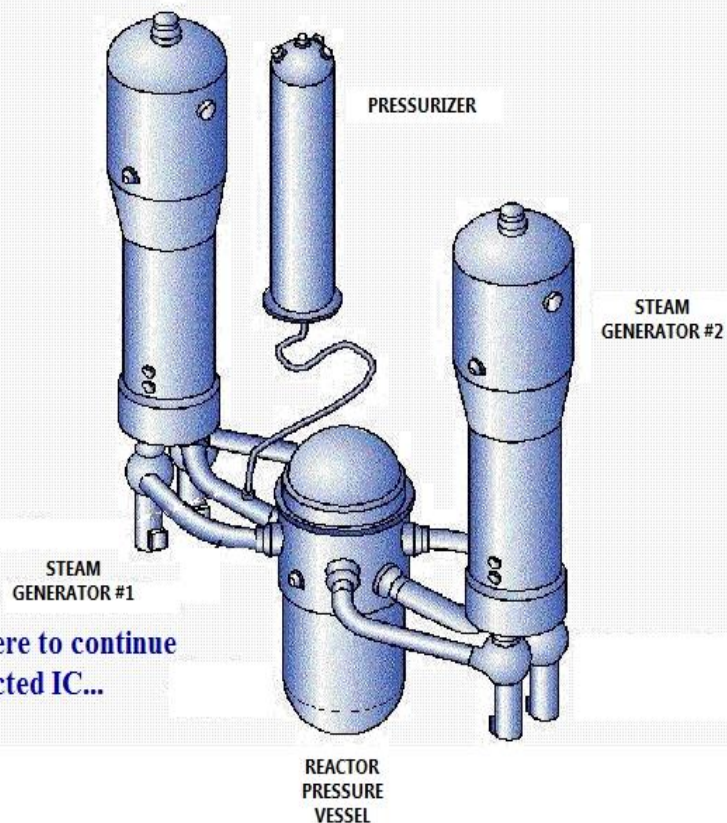
10% FP

Zero Power Hot - No Scram

Zero Power Hot - After Scram

Other...

IC Filename: FP_100.IC



Developed by

Cassiopeia Technologies Inc.

About PWR Simulator

600 MW(e) Passive PWR Simulator



Simulator
Display
Screens

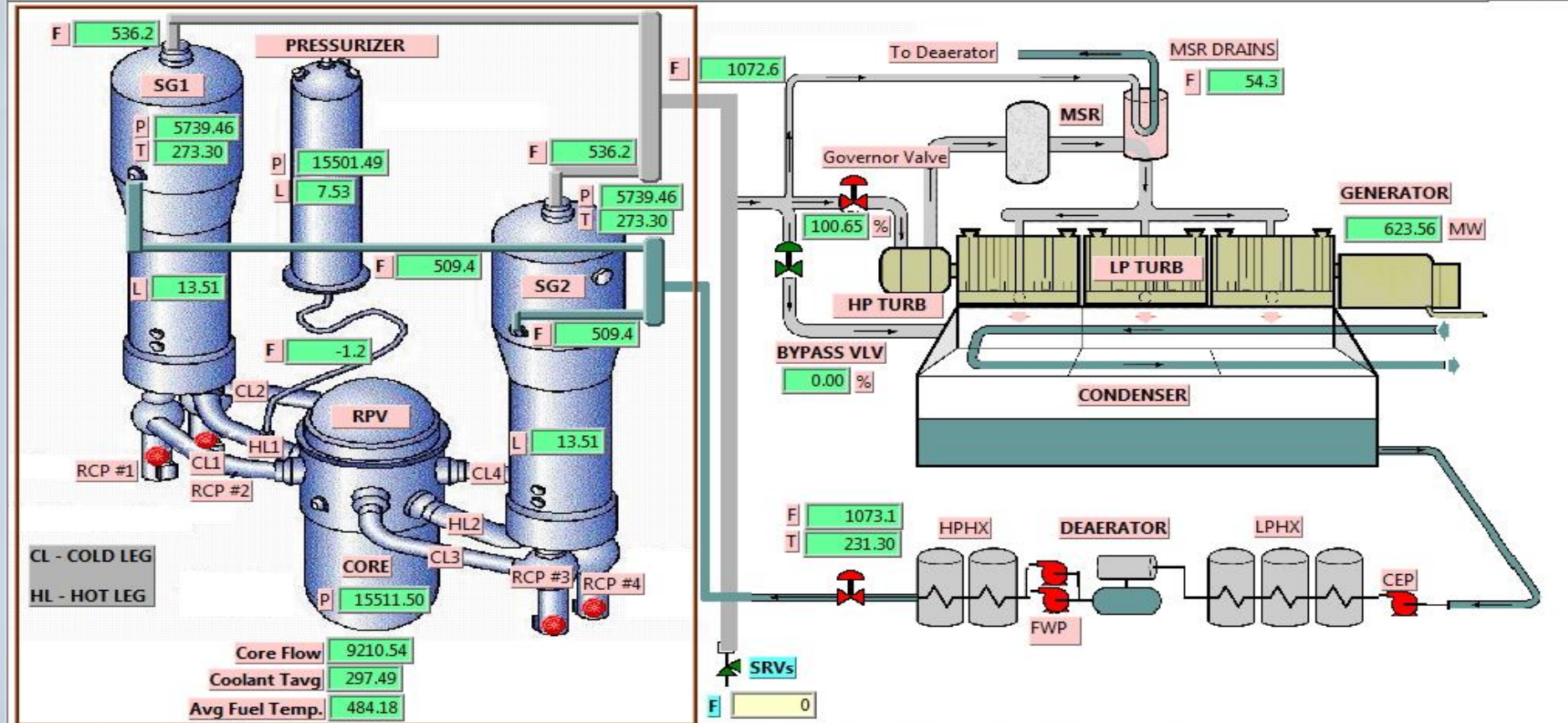
- I. Plant overview
- II. Control loops
- III. Control/shutdown rods & reactivity
- IV. Reactor power control
- V. Trip parameters
- VI. Reactor coolant system
- VII. Coolant inventory & pressurizer
- VIII. Coolant inventory control
- IX. Coolant pressure control
- X. Turbine generator
- XI. Feedwater & extraction steam
- XII. MW demand SP & SGPC
- XIII. Passive core cooling
- XIV. Trends

Plant Overview Screen

PWR Plant Overview



Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	307
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							1694



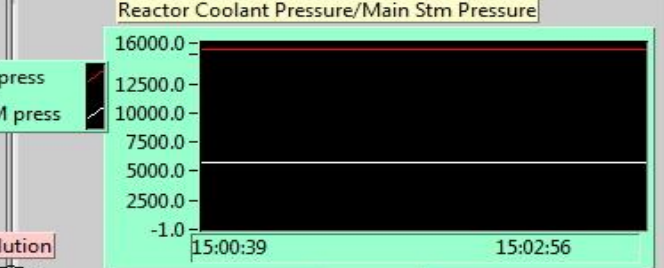
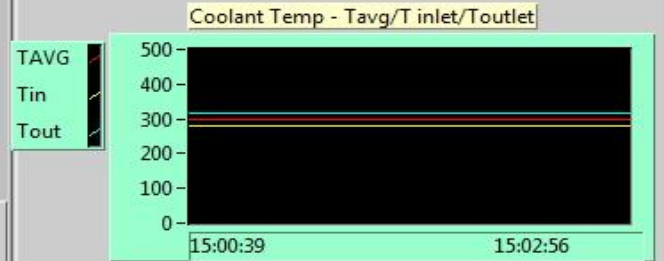
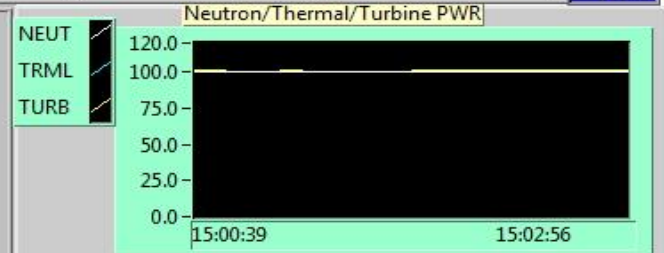
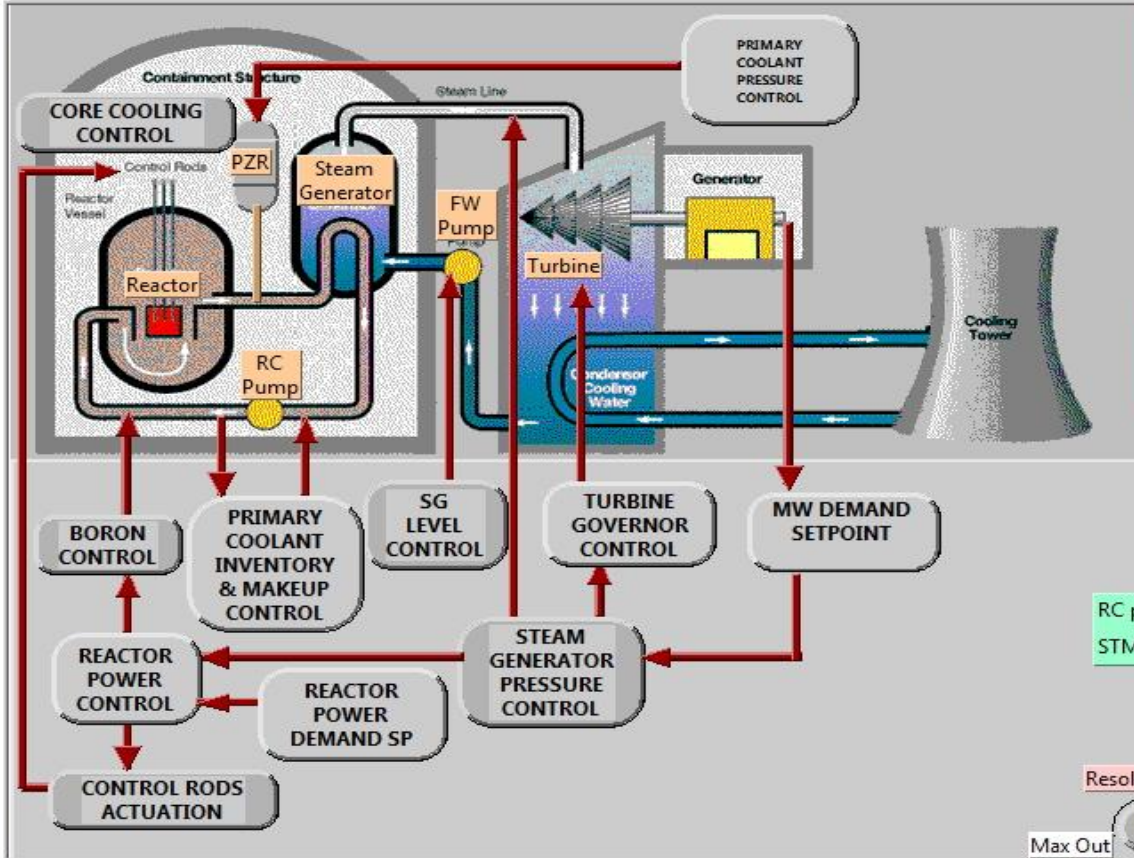
PWR Plant Overview		Reactor Neutron Pwr (%)	Reactor Thermal Pwr (%)	Generator Output (%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp	Freeze	Run	Iterate
Reactor Trip	Turbine Trip	100.03	100.36	100.74	15511.50	9210.54	5739.5	1018.8	484.2	IC	Malf	Help

PWR Control Loops Screen

PWR Control Loops



Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	10
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							2697



Resolution Max Out Max In

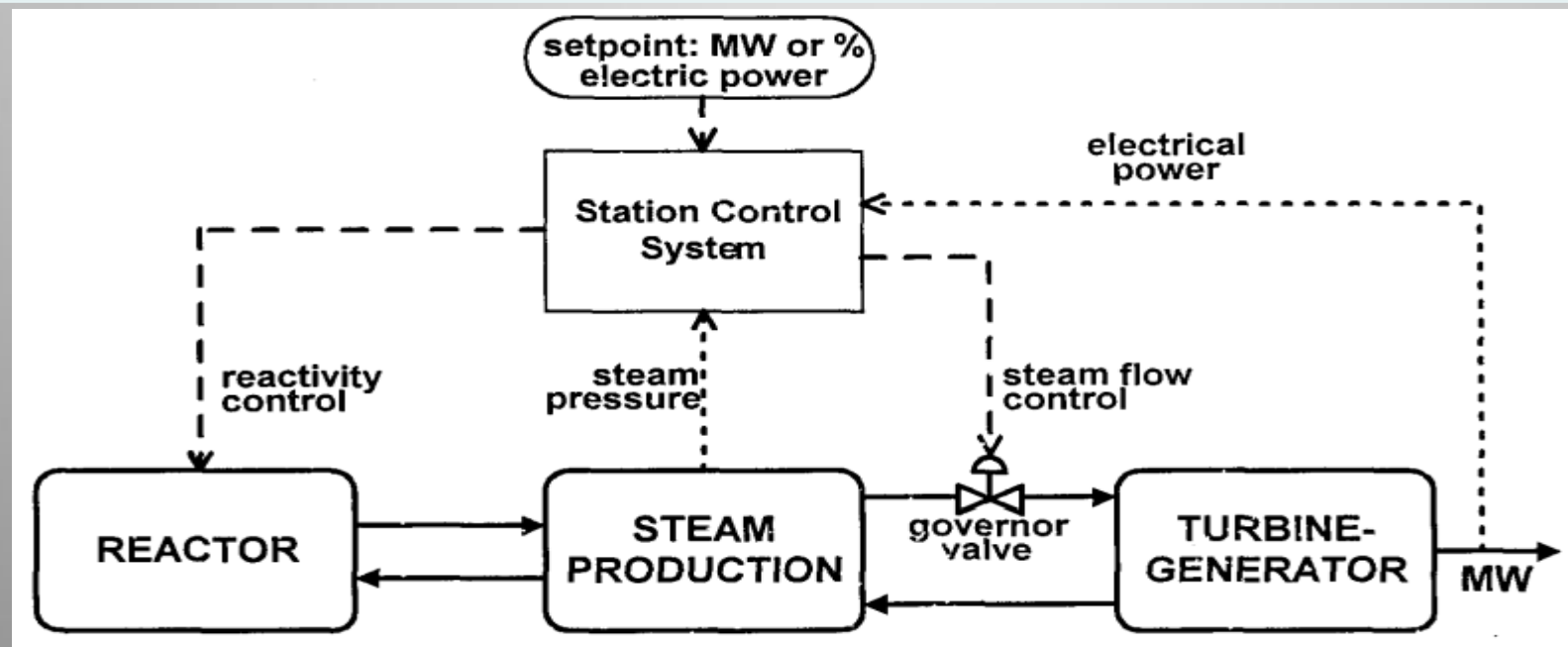
Time Scroll

PWR Control Loops		Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp	Freeze	Run	Iterate	
Reactor Trip	Turbine Trip	100.02	100.36	101.04	15515.02	9208.77	5740.2	1076.3	1020.0	484.2	IC	Malf	Help

PWR Control Modes

Turbine Leading

- Setpoint diatur berdasarkan permintaan daya keluaran generator (megawatt).
- Jika terdapat perbedaan antara setpoint dengan tingkat daya aktual, sistem kontrol melakukan koreksi dengan mengubah bukaan katup pengatur dan dengan demikian mengubah jumlah aliran uap yang menuju turbin.
- Sistem kontrol menyesuaikan daya reaktor dengan mengubah posisi perangkat kontrol reaktivitas untuk menjaga tekanan generator uap pada setpointnya.



Source: Dr. George Bereznai; www.nuceng.ca/canteachmirror/library/20044402.pdf

PWR Control Modes

Reactor Leading

- Setpoint diatur berdasarkan permintaan daya keluaran reaktor.
- Jika terdapat perbedaan antara setpoint dengan tingkat daya reaktor aktual, sistem kontrol melakukan koreksi dengan mengubah posisi perangkat kontrol reaktivitas dan dengan demikian mengubah fluks neutron reaktor.
- Sistem kontrol tekanan generator uap menyesuaikan aliran uap dan dengan demikian mengubah daya turbin dengan mengatur posisi katup pengatur untuk menjaga tekanan generator uap pada setpointnya.

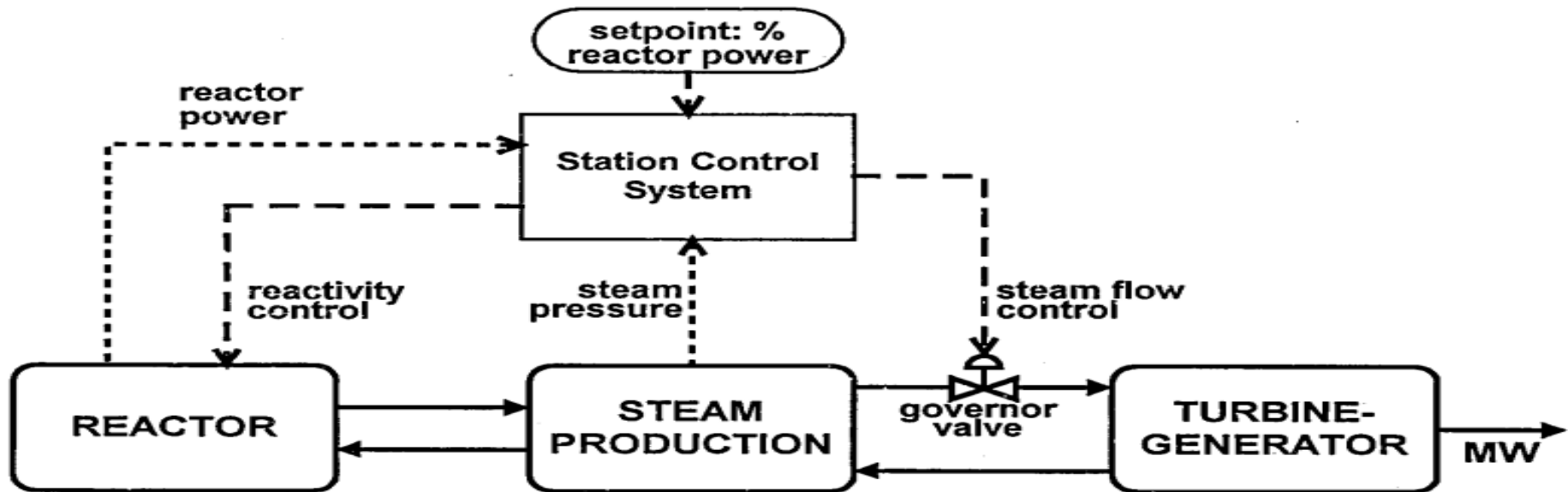


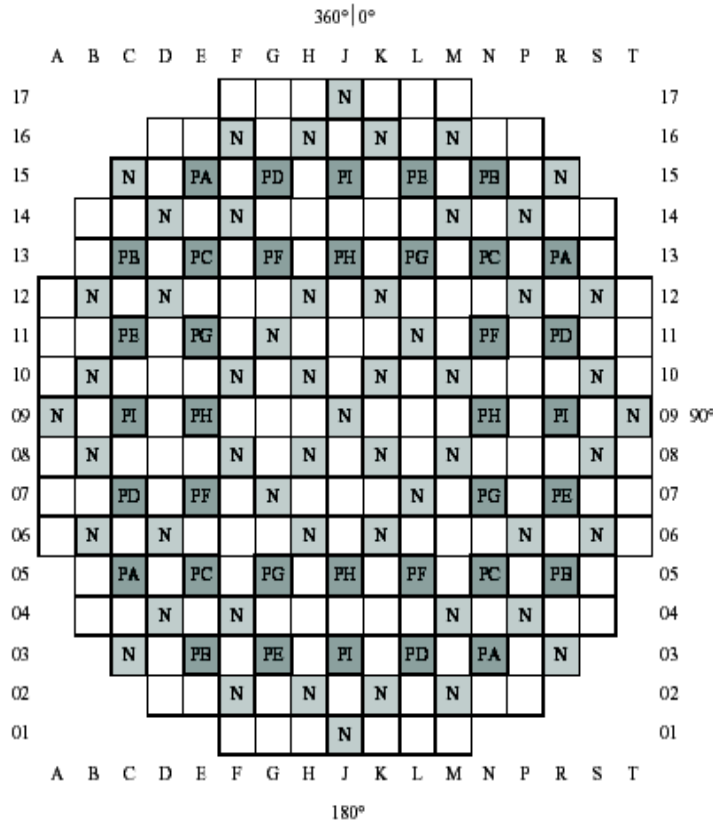
Figure 5: Simplified reactor-leads-turbine overall unit control system

Source: Dr. George Bereznai; www.nuceng.ca/canteachmirror/library/20044402.pdf

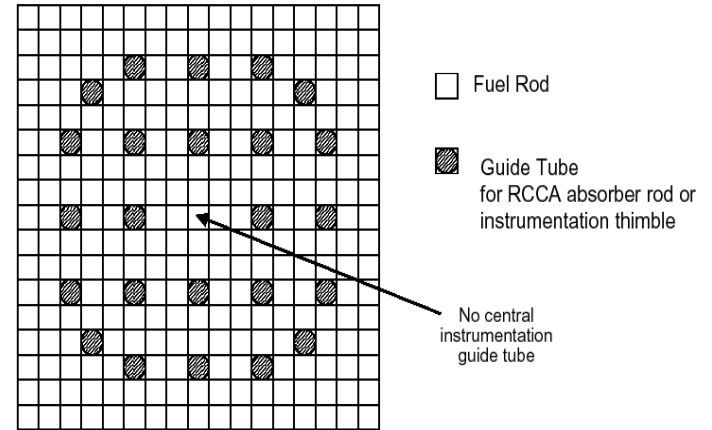
PWR Control Means

RCCA Pattern

- 89 RCCA for maximizing the shutdown margin
- 53 for shutdown (N)
- 36 for control
 - 9 banks of 4 rods symmetrically located 270° (PA to PI)
 - The 4 rods move at the same time with the same signal
- Assignment of bank to control groups can be changed during the fuel cycle



17x17 ASSEMBLY



Rod Cluster Control Assembly (RCCA):

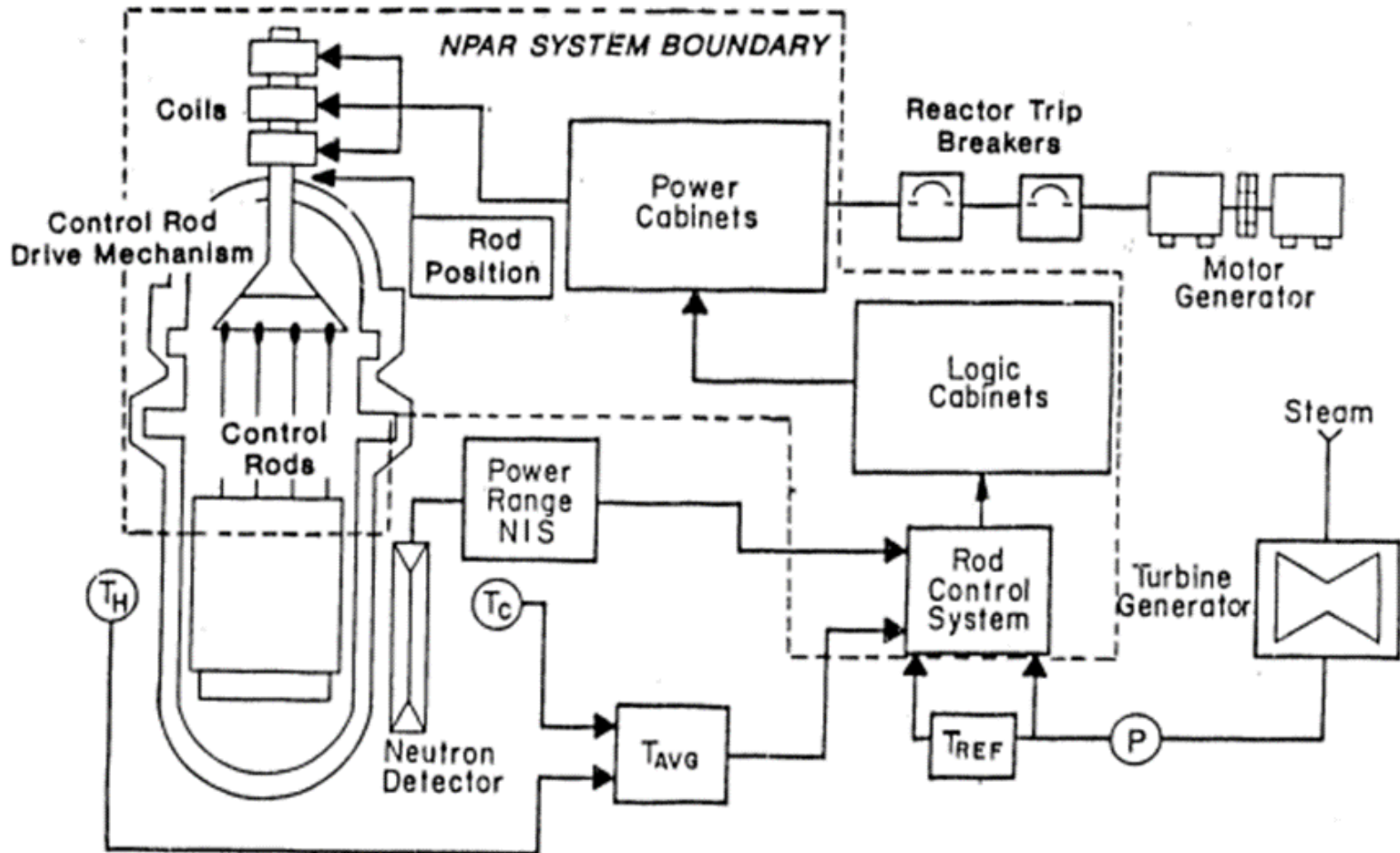
- Shutdown rod bank
- Heavy-worth control rods bank (dark rod)
- Light-worth control rods bank (gray rod)

Soluble neutron absorber (boric acid)

Source: Dr. Larry Foulke; Lecture Material on the IAEA Workshop on Nuclear Power Plants Simulator, Politecnico di Milano, Milan, Italy, 2011

CONTROL ROD DRIVE SYSTEM

Westinghouse PWRs



(Source: Gunther and Sullivan, DETECTION AND MITIGATING ROD DRIVE CONTROL SYSTEM DEGRADATION IN WESTINGHOUSE PWRs, BNL-NUREG-45316, Dec. 1991)

Control Rods & Reactivity Screen

PWR Control Rods and SD Rods

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	224
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							4153

SHUTDOWN RODS STATUS

BORON CTRL

MODE AUTO

LOAD 213.21 ppm

MAN CTRL

REACTOR SCRAM

NO

BANK 1

0.0

50.0

100.0

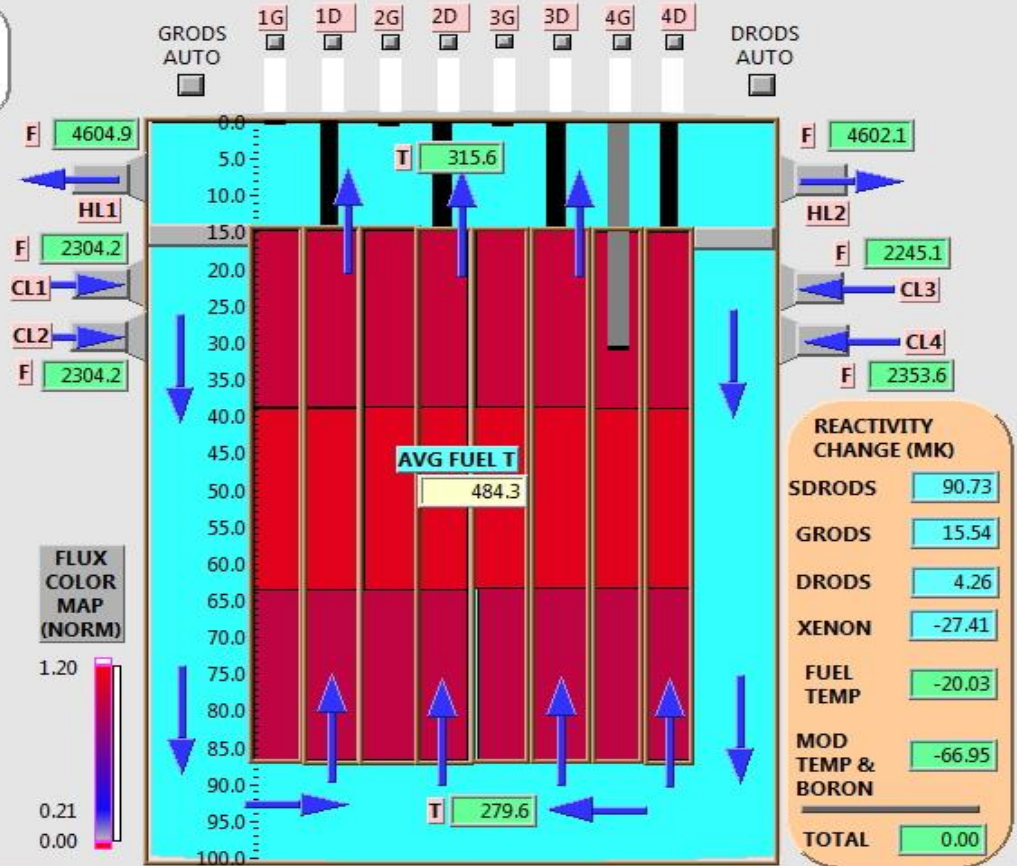
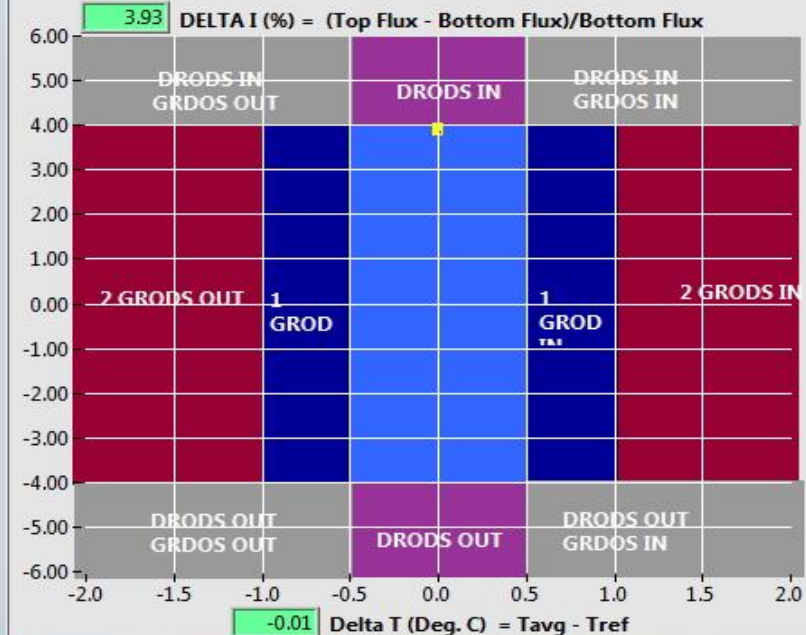
BANK 2

0.0

50.0

100.0

SD RODS RESET



Control/SD Rods & Reactivity	Reactor Neutron Pwr (%)	Reactor Thermal Pwr (%)	Generator Output (%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	5740.6	Freeze	Run	Iterate
	FW Flow	100.02	100.36	100.98	15512.67	9206.98	1075.3	IC	Malf	Help
Reactor Trip	Turbine Trip					Fuel Temp	484.3			

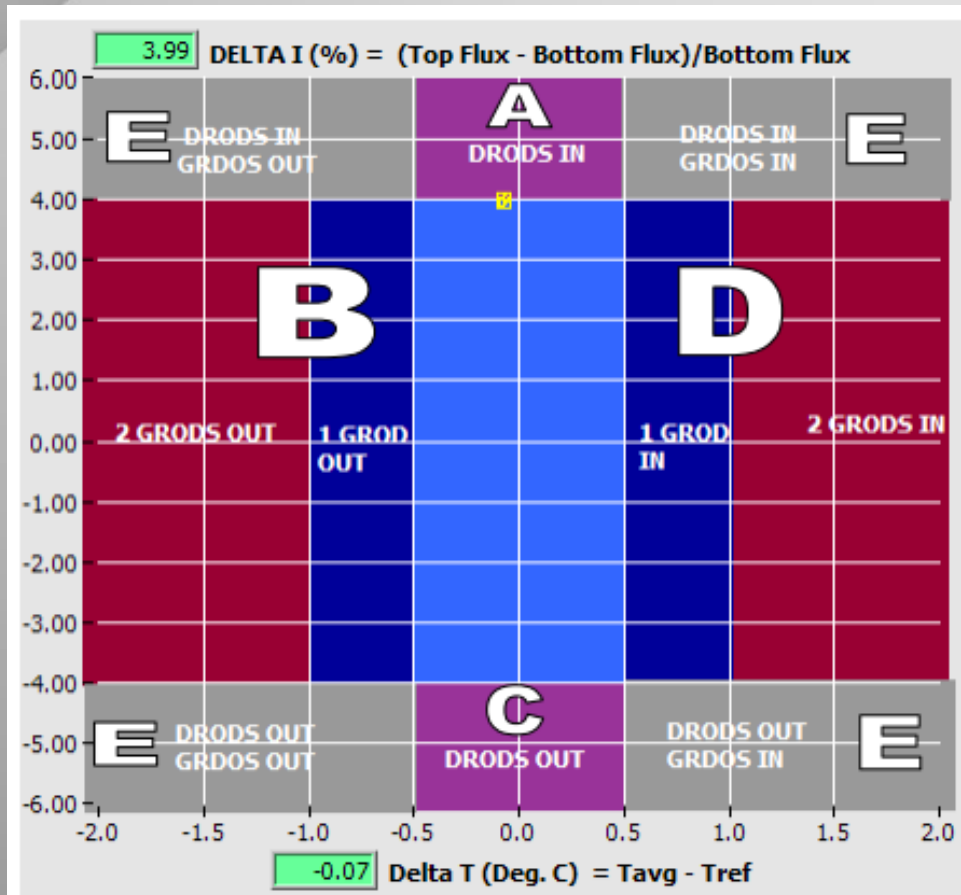
Mode K Reactor Control Strategy

(Paper - “Automatic Reactor Power Control for a Pressurized Water Reactor “ by Jung-In Choi et al, Kyungwon University, Korea (August 27, 1992) - Nuclear Technology, Volume 102, May 1993, p.277)

- ❖ **Double closed loop control**
 - (1) reactor coolant temperature
 - (2) axial power difference
- ❖ **Heavy-worth control rods bank (dark rods) dedicated to axial shape control.**
- ❖ **Light-worth control rods bank (gray rods) for controlling coolant temperature at setpoint.**

Source: Lecture Material on the IAEA Workshop on Nuclear Power Plants Simulator, Politecnico di Milano, Milan, Italy, 2011

Mode K Reactor Control Strategy



Region A: $FT > 4$; $-0.5 < DT < 0.5$

Region C: $FT < -4$; $-0.5 < DT < 0.5$

Region B: $-4 < FT < 4$; $DT < -0.5$

Region D: $-4 < FT < 4$; $DT > 0.5$

Region E: the four corners

$FT > 4$; $DT < -0.5$;

$FT > 4$; $DT > 0.5$;

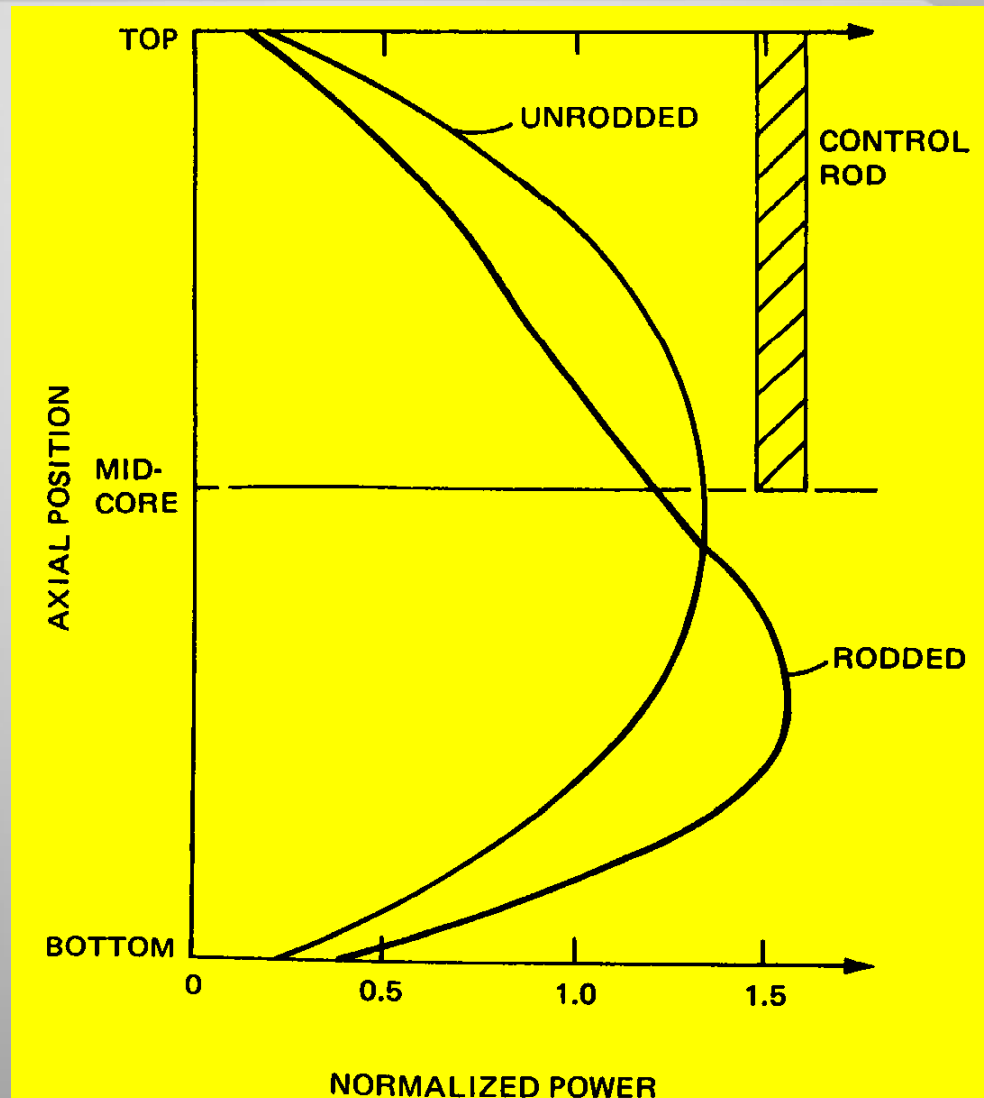
$FT < -4$; $DT < -0.5$;

$FT < -4$; $DT > 0.5$

Boron will be used if Gray rods limiting position has been reached

Axial Flux with Control Rods

Axial Flux with Control Rods



Source: Dr. Larry Foulke; Lecture Material on the IAEA Workshop on Nuclear Power Plants Simulator, Politecnico di Milano, Milan, Italy, 2011

Gray Rods Position Limits

Reactor Power (%)	Average Gray Rods Position (average of the rod positions for the individual four banks)
0 – 10 %	93 % - 87 % in core
10 – 20 %	87 % - 83 % in core
20 – 30 %	83 % - 70 % in core
30 – 40%	70 % - 60 % in core
40 – 50 %	60 % - 53 % in core
50 – 60 %	53 % - 48 % in core
60 – 70 %	48 % - 44 % in core
70 – 80%	44 % - 40 % in core
80 – 90 %	40 % - 35 % in core
90 – 100 %	35 % - 30 % in core

- ❖ Batasan ini dirancang untuk menjaga:
 - ✓ reaktivitas batang kendali yang cukup pada berbagai titik daya, untuk manuver daya,
 - ✓ margin operasi yang cukup untuk memungkinkan penyisipan batang secara tiba-tiba seperti pada saat reactor power stepback, atau setback
- ❖ Jika posisi rata-rata Gray Rods telah tercapai pada posisi daya tertentu, Gray Rods TIDAK akan dipindahkan lagi (hingga rentang daya lain ditemukan).
- ❖ Jika batasan Gray Rods sudah tercapai dan daya reaktor target masih belum tercapai, maka soluble boron akan digunakan (injection atau removal) untuk mencapai target daya.

Constant Tav Program

Constant Tav Program

Advantages:

- Least amount of external control
- Preferred by reactor
- Small pressurizer (minimum expansion of coolant volume as power changes)

Disadvantages

- Drop off of steam temperature and pressure
- Poor turbine efficiency

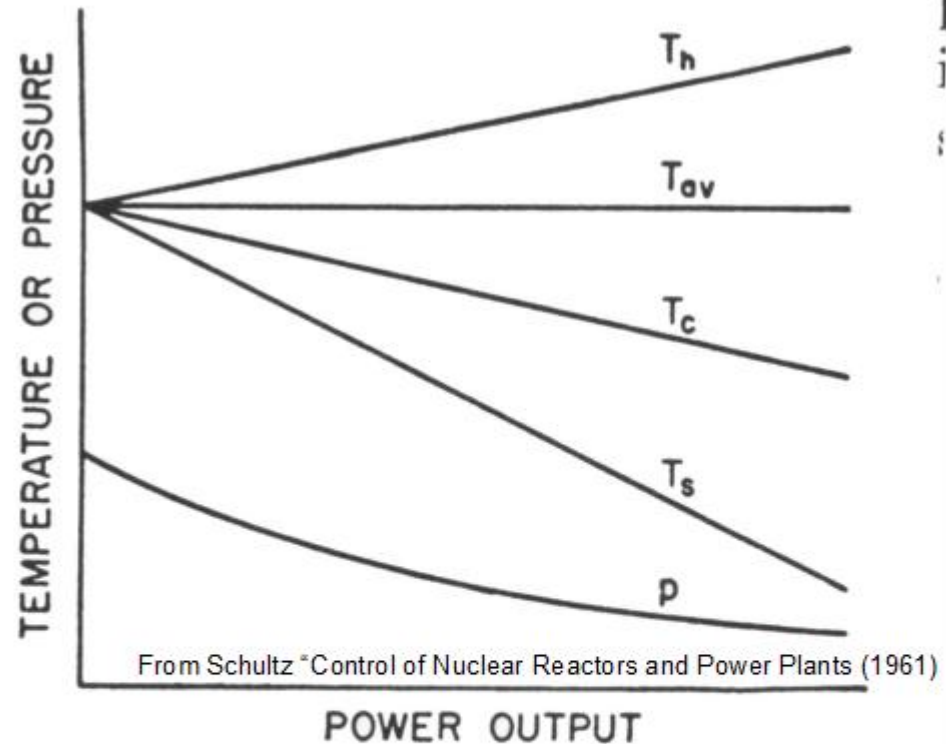


FIG. 8-4. Variations in temperatures and pressure as a function of power output for constant-average-temperature program with fixed coolant flow.

Constant Th Program

Constant Th Program

Advantages:

- Least stressful to materials

Disadvantages

- Huge drop off of steam temperature and pressure
- Poorest turbine efficiency
- Requires external reactivity control

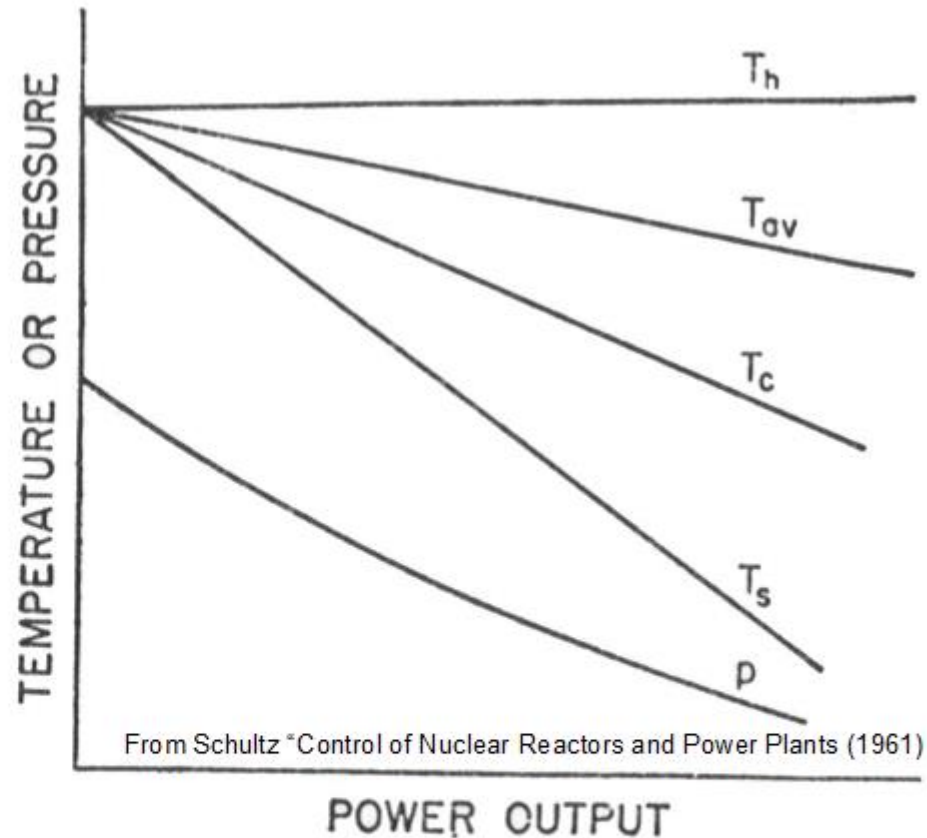
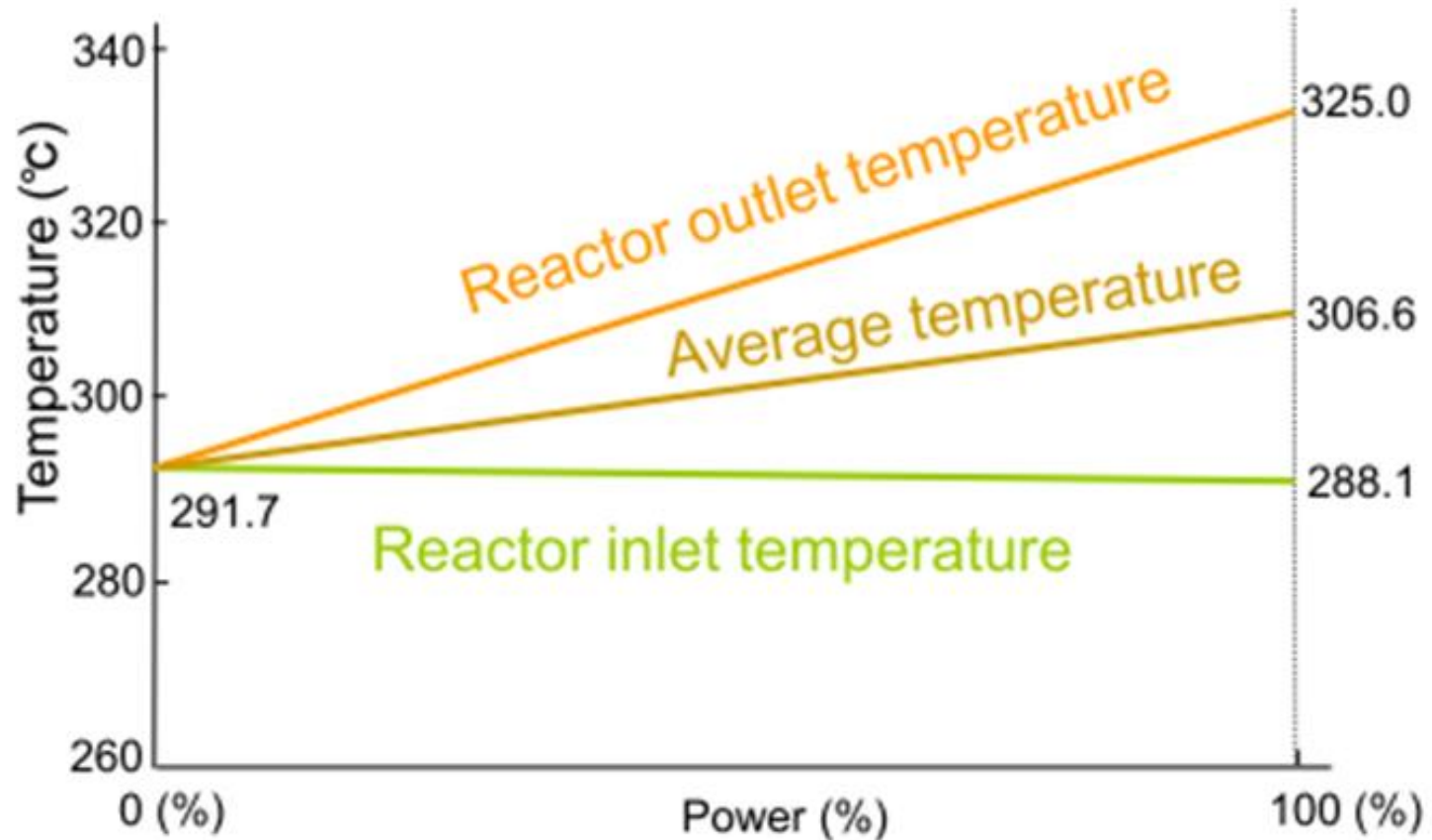


FIG. 8-6. Variations in temperatures and pressure as a function of power output for constant-outlet-temperature program.

Source: Dr. Larry Foulke; Lecture Material on the IAEA Workshop on Nuclear Power Plants Simulator, Politecnico di Milano, Milan, Italy, 2011



Temperatur terprogram pendingin reaktor (APWR, Mitsubishi Heavy Industries, IAEA INPRO 7th Dialogue Forum, Nov. 2013)

Reactor Power Control Screen

PWR Reactor Power Control

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	45
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							4945

HOLD POWER

MODE **REACTOR LEAD**

SETBACK **NO**

STEPBACK **NO**

SCRAM **NO**

RCTR

TRML

TURB

TURB LEAD PWR DEMAND SETPOINT

101.03 %FP

LIMITS

MAX 110.00

MIN 0.00

(% full power)

ACTUAL SETPOINT

100.00 %FP

REACTOR LEAD POWER DEMAND SETPOINT

100.00 %FP

DEMANDED POWER SETPOINT

100.00 %FP

DEMANDED RATE SETPOINT

0.000 %FP/s

POWER ERROR

0.011 %

BORON CTRL

MODE AUTO

LOAD 213.223 ppm

MAN CTRL

DARK RODS CTRL

MODE AUTO

SPEED 0.01 %/s

AVE POS 14.1 %

GRAY RODS CONTROL

MODE AUTO

SPEED 0.67 %/s

AVE POS 7.6 %

ACT & DEMANDED SP (%)

110.0

80.0

60.0

40.0

20.0

0.0

15:04:44 15:07:01

Flux Tilt Error (%)

50.0

20.0

0.0

-20.0

-50.0

15:04:44 15:07:01

Dark & Gray Rods Avg Pos (%)

100.0

80.0

60.0

40.0

20.0

0.0

15:04:44 15:07:01

Coolant Delta T Error (Deg.C)

5.0

2.0

0.0

-2.0

-5.0

15:04:44 15:07:01

Reactivity Change - Delta K (mk)

10.0

5.0

0.0

-5.0

-10.0

15:04:44 15:07:01

Rctr Pwr /Th Pwr /Tur Pwr (%)

110.0

80.0

60.0

40.0

20.0

0.0

15:04:44 15:07:01

Resolution

Max Out Max In

Time Scroll

Reactor Power Control

Reactor Neutron Pwr (%)

Reactor Thermal Pwr(%)

Generator Output(%)

Primary Coolant Pressure (kPa)

Core Flow (kg/s)

Main STM

BOP STM Flow

FW Flow

Fuel Temp

100.01

100.36

101.03

15509.12

9207.10

5739.6

1076.3

1021.0

484.3

Freeze

Run

IC

Malf

Iterate

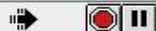
Help

Reactor Power Control Screen

- ❖ REACTOR POWER SETPOINT target and rate are specified by the user on the simulator in terms of %FP (Full Power) and %FP/sec.
- ❖ TURB LEAD PWR DEMAND SETPOINT is set equal to the TARGET LOAD (% FP) SETPOINT under “TURBINE LEADING” control; the upper and lower limits on this setpoint can be specified here.
- ❖ ACTUAL SETPOINT is set equal to the accepted “REACTOR POWER SETPOINT” TARGET under RPC control in “REACTOR LEADING” mode.
- ❖ HOLD POWER 'On' will select 'REACTOR LEADING' mode and stops any requested changes in DEMANDED POWER SETPOINT.
- ❖ DEMANDED RATE SETPOINT is set equal to the accepted “REACTOR POWER SETPOINT” RATE, limited by the maximum rate of 0.8 % of full power per second.
- ❖ DEMANDED POWER SETPOINT is the incremental power target, which is set equal to current reactor power (%) + rate (% / s) * program cycle time (sec). In this way, the DEMANDED POWER SETPOINT is “ramping” towards the REACTOR POWER SETPOINT target, at the accepted rate of change.

Reactor Trip Parameters Screen

PWR Trip Parameters



Labview
57
CASSIM
6223

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn
Hi Neutron Pwr	RC 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	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active

REACTOR TRIP PARAMETERS

FIRST OUT	SCRAM CAUSES
<input type="radio"/>	Low Coolant Pressure Trip
<input type="radio"/>	Low Steam Generator Level Trip
<input type="radio"/>	High Coolant Pressure Trip
<input type="radio"/>	High Neutron Flux Trip
<input type="radio"/>	High Log Rate Trip
<input type="radio"/>	Low Coolant Flow Trip
<input type="radio"/>	Low Pressurizer Level Trip
<input type="radio"/>	Low Feedwater Discharge Header Pressure Trip
<input type="radio"/>	High Steam Flow Trip
<input type="radio"/>	Departure from Nucleate Boiling (DNB) Trip
<input type="radio"/>	Containment High Pressure Trip
<input type="radio"/>	Manual Trip

SDS Reactor Trip Setpoint For High Neutron Flux 120.0 %FP

REACTOR STEPBACK CAUSES

- Hi RC Pressure
- Loss of 1 RC Pump
- Loss of 2 RC Pumps
- Hi Log Rate
- Manual Stepback
- Hi Zone Flux
- Press to clear

REACTOR SETPBCK CAUSES

- Main Steam Header Press Hi
- Hi Pressurizer Level
- Manual Setback in progress
- Lo Steam Generator Level
- Lo Deaerator Level
- Hi Flux Tilt
- Hi Zonal Flux
- Press to clear

Trip Parameters		Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	5739.8	Freeze	Run	Iterate
Reactor Trip	Turbine Trip	100.02	100.39	100.81	15511.84	9210.49	FW Flow	1019.2	IC	Malf	Help
							Fuel Temp	484.2			

Reactor Trip Parameters

- Low reactor outlet header (hot legs) coolant pressure trip — trip setpoint = 14,380 kPa.
- Low steam generator level trip — trip setpoint = 11.94 m
- High reactor outlet coolant pressure trip — trip setpoint = 16,200 kPa
- High neutron flux trip — trip setpoint = 120 % of Neutron Flux at full power
- High log rate trip — trip setpoint = 8 % /s
- Low coolant flow trip — trip setpoint = 2,000 kg/s
- Low pressurizer level trip — trip setpoint = 2.7 m
- Low feedwater discharge header pressure — trip setpoint = 5200 kPa
- High Steam Flow “High Steam Flow” – reactor will be tripped, when the steam flow from Steam Generator #1, OR from Steam Generator #2, exceeds 120 % of Full Power steam flow (644 kg/sec), OR the total steam flow from the main steam header exceeds 120 % of Full Power steam flow (1289 kg/s).
- “DNB Trip” – Departure from Nucleate Boiling (DNB) reactor trip will occur when the average heat flux in the core exceeds 110 % of the nominal full load design value of 464 kW/m².
- Containment High Pressure Trip – reactor will be tripped when the containment pressure (which is kept at sub-atmospheric pressure) exceeds 105 kPa, in the unlikely event of a LOCA event occurring inside containment boundary.
- Manual trip

Reactor Stepback & Setback Parameters

- Reactor stepback is the reduction of reactor power in a large step, in response to certain process parameters exceeding alarm limits.
- Reactor setback is the ramping of reactor power at fixed rate, to setback target, in response to certain process parameters exceeding alarm limits.

The causes for REACTOR STEPBACK :

- ✓ High reactor coolant pressure (initiated at $P > 16051$ kPa; target 2 % FP)
- ✓ Loss of one reactor coolant pump (target 60 % FP)
- ✓ Loss of two reactor coolant pumps (target 2 % FP)
- ✓ High log rate (initiated when $d(\ln P)/dt > 7$ %/s; target 2 % FP)
- ✓ Manual stepback (initiated by operator; target set by operator)
- ✓ Hi zone flux (initiated if zone flux is > 115 % of nominal zone flux at full power)

The causes for REACTOR SETBACK are:

- ✓ Main steam header pressure H_i — setback if > 6150 kPa
- ✓ H_i pressurizer level — setback if > 12 m
- ✓ Manual setback in progress
- ✓ Low steam generator level — setback if < 12 m
- ✓ Low deaerator level — setback if < 2 m
- ✓ H_i flux tilt — setback if > 20 %
- ✓ H_i zonal flux — setback if > 110 %

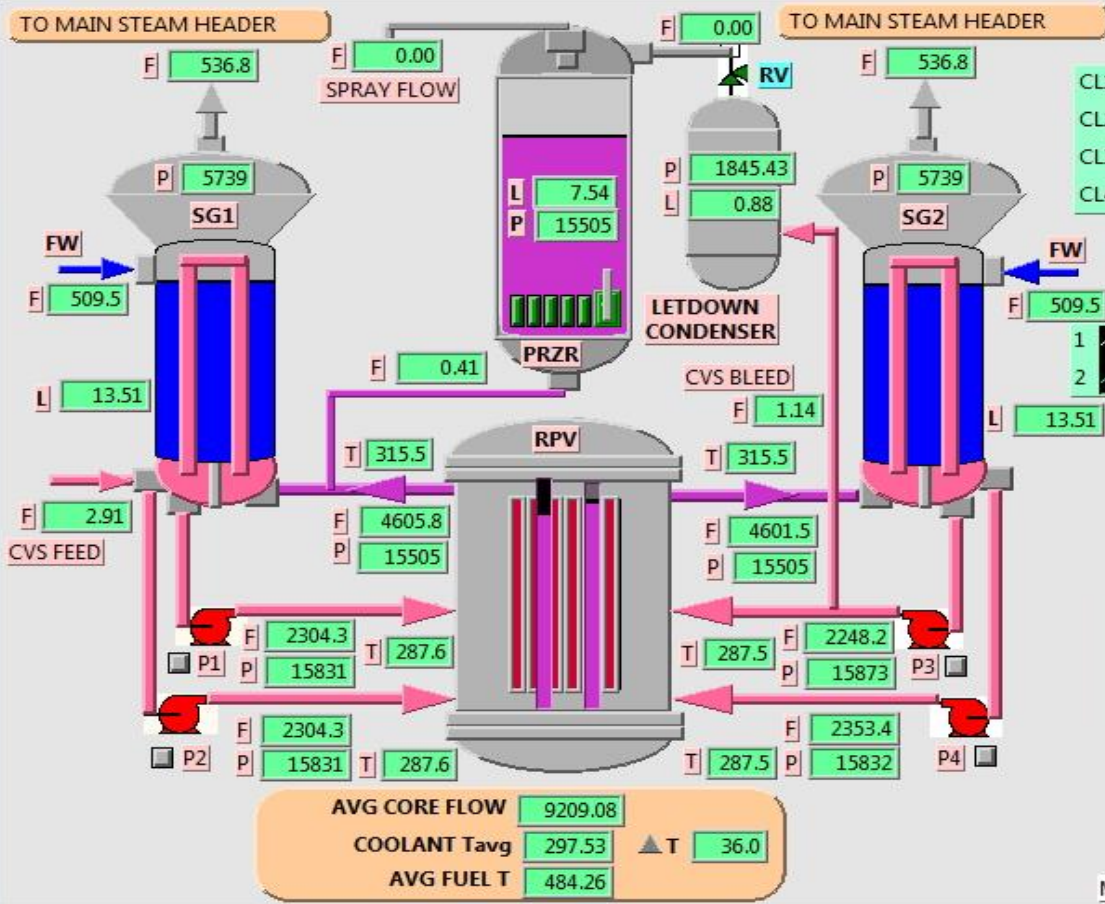
Reactor Coolant System Screen

PWR Reactor Coolant System



Labview
38
CASSIM
7010

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn
Hi Neutron Pwr	RC 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	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active



Resolution Time Scroll

Max Out | | Max In

Reactor Coolant System		Reactor Neutron Pwr (%)	Reactor Thermal Pwr (%)	Generator Output (%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp	Freeze	Run	Iterate
Reactor Trip	Turbine Trip	100.06	100.38	100.67	15514.67	9209.08	5739.4	1019.1	484.3	IC	Malf	Help

Reactor Coolant System

The system components and parameters shown are:

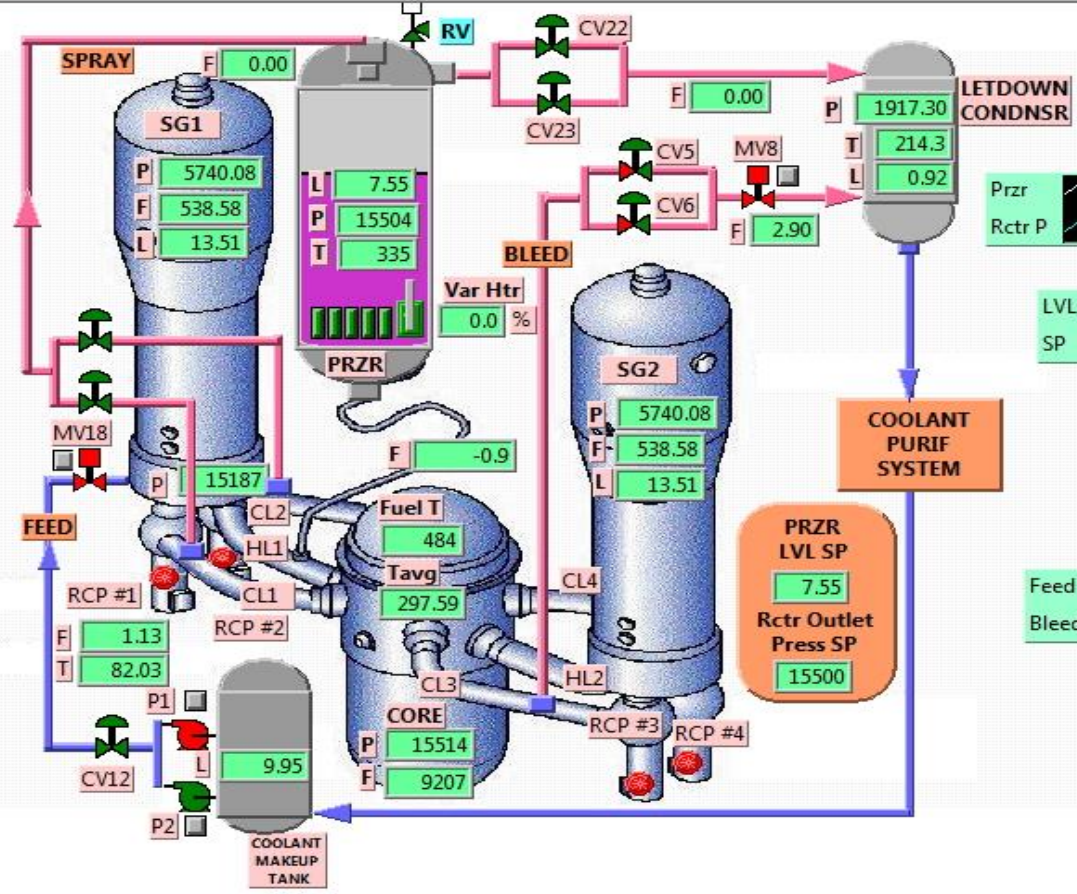
- Average fuel temperature ($^{\circ}\text{C}$); average coolant temperature ($^{\circ}\text{C}$); average core flow (kg/s); ΔT across the core = coolant outlet temperature - coolant inlet temperature.
- Reactor coolant pump's discharge flow (kg); discharge pressure (kPa); discharge temperature ($^{\circ}\text{C}$)
- Reactor coolant pump pop-up control which allows 'START', 'STOP' and 'RESET' operations
- Pressure (kPa), flow (kg/s) and temperature ($^{\circ}\text{C}$) at the hot legs outlet of the Reactor Pressure Vessel.
- Coolant flow (kg/s) to the pressurizer from one hot leg.
- For each steam generator (SG) — feedwater flow (kg/s); feedwater level in drum (m); steam drum pressure (kPa); main steam flow from SG to main steam header (kg/s). For SG1, the feed flow (kg/s) from chemical & volume control system (CVS) is shown. More explanation of this feed flow will be provided in the PWR coolant inventory & pressurizer screen.
- In the pressurizer, there are five electric on/off heaters, and one variable heater. They are controlled by the coolant pressure control system. The color will be red when heater is 'on'; green when off. The following process parameters are shown: pressurizer vapor pressure (kPa); pressurizer liquid level (m); spray flow into the pressurizer (kg/s), to control pressure; pressure relief flow (kg/s) to the letdown condenser to relieve over-pressure in the pressurizer.

Reactor Coolant Inventory & Pressurizer Screen

PWR Coolant Inventory and Pressurizer



Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	101
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM 8108



Coolant Inventory & Pressurizer

Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp
100.00	100.38	101.15	15514.06	9207.41	5740.1	1077.6	1021.2
Reactor Trip	Turbine Trip						

Freeze	Run	Iterate
IC	Malf	Help

Reactor Coolant Inventory Control Screen

PWR Coolant Inventory Control



Labview
15
CASSIM
8680

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn
Hi Neutron Pwr	RC 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	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active

PRIMARY COOLANT INVENTORY CONTROL

PRZR LEVEL CONTROL

PRZR LVL(M) 7.557 MODE AUTO

PRZR LVL SETPOINT(M) 7.545 MANUAL SETPOINT(M)

MAN SP NOT OK

COOLANT INVENTORY FEED/BLEED VALVES AUTO/MAN CONTROLS & BIAS

Direct Feed Vlv(%) AUTO POS 0.00 MAN O/P MAN O/P NOT OK

Bleed Vlv CV5(%) AUTO POS 5.132 MAN O/P MAN O/P NOT OK

Bleed Vlv CV6(%) AUTO POS 5.132 MAN O/P MAN O/P NOT OK

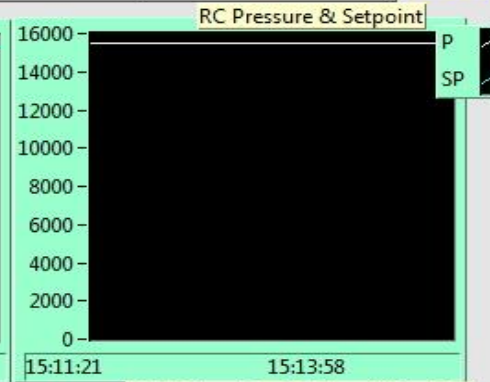
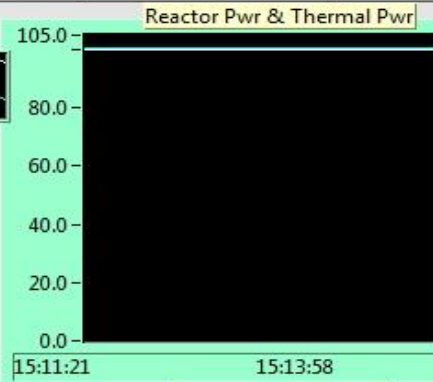
BLEED BIAS% 2.50

REACTOR COOLANT PRESSURE CONTROL SETPOINT

Coolant Pressure - Reactor Outlet - 15512 KPA PRESS SETPOINT 15500 KPA

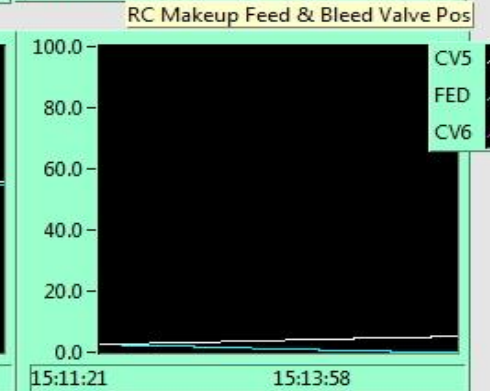
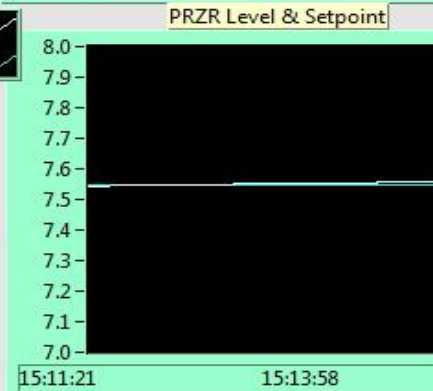
RCTR

TRML



LVL

SP



Resolution

Time Scroll

Max Out Max In

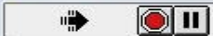
Coolant Inventory Control	
Reactor Trip	Turbine Trip

Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	5739.8
100.05	100.39	101.07	15512.27	9206.98	FW Flow	1076.4
					Fuel Temp	1021.9
						484.3

Freeze	Run	Iterate
IC	Malf	Help

Reactor Coolant Pressure Control Screen

PWR Coolant Pressure Control



Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn
Hi Neutron Pwr	RC 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	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active

Labview
15
CASSIM
9193

PRIMARY COOLANT PRESSURE CONTROL

MAN O/P NOT OK PRESSURIZER HEATERS CONTROL

1	AUTO	79.81	3	AUTO	OFF	5	AUTO	OFF
2	AUTO	OFF	4	AUTO	OFF	6	AUTO	OFF

PRESSURIZER POWER OPERATED RELIEF VALVES CONTROL

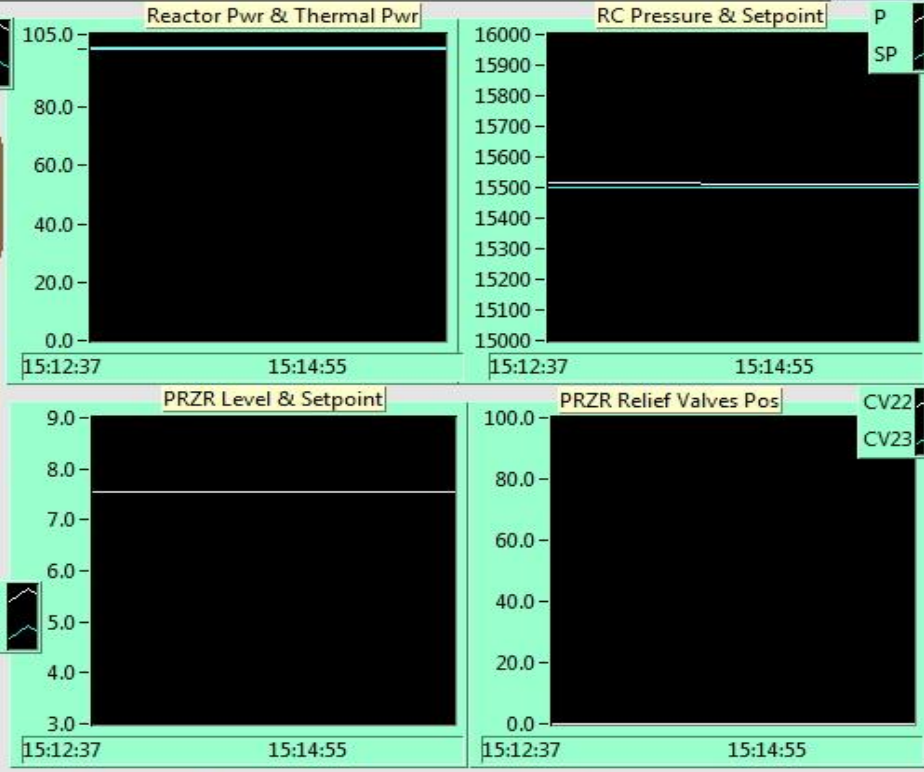
CV22(%)	AUTO	POS	0.00	MAN O/P	MAN O/P NOT OK
CV23(%)	AUTO	POS	0.00	MAN O/P	MAN O/P NOT OK

PRESSURIZER SPRAY VALVES CONTROL

SCV1 (%)	AUTO	POS	0.00	MAN O/P	MAN O/P NOT OK
SCV2(%)	AUTO	POS	0.00	MAN O/P	MAN O/P NOT OK

REACTOR COOLANT PRESSURE SETPOINT CONTROL

Coolant Pressure - Reactor Outlet: 15510 KPA RC PRESS SETPOINT: 15500 KPA



Resolution: Max Out | Max In Time Scroll: [Slider]

Coolant Pressure Control		Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	5739.0	Freeze	Run	Iterate
Reactor Trip	Turbine Trip	100.01	100.39	100.89	15509.89	9206.93	FW Flow	1021.6	IC	Malf	Help
							Fuel Temp	484.3			

Turbine Generator Screen

PWR Turbine Generator

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	16
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							9710

Main Steam Header P
5739.9

STATION SERVICES
85.00 MW

GENERATOR
OUTPUT: 623.64 MW
SPEED: 1800.0 RPM
BREAKER: CLOSED

TURBINE
Turbine Gov. Position %: 100.76

CONDENSER
To Feedwater System

Byproduct Data:
CV POS: 101 %
MSV: 1019.4
BYP VLV: 0.0000 %
SRV'S: 1, 2, 3, 4

Graphs:
 - RCTR Neut/Thrm Pwr: 0.0 to 105.0
 - Generator Output (MW): 0.0 to 700.0
 - Turb Steam/BYP Flow: 0.0 to 1500.0
 - Turbine Speed: 0 to 1900
 - Governor Position: 0.0 to 105.0
 - MSV Inlet Pressure: 3000 to 6500

TURBINE TRIP STATUS
 RESET:
 TURBINE CV CONTROL: AUTO
 TURBINE RUNBACK:
 TURBINE RUNUP: ENABLE
 TURBINE RUNUP: SPEEDUP
 TURBINE RUNUP: INACTIVE

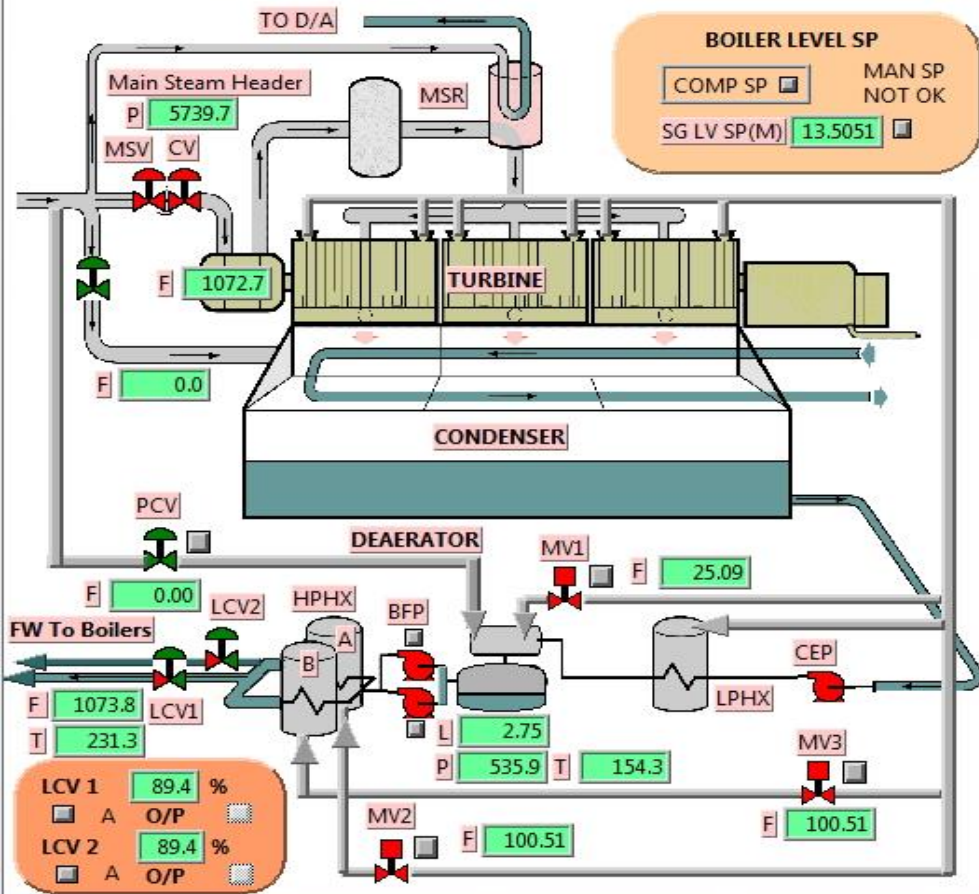
Resolution and **Time Scroll** controls are present at the bottom right.

PWR Turbine Generator	Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp	Freeze	Run	Iterate	
Reactor Trip	Turbine Trip	100.03	100.37	100.75	15508.44	5739.9	1074.0	1020.3	484.3	IC	Malf	Help

Feedwater & Extraction Steam

PWR Feedwater and Extraction Steam

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	29
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM 10416



Feedwater & Extraction Steam

Reactor Trip	Turbine Trip
--------------	--------------

Reactor Neutron Pwr (%)	Reactor Thermal Pwr (%)	Generator Output (%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp
100.01	100.37	100.74	15510.22	9210.49	5739.7	1072.7	484.2

Freeze	Run	Iterate
IC	Malf	Help

MW Demand & SGPC Screen

PWR MW Demand SP and SGPC



Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	58
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							11230

PLANT MODE REACTOR LEADING

POWER RATE & TARGET LOAD

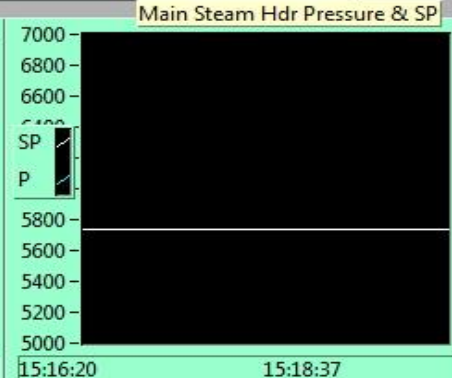
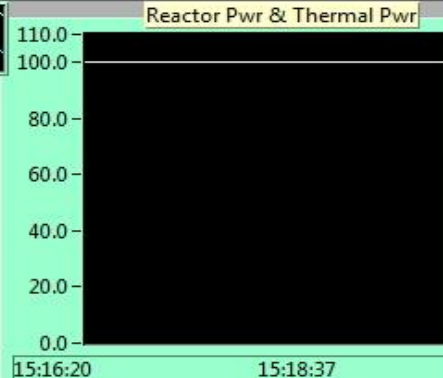
CONTROLLED VARIABLE	CURRENT TARGET	OPERATOR INPUT TARGET	RANGE
TARGET LOAD(%) <input type="checkbox"/>	100.77	100.00	5 TO 100
POWER RATE (%/S)	0.10	0.10	0.01 TO 1

STEAM GENERATOR PRESSURE SETPOINT CONTROL

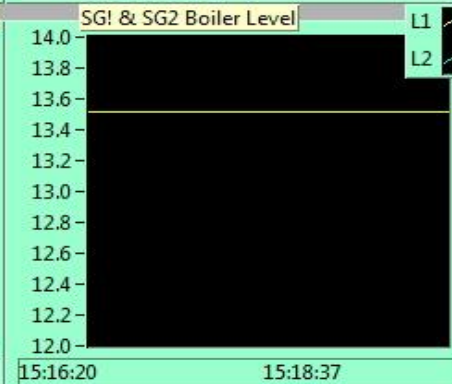
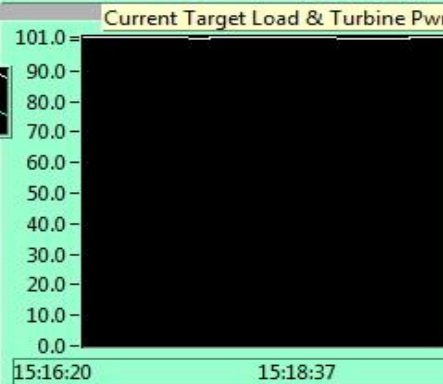
Main Steam Hdr Pressure 5740 KPA SP MODE HOLD 5740 SP (KPA)

SP Recovery PRESSURE SP CHANGE RATE

RCTR
TRML



LOAD
PWR



Resolution 0 Time Scroll

Max Out Max In

MW Demand & SGPC

Reactor Trip Turbine Trip

Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp
100.03	100.39	100.77	15514.57	9209.48	5740.2	1072.6	1018.7
						484.3	

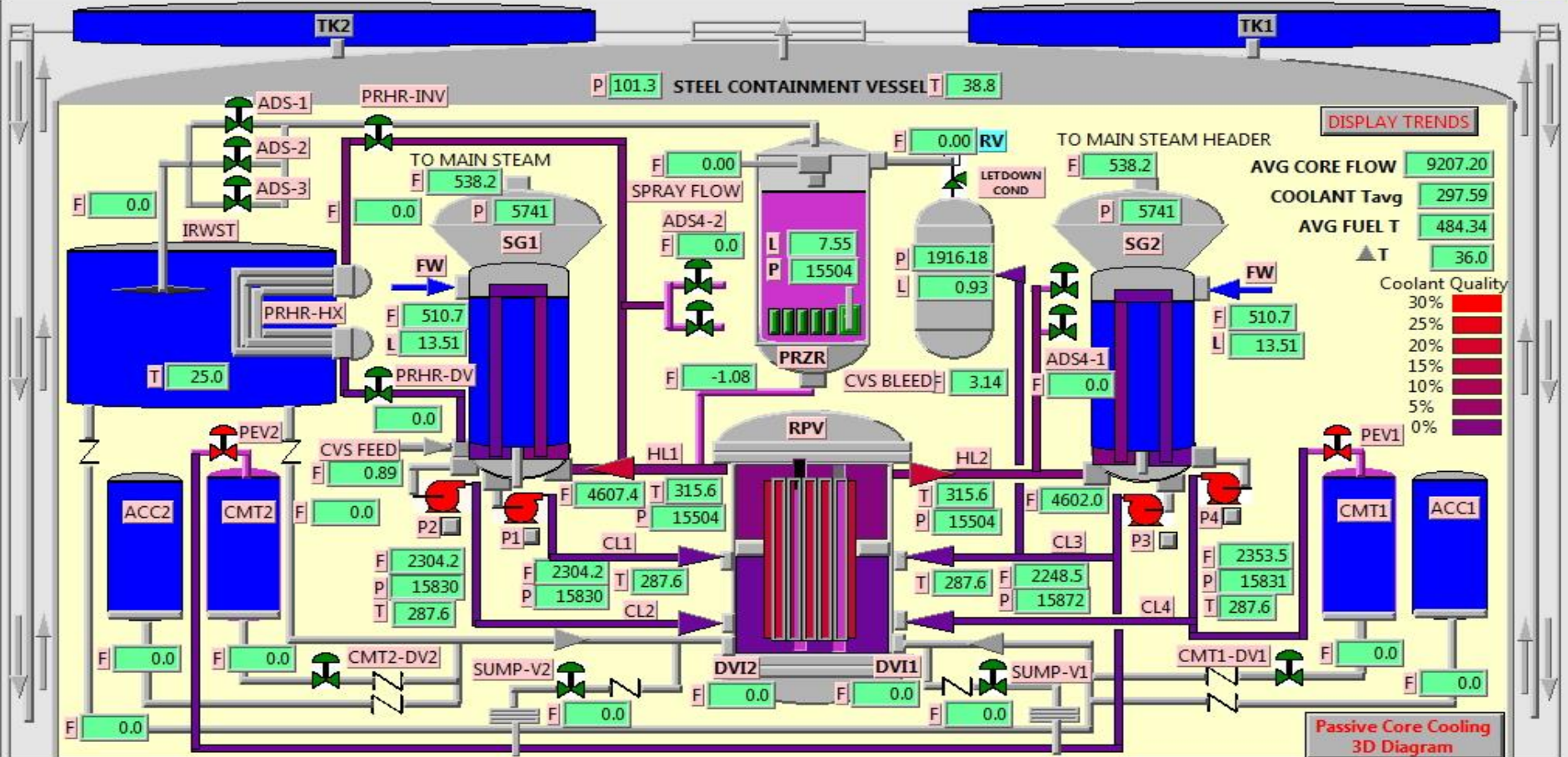
Freeze Run Iterate

IC Malf Help

Passive Core Cooling Screen

PWR Passive Core Cooling

Reactor Trip	Turbine Trip	RC Press Lo Lo	Step Back Req'd	Setback Req'd	Turbine Runback	Gen Breaker Opn	Labview
Hi Neutron Pwr	RC Press Hi Hi	Coolant Flow Lo	Stm Gen Level Lo	PRZR Lvl Hi	Low Fwd Pwr Trip	Main BFP(s) Trip	41
Hi Neut Pwr LogR	RC Press Hi	Main Stm Pres Hi	Stm Gen Level Hi	Turbine Gov in Man	Loss RC Pmp(s)	Malfunction Active	CASSIM
							12732

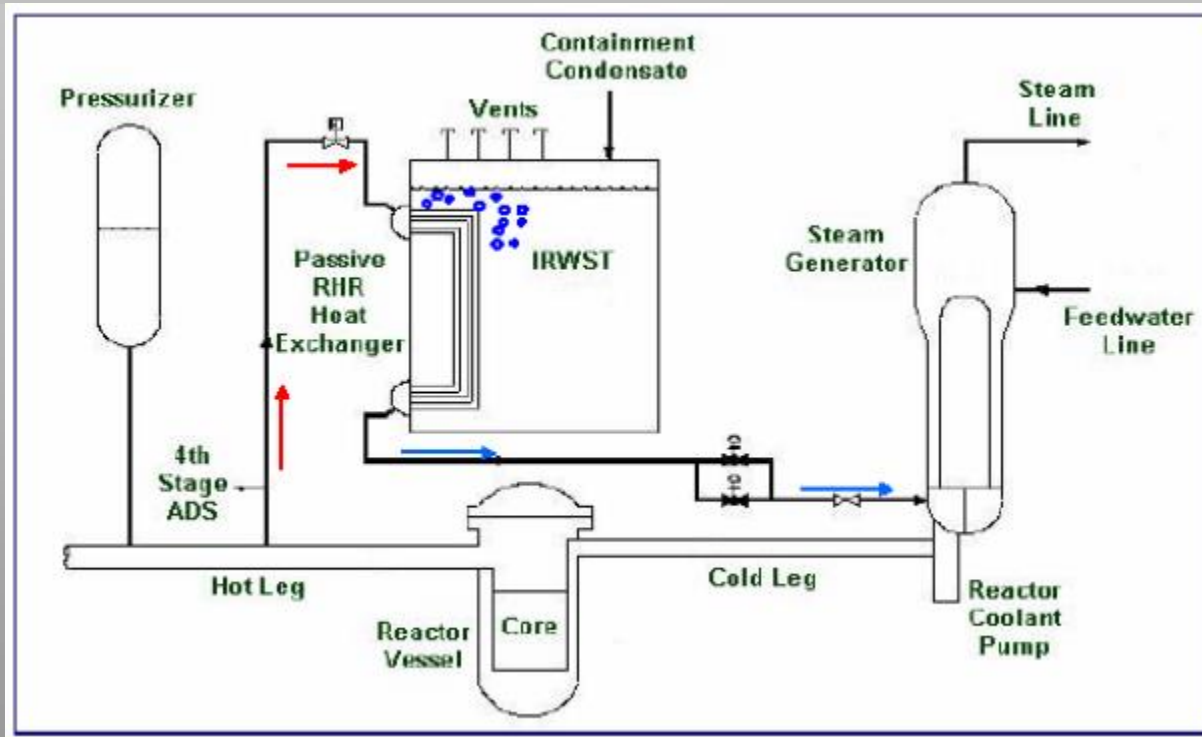


PWR Passive Core Cooling		Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp	Freeze	Run	Iterate	
Reactor Trip	Turbine Trip	100.03	100.39	101.09	15513.89	9207.20	5740.6	1076.4	1021.5	484.3	IC	Malf	Help

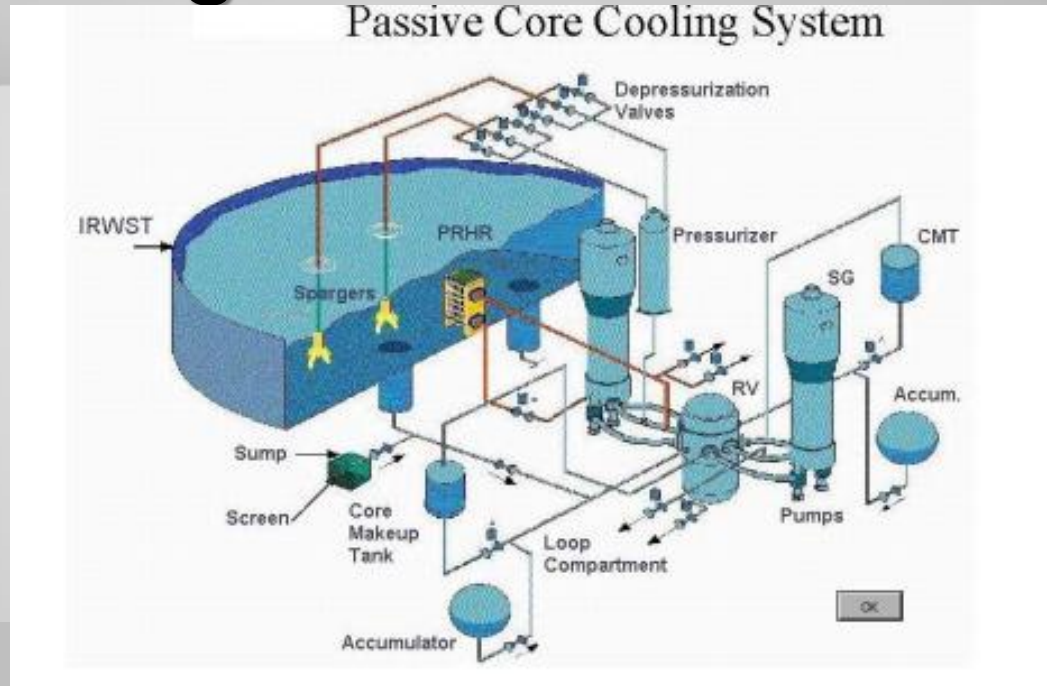
Passive Core Cooling Screen

Passive Residual Heat Removal (PRHR) System :

- Terdiri dari penukar kalor jenis C-Tube yang berada di dalam In-containment Refueling Water Storage Tank (IRWST), yang terisi air.
- Berfungsi untuk memindahkan panas dari teras melalui loop sirkulasi alamiah. Air panas naik melalui saluran masuk PRHR yang terpasang pada salah satu pipa hot legs. Air panas memasuki tubesheet di header atas penukar kalor PRHR pada tekanan dan suhu sistem penuh.



Passive Core Cooling Screen



Core Make-up Tank (CMT)

CMT secara efektif menggantikan high-pressure safety injection systems yang terdapat pada PWR konvensional. CMT terdiri dari tangki stainless steel volume besar dengan jalur inlet yang terhubung pada salah satu pipa cold legs ke bagian atas CMT dan jalur outlet yang terhubung pada bagian bawah CMT ke jalur Direct Vessel Injection (DVI). Jalur DVI terhubung ke downcomer bejana reaktor. CMT berisikan cold borated water. Katup inlet CMT secara normal terbuka dan karenanya CMT normalnya berada pada tekanan sistem primer. Katup outlet CMT secara normal tertutup, mencegah sirkulasi alamiah selama operasi normal. Ketika katup outlet terbuka, jalur sirkulasi alamiah terjadi. Air borat dingin mengalir ke bejana reaktor serta fluida primer panas mengalir ke atas dan masuk ke bagian atas CMT.

Passive Core Cooling Screen

Automatic Depressurization System (ADS)

ADS terdiri dari empat tahap katup yang berfungsi untuk pengurangan tekanan sistem primer secara terkendali. Tiga tahap pertama terdiri dari dua rangkaian katup yang terhubung ke bagian atas pressurizer. Tahap pertama terbuka pada level cairan CMT. Tahap ADS kedua dan ketiga terbuka segera setelahnya dengan mengikuti timer. Katup ADS 1-3 mengeluarkan uap sistem primer ke dalam saluran sparger yang mengalir ke IRWST. Uap tersebut dikondensasikan melalui kontak langsung dengan air yang sangat dingin di IRWST. Tahap keempat ADS terdiri dari dua katup besar yang terpasang pada saluran ADS pada setiap hot leg. Katup ADS-4 terbuka pada level cairan CMT rendah dan secara efektif menurunkan tekanan sisi primer ke kondisi tekanan containment. Katup ADS-4 mengalir langsung ke dalam ruangan bangunan containment.

Accumulators (ACC)

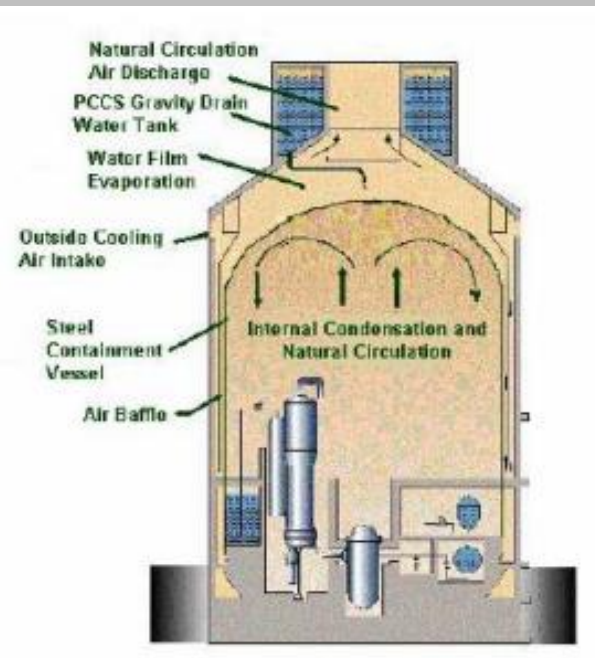
Akumulator ini mirip dengan yang ditemukan pada PWR konvensional. Akumulator ini berupa tangki bulat besar yang sekitar tiga perempatnya diisi dengan air dingin yang mengandung boraks dan diberi tekanan awal dengan nitrogen. Saluran keluar akumulator terhubung ke saluran DVI. Sepasang check-valve mencegah aliran injeksi selama kondisi operasi normal. Ketika tekanan sistem turun di bawah tekanan akumulator, check-valve terbuka sehingga memungkinkan injeksi cairan pendingin ke downcomer reaktor melalui saluran DVI.

Passive Core Cooling

In-containment Refueling Water Storage Tank (IRWST)

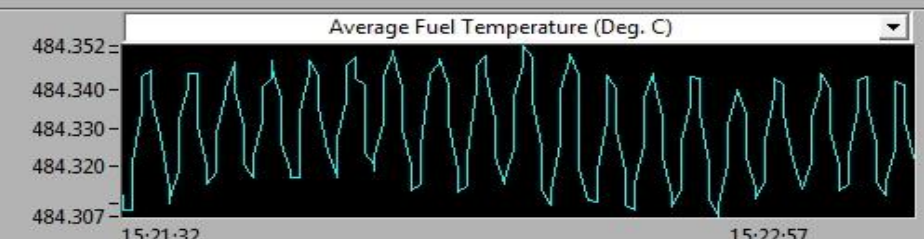
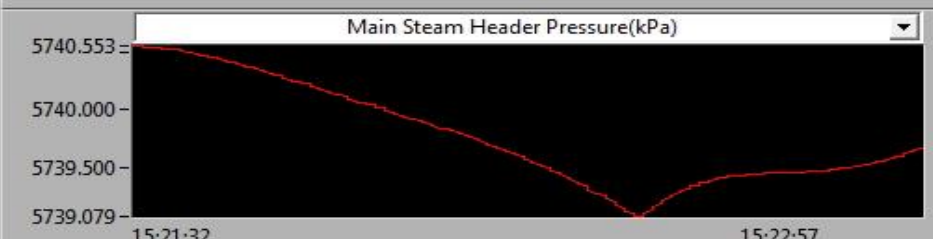
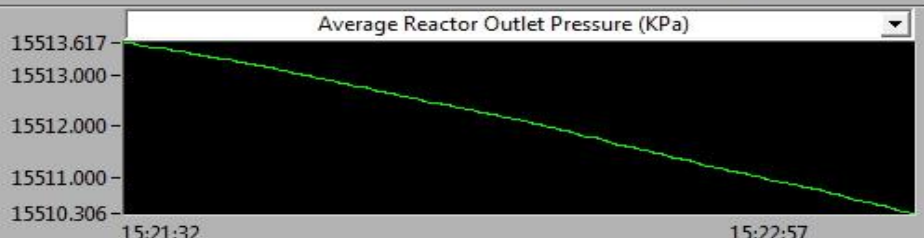
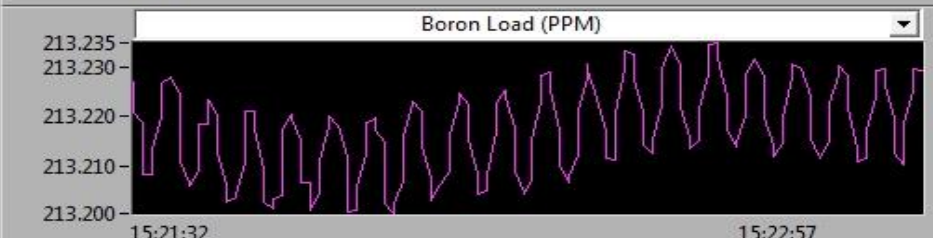
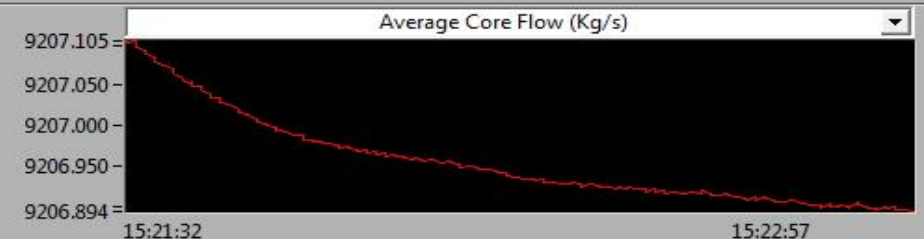
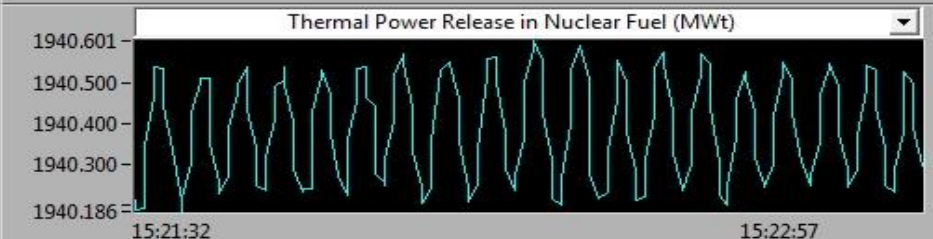
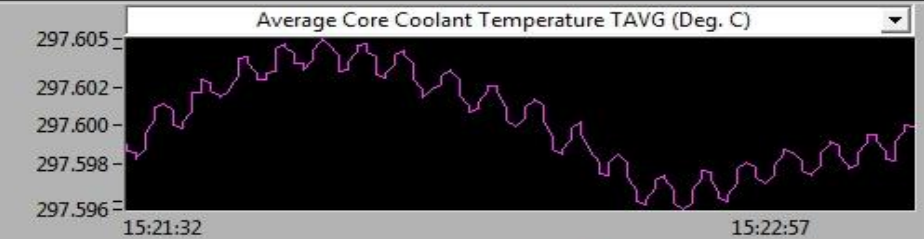
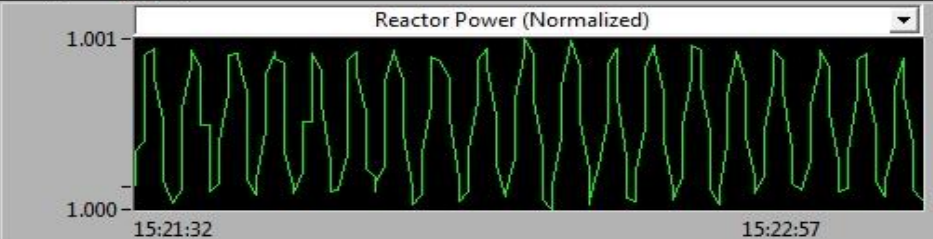
IRWST adalah kolam beton yang sangat besar yang diisi dengan air dingin yang mengandung borat. Kolam ini berfungsi sebagai penyerap panas untuk penukar panas PRHR dan sumber air untuk injeksi IRWST. IRWST memiliki dua saluran injeksi yang terhubung ke saluran DVI bejana reaktor. Jalur aliran ini biasanya diisolasi oleh dua check-valve yang dipasang secara seri. Ketika tekanan primer turun di bawah tekanan air di IRWST, jalur aliran terbentuk melalui DVI ke downcomer bejana reaktor. Air IRWST cukup untuk membanjiri kompartemen containment bagian bawah hingga ke tingkat di atas kepala bejana reaktor dan di bawah outlet saluran ADS-4.

Containment and Passive Containment Cooling System (PCCS)



Reactor Trends Screen

PWR Trends



AUTOSCALE Resolution Max Out Max In Time Scroll

PWR Trend Screen

Reactor Trip Turbine Trip

Reactor Neutron Pwr (%)	Reactor Thermal Pwr(%)	Generator Output(%)	Primary Coolant Pressure (kPa)	Core Flow (kg/s)	Main STM BOP STM Flow	FW Flow	Fuel Temp
100.00	100.38	100.97	15510.29	9206.89	5739.7	1075.1	1020.9
						484.3	

Freeze	Run	Iterate
IC	Malf	Help

thank you 😊

