B&W ADVANCED TECHNOLOGY LESSON PLAN		
Lesson No.506-4	Title:TRANSIENT INTRODUCTION WITH 3.1, 3.2, 3.3, & 3.4	
Written by:Larry Bell	Approved by: Larry Bell	Date: 11/6/91

1.0 Training Aids

1.1 ICS Color Transparency

1.2 Transparency Packages for transients 3.1 through 3.4.

2.0 Reference Material

2.1 B&W Technology Manual - Chapter 12

2.2 ICS Technical Manual

2.3 B&W Advanced Manual - Chapters 2 & 3.

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3.0 Objectives
- 3.1 To list the inputs for the parameter curves.
- 3.2 To cover transients 3.1 through 3.4

4.0 Presentation

- 4.1 Three types of transients presented in 506 course
  - 4.1.1 Normal Plant Transients
    - 4.1.1.1 Power Level Changes
    - 4.1.1.2 Runbacks
  - 4.1.2 ICS Input Failures
  - 4.1.3 Accidents
- 4.2 General Information
  - 4.2.1 Determine if a power mismatch has occurred
  - 4.2.2 Power mismatch determines changes in RCS temperature
    - 4.2.2.1 RCS Temperature change determines change in pressurizer level and pressure
    - 4.2.2.2 Power mismatch affects reactivity coefficients
  - 4.2.3 Instrument Failures
    - 4.2.3.1 Determine affected subassemblies
    - 4.2.3.2 Determine actions of affected subassemblies
  - 4.2.4 Accidents
    - 4.2.4.1 Determine accident by pressure changes

- 4.3 Transient Parameters
  - 4.3.1 Unit Load Demand - measured downstream of frequency correction
  - 4.3.2 Generated Megawatts - generator output
  - 4.3.3 FW Demands - measured upstream the FW hand/auto stations
  - 4.3.4 FW Flows - The non-selected input from main fw flow
    - 4.3.4.1 Note that FW flow is in units of percent. In the real world, FW is measured in lbm/hr.
    - 4.3.4.2 FW converted to percent by dividing by 100% flow value. Makes detection of crosslimits easier.
  - 4.3.5 OTSG Levels - ECI Startup channels
  - 4.3.6 Reactor Power - ~~RPS~~ Input ICS
  - 4.3.7 Reactor Demand - Input to hand/automatic station
  - 4.3.8 T Average - ICS Input from auto/manual selector switch
  - 4.3.8 Pressurizer Level - ~~RPS~~ Input NNI

Solid lines represent the left hand axis and the dashed lines represent the right hand parameters.

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4.3.10 NR Pressure - RPS Loop Pressure
4.3.11 WR Pressure - ESFAS Loop Pressure
4.3.12 RCS Flow - Non-Selected NNI flow
  4.3.12.1 Converted to percent of loop flow
4.3.13 Delta Tc - Calculated by subtracting Loop B Tc from Loop A Tc . Calculation performed in spreadsheet.
4.3.14 Neutron Error - Input to Diamond Station
4.3.15 FW Flow Error - calculated by ((FWDa +FWDb)/2) - ((Loop A + LoopB)/100% FW flow) - provided for crosslimits indication
4.3.16 Break Flows - Simulator generated
4.3.17 HPI Flow - 4 times the flow in one header.
4.3.18 Rod Position - Group Avg Position

4.4 Student Transient Analysis - will be responsible for numbered points only.

4.5 Cover transients 3.1 through 3.4 - instructor sheets

4.6 Pass out student transient explanations.

4.3.19 Header Pressure - Non-selected steam header pressure
4.3.20 OTSG Pressure - ESFAS OTSG pressure
4.3.21 RB Pressure - ESFAS RB pressure

Transient 3.1 - Ramp Increase in Power from 75% to 100% at 2%/min

Simulator Setup

IC Set: 14 Malfunction Category: N/A

Malfunction ID: N/A Severity: N/A

Notes:

1. This transient was initiated by manually increasing the ULD output from 75% to 100%.

Point Explanation

1. As the output of the ULD changes, the ICS increases generated MWe by changing the header pressure setpoint. When the header pressure setpoint is changed, actual header pressure is compared with the "new" (reduced) setpoint. The resulting error opens the governor valves.

2. The increase in ULD output causes an increase in the input to the FW demand subassembly. In the FW subassembly, actual feedwater flow is compared with the increase in demand, and the FW reg valve opens to increase flow.

3. The increasing portions of the sawtooths in neutron error are created by a 1% difference between the reactor demand signal that is being increased by the ULD output and actual reactor power. When the rods move out, actual reactor power is increased, and neutron error drops.

4. Group 7 moves outward in response to the neutron error signal.

5. Reactor Power increases because of the positive reactivity added by the withdrawal of group 7.

Transient 3.2 - Ramp Decrease in Power from 100% to 75% at 2%/min

Simulator Setup

IC Set: 14 Malfunction Category: N/A

Malfunction ID: N/A Severity: N/A

Notes:

1. This transient was initiated by manually decreasing the ULD output from 100% to 75%.

Point Explanation

1. As the output of the ULD changes, the ICS decreases generated MWe by changing the header pressure setpoint. When the header pressure setpoint is changed, actual header pressure is compared with the "new" (increased) setpoint. The resulting error closes the governor valves.

2. The decrease in ULD output causes a decrease in the input to the FW demand subassembly. In the FW subassembly, actual feedwater flow is compared with the decrease in demand, and the FW reg valves close to decrease flow.

3. The decreasing portions of the sawtooths in neutron error are created by a 1% difference between the reactor demand signal that is being decreased by the ULD output and actual reactor power. When the rods move in, actual reactor power is decreased, and neutron error drops.

4. Group 7 moves ~~out~~ in-ward in response to the neutron error signal.

5. Reactor Power decreases because of the negative reactivity added by the insertion of group 7.

Transient 3.3 - Ramp Decrease 100%-85%, SG/Rx in Manual

Simulator Setup

IC Set: 14 Malfunction Category: N/A

Malfunction ID: N/A Severity: N/A

Notes:

1. This transient was initiated by manually decreasing the output of the SG/Rx master by 15%.

Point Explanation:

1. The decrease in the SG/Rx master output is supplied to the reactor demand subassembly, decreasing its output. The output of the reactor demand subassembly drops faster than reactor power, and cross limits are generated.

2. The decrease in feedwater demand is caused by the combination of the decrease in output of the SG/Rx master and reactor cross limits. The decrease in feedwater demand is faster than the decrease in flow, and a third tracking signal is generated.

3. Group 7 is inserted by the neutron error signal. Reactor power is greater than demand.

4. The ICS is in the tracking mode of operation. When power and feedwater flow are reduced, header pressure drops, and the governor valves close. When the valves close, generated megawatts decrease.

Transient 3.4 - Ramp Decrease from 100% to 90% - Rx Demand in Manual

Simulator Setup

IC Set: 14 | Malfunction Category: N/A

Malfunction ID: N/A | Severity: N/A

Notes:

1. This transient was initiated by manually reducing the Rx demand's output by 10%.
2. The reactor demand signal is monitored upstream of the signal limiter - not the output of the H/A station.

Point Explanation:

1. When the output of the reactor demand Hand/Automatic station is decreased, a large negative neutron error is created. This error inserts group 7.

2. As group 7 is inserted, the rods add negative reactivity, which reduces reactor power.

3. When the output of the reactor demand station was reduced, reactor demand was less than reactor power by at least 5%. This difference resulted in reactor cross limits to feedwater and increased FW demand.

4. T average decreases because reactor power is less than secondary power. This power mismatch reduces temperature.

~~5.~~ 6. Header pressure decreases because of the drop in RCS temperatures.

~~6.~~ 5. The ICS is in track, and less energy is being deposited into the steam generators. The turbine is attempting to maintain header pressure by reducing load. Turbine governor valves are closing, and generated MW are decreasing.

7. The reactor demand signal is monitored at ~~output of~~ the input to the limits amplifier so this signal reflects the output of the ULD, ~~which is changing because of the tracking signal~~ as modified by the Taverage error. Initially, the reactor demand is reduced by the ULD output, which is decreasing with generated MW (ICS is in track). The reactor demand then increases as Tave. falls below its setpoint.

8. Since the ICS is in track, FW flow is reduced by the ULD output which , in turn, is being lowered by the reduction in generated megawatts. The Taverage error is also decreasing FW demand (with the reactor demand H/A station in manual, Taverage control is transferred to the FW demand subassembly).

Transient 3.5 - Power Decrease - Turbine in Manual

Simulator Setup

IC Set: 14
Malfunction ID: N/A
Malfunction Category: N/A
Severity: N/A

Notes:

1. This transient was initiated by selecting turbine manual and decreasing governor valve position.

Point Explanation:

1. The governor valves are manually throttled, and generated MW decrease.

2. Since the ICS is in track, FW demand decreases as generated MW decrease.

3. Since the ICS is in track, reactor demand decreases as generated MW decrease.

4. When reactor demand decreases below reactor power, the resulting neutron error causes the group 7 rods to be inserted.

Transient 3.6 - Power Decrease - FW in Manual

Simulator Setup

IC Set: 14 Malfunction Category: N/A
Malfunction ID: N/A Severity: N/A

Notes:

1. The FW demand signal is monitored on the input to the H/A stations.

2. The parameters do not change significantly until the heat transfer area in the OTSG is affected by the change in FW flow. (See OTSG Level)

Point Explanation:

1. The decrease in FW flow is caused by the manual decrease in FW demands.

2. The FW subassembly sends a cross limits signal to the reactor demand subassembly when FW flow drops 5% or greater below FW demand.

3. The reduction in FW flow affects the heat transfer in the OTSGs. When header pressure starts to decrease, generated MW decrease because the ICS is in track.

4. Feedwater demand responds to the decrease in ULD output.

5. Reactor power is decreased by the decreased reactor demand signal. Reactor demand is decreased by the decreased ULD output.

Transient 3.7 - Main Feed Pump Trip

Simulator Setup

IC Set: 14 — Malfunction Category: FWS

Malfunction ID: FWS-1A — Severity: N/A

Notes:

1. Both cross-limits exited during this transient
2. There appears to be a 110% limit on FW demand. If the tech manual reflects this limit, the appropriate sheets will be included in the instructor guide.

Point Explanation:

1. The rapid decrease in feedwater flow is caused by the tripping of the main feed pump. Since the FW headers are cross connected, both flows decrease.

2. The increase in feedwater flow error results from the comparison in feedwater demand and the decreasing feedwater flow. As can be seen on the curve, cross limits are generated.

3. The feedwater cross limits reduce the reactor demand signal. Reactor demand is reduced quickly below reactor power.

4. The reduction in reactor demand by feedwater cross limits results in reactor cross limits to feedwater. These cross limits increase feedwater demand.

5. The cross limits signal and the runback signal create a large neutron error that causes rod insertion.

6. The decrease in generated megawatts is caused by the runback signal.

Discussion Items:

1. The majority of PWR reactor trips are caused by FW problems.

2. The Power Conversion system is an initiator of PRA events.

Transient 3.8 - RCP Trip

Simulator Setup

IC Set: 59
Malfunction ID: N/A
Malfunction Category: N/A
Severity: N/A

Notes:
1. IC 59 is a modified IC-14.
2. The transient was initiated by manually tripping the "A" RCP.

Point Explanation:

1. The trip of the RCP decreases RCS flow.

2. The trip of a loop A RCP is sensed by the FW subassembly, and FW to the A OTSG is decreased.

3. The trip of a loop A RCP is sensed by the FW subassembly, and FW to the B OTSG is increased.

4. The heat transfer from the A OTSG initially remains constant (until FW is correctly rationed), this overcools the A loop. Negative values of delta Tc indicate that B Tc is greater than A Tc.

5. The decrease in generated MW is caused by the runback signal.

6. The decrease in reactor demand is caused by the runback signal.

7. Feedwater flow has been rationed based upon RCS flow and delta Tc.

8. The trip of the RCP decreases the discharge pressure seen by the loop B pumps and flow increases.

Transient 3.9 - Dropped Rod

Simulator Setup

IC Set: 14 Malfunction Category: CRD

Malfunction ID: CRD-5E Severity: N/A

Notes:

1. Rod 10 in group 6 dropped.

2. The oscillations in FW flow result from a rapid decrease in demand during the runback. This causes a decrease in MFP speed which lowers delta P. When dP is below setpoint speed is increased. The change in speed causes the oscillations in flow.

Point Explanation:

1. The decrease in group six rod position is caused by the dropped rod. Group 6 has 12 rods - eleven are at 100% and one is at 0%. This gives an average rod position of 91.67%.

2. Negative reactivity is added by the dropped rod, and power decreases.

3. When reactor power drops below reactor demand, cross limits are generated. The cross limit from the reactor demand subassembly rapidly reduces feedwater demand. Note that the general decrease in feedwater demand is due to the runback signal.

4. A dropped rod causes a runback to 60% at a rate of 30% per minute. Generator load is decreasing because of the runback signal.

5. During the first ~85 seconds of this transient, reactor demand is above reactor power and rods should be moving out. But, if reactor power is greater than 60% and a dropped rod exists, an out inhibit is generated. So, group 7 cannot be withdrawn by the ICS.

6. When the rod drops, reactor power is lowered to a value that is below turbine power. This causes a decrease in T avg and the associated drop in pressurizer level.

7. As feedwater flow is reduced by the runback, OTSG levels decrease.

Transient 3.10 - RCP Trip and Dropped Rod

Simulator Setup

IC Set: 59 Malfunction Category: CRD
Malfunction ID: CRD-5B Severity: N/A

Notes:

1. IC-59 is a modified IC-14.
2. This transient was initiated by manually tripping a RCP and initiating CRD-5B
3. The pressurizer level trips were bypassed for this transient.

Point Explanation:

1. RCS flow decreases because of the RCP trip.

2. The group 6 average position includes the dropped rod.

3. The trip of a loop A RCP is sensed by the FW subassembly, and the FW flow to the A OTSG is decreased.

4. The trip of a loop A RCP is sensed by the FW subassembly, and the FW flow to the B OTSG is increased.

5. The negative reactivity of the dropped rod reduces reactor power.

6. Neutron error increases because the dropped rod drives power below the reactor demand.

7. Outward rod motion is inhibited if an asymmetric rod condition exists and reactor power is greater than 60%.

8. The runback signal is decreasing generated MW.

9. Reactor power has been lowered by the dropped rod and is lower than secondary power. This power mismatch drops T Average.

10. The decreasing T Average causes an outsurge from the pressurizer resulting in a expansion of the steam bubble.

Transient 3.11 - Turbine Trip

Simulator Setup

IC Set: 14 | Malfunction Category: N/A

Malfunction ID: N/A | Severity: N/A

Notes:

1. This transient was initiated by manually tripping the turbine.

2. The oscillations in feedwater flow result from rapid changes in feedwater demand which, in turn, cause changes in MFP speed. The change in speed creates a delta P error which changes speed again. In a real plant, this would be tuned to eliminate the swings in flow.

Point Explanation:

1. The step change in generated megawatts is caused by the turbine trip. When the turbine is tripped, the load break switch and the exciter field breaker open.

2. When the turbine trips, the RCS is isothermal. When the increase in temperatures raises header pressure to the turbine trip ~~on line~~ bias values, the turbine bypass and atmospheric dump valves open.

3. The increase in T avg is caused by the closure of the turbine valves. When these valves close, the energy removal from the RCS decreases significantly. The core's energy is deposited into the coolant and temperatures increase.

4. As the RCS heats up, its density decreases causing a large insurge into the pressurizer. The insurge compresses the steam bubble and raises pressure.

5. The oscillations in header pressure are caused by the bistable control of header pressure by the atmospheric dumps. As the valve open and close, header pressure oscillates.

6. The ICS is placed in a tracking condition when the turbine trips. The unit load demand signal is being decreased to zero at a rate of 20% per minute. The general downward trend of the feedwater demand signal is at this rate; however, the header pressure kicker signal is causing the oscillations in demand.

3.11 (cont.)

7. The decrease in reactor demand is due to the tracking conditions. The oscillations in header pressure also affect this signal.

8. Group 7 is inserted in response to the decreasing reactor demand signal.

Transient 3.12 - Load Rejection

Simulator Setup

IC Set: 15 Malfunction Category: N/A

Malfunction ID: N/A Severity: N/A

Notes:

1. This transient was initiated by manually opening the load break switch.
2. The auxiliary boiler was placed in service for feed water heating prior to initiating the transient.
3. The MFP low feed water temperature inhibit switch was placed in inhibit prior to initiating the transient.

Point Explanation [1]

1. The step decrease in generated megawatts was caused by the opening of the load break switch.
2. When the load break switch was opened, the heat removal from the RCS was rapidly reduced. This caused an increase in T average.
3. The decrease in reactor demand was caused by the T average error signal and the tracking signal from the ULD. + Kicker
4. The decrease in feedwater demand is caused by the tracking signal from the ULD.
5. The oscillations in header pressure were caused by the actions of the turbine bypass and atmospheric dump valves.
6. The oscillations in feedwater demand are caused by the kicker signal corrections to the feedwater and reactor subassemblies.
7. The decrease in group 6 position was caused the decrease in reactor demand. Note the overlap with group 7.
8. The increase in RCS flow was caused by the decrease in hot leg temperature.

Transient 3.13 - Power Range Fails High

Simulator Setup

IC Set: 14 | Malfunction Category: Nuc Inst.

Malfunction ID: NIS-4A | Severity: N/A

Notes:

1. The students should be reminded of the Power Range Input to the ICS.
2. The plant stabilizes at a new power level following the transient. The input failure is not severe.

Point Explanation:

1. The increase in reactor power is caused by the power range failure.
2. The failure of the power range channel creates a large neutron error.
3. The large neutron error signal inserts group 7.
4. The increase in feed water flow is caused by reactor cross limits to feedwater.
5. The insertion of group 7 decreases actual reactor power below secondary power, and T average drops. Also, a small overfeed has occurred because of the cross limits signal.
6. The T average error signal increases the reactor demand signal.

Transient 3.14 - Th Fails Low - Btu Limits Enabled

Simulator Setup

IC Set: 15
Malfunction ID: RCS-18B
Malfunction Category: RCS Inst.
Severity: N/A

Notes:

1. Th selector switch placed in the loop A position prior to the transient.

2. The reactor tripped on high RCS pressure at t=18 seconds.

Point Explanation:

1. Btu Limits circuitry reduces FW flow because Th is low.

2. The reduced FW flow lowers OTSG levels.

3. Feedwater cross limits reduce reactor demand.

4. The lower OTSG levels result in less heat transfer area, and less heat is transferred from the RCS. As a result, RCS temperatures increase.

5. The insurge into the pressurizer raises RCS pressure.

6. The reactor trips on high RCS pressure at t=18 seconds.

7. The rapid increase in OTSG levels is caused by the addition of feedwater by the main and auxiliary feedwater systems. Note that level decreased below 12 inches, and both the AFW and Startup valves opened fully to restore level. Since a finite time is required for the valves to close, levels exceed the 24 inch setpoint.

8. The AFW and Startup feedwater valves are closed, and OTSG inventory is reduced by steam flow through the turbine bypass valves.

Transient 3.15 - T hot Fails Low

Simulator Setup

IC Set: 15

Malfunction Category: RCS Instrumentation

Malfunction ID: RCS-18B

Severity: N/A

Notes:

1. Btu limits not in effect.
2. Reactor trip on high RCS pressure at t=54 seconds
3. The temperature curves do not reflect the failure.

POINT EXPLANATION

1. When Th fails low, a large Tavg error is created and increases the reactor demand signal.
2. The increased reactor demand signal is compared with actual power and results in an increased neutron error.
3. Neutron error (created by the large Tavg error) causes outward rod motion in an effort to raise Tavg.
4. The withdrawal of the rods adds positive reactivity and increases reactor power.
5. Since the energy removal is almost constant, the higher reactor power increases RCS temperatures.
6. Increased temperatures in the RCS raise header pressure, and the kicker signal reduces the feedwater demand signal.
7. As RCS temperatures increase, an insurge into the pressurizer occurs. The insurge compresses the steam bubble and increases RCS pressure.
8. The reactor trips on high RCS pressure at t=54 seconds.

DISCUSSION ITEMS

1. This transient will not occur on an operating plant if the SASS functions correctly.
2. Operator action: (1) Place the diamond and rx demand stations in manual. (2) Select an operable T hot instrument.

Transient 3.16 - Cold Leg Temperature Fails High

Simulator Setup

IC Set: 14 — Malfunction Category: RCS

Malfunction ID: RCS-19H — Severity: N/A

Notes:

1. Transient Curves reflect actual temperatures.
2. TT4A8 selected for ICS input prior to failure.

Point Explanation:

1. When the loop A Tc input fails high, the delta Tc error increases the feedwater demand to A OTSG. Note that the actual feedwater flow to the A OTSG cannot increase above 110%.
2. Since B FW demand is equal to Total FW demand - A FW demand, when A FW demand increases, B FW demand decreases.
3. A large Tavg error is created when the RTD fails high. [((629 + 650)/2) = 639.5 or a 38.5 degree error]. This error signal ,combined with FW cross limits, reduces the reactor demand.
4. When the feedwater demand signals change FW flow, the A OTSG is overfed, and the B OTSG is underfed. This cools down loop A and heats up loop B.
5. Group 7 drives in to correct for the Tavg error.
6. As reactor power is lowered below secondary power, Tavg drops.
7. The decrease in Tavg causes an outsurge from the pressurizer.
8. The reactor trip was caused by low pressurizer level.

Transient 3.17 - RCS Flow Transmitter Fails Low

Simulator Setup

IC Set: 15
Malfunction ID: RCS-14E

Malfunction Category: RCS Inst.
Severity: N/A

Notes:

1. The RCS flow curve does not show the effect of the flow transmitter failure. (Comes from RPS Flow)
2. The reactor tripped on high RCS pressure at t=51 seconds.

Point Explanation:

1. When the flow transmitter fails low, feedwater flow is rationed to the OTSGs. Since the failure is associated with RCS loop A, the A FW flow is decreased.
2. When the flow transmitter fails low, feedwater flow is rationed to the OTSGs. Since the failure is associated with RCS loop A, the B FW flow is increased.
3. A reduced A feedwater flow results in a lower A OTSG level.
4. As the level in the A OTSG decreases, less heat transfer area is available, and less heat is removed by the steam generator. The lack of heat removal increases A loop Tc.
5. The lack of proper heat removal in the A RCS loop increases T Average.
6. The increase in T Average increases pressurizer level which, in turn, increases RCS pressure.
7. The reactor trips on high RCS pressure.

TRANSIENT 3.18 - FW FLOW TRANSMITTER FAILS HIGH

INITIAL CONDITIONS

Reactor Power: 100%	Generated MW: 1338
T Average: 602 F	RCS Pressure: 2200 psig
Pzr Level: 225 in.	Rod Index: 278

Transient Initiator: B Loop FW Flow transmitter fails high.

Point Explanation:

1. When the B FW flow transmitter fails high, the FW subassembly closes the B loop FW regulating valves.

2. When FW flow is reduced, B OTSG level decreases.

3. As the level drops in the B OTSG, less heat is transferred in the steam generator. Less energy is removed from the B RCS loop and Tc increases.

4. As header pressure drops because of the reduced steam production, actual generated MW decrease. The decrease in generated MW creates a megawatt error (ULD output has not changed) that modifies the header pressure setpoint The setpoint modification more than compensates for the reduction in header pressure, and a positive pressure error opens the governor valves. When all of the governor valves are fully open, generated MW decrease.

5. Header pressure is decreasing because of the reduced steam production in the B OTSG.

Transient 3.19 - FW Flow Transmitter Fails Low

Simulator Setup

IC Set: 15
Malfunction ID: FWS-9F
Malfunction Category: FW Inst.
Severity: N/A

Notes:

1. The reactor tripped on low pressurizer level at t=81 seconds.

Point Explanation:

1. When the failed low input signal is compared with loop B feedwater demand, the resulting large error signal opens the main feed reg valve.

2. Feedwater demand remains at 100%, and FW flow is reduced by half due to the failure. A very large cross limits signal is generated.

3. The large FW to Reactor cross limit signal rapidly reduces reactor demand.

4. The FW to Reactor cross limit signal rapidly reduces the reactor demand signal and creates a large neutron error signal.

5. Feedwater demand is increased by the reactor to feedwater cross limit signal.

6. Group 7 responds to the large neutron error signal.

7. The RCS is being overcooled by the "extra" feedwater, and reactor power is being quickly reduced by the insertion of group 7. These factors combine to lower T Average, and the volumetric contraction lowers pressurizer level.

8. Low pressurizer level trips the reactor at t=81 seconds.

Transient 3.20 - Pressurizer Pressure Transmitter Fails High

Simulator Setup

IC Set: 14 Malfunction Category: RCS
Instrumentation

Malfunction ID: RCS-23G Severity: N/A

Notes:

1. Reactor Trip on low RCS pressure at t=60 seconds.

2. ESFAS channels one and 2 were actuated by low RCS pressure

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POINT EXPLANATION

1. When the pressure transmitter fails high, signals are sent to open the spray valve and the power operated relief valve. Both valves reduce RCS pressure.

2. The reactor trips on low RCS pressure at t=60 seconds.

3. When the reactor trips, the ICS selects the reactor trip bias values for header pressure control. The bias increases the setpoint to 1200 psig.

4. As RCS pressure continues to decrease, ESFAS channels 1 and 2 are actuated by low RCS pressure.

5. ESFAS closes the MSIVs, and header pressure decays to zero.

6. ESFAS also actuates AFW, and AFW flow raises OTSG levels.

7. The increase in pressurizer level is caused by HPI flow.

DISCUSSION ITEMS

1. This transient can be terminated by closing the spray and PORV block valves. Once the valves are closed, the operator should select an operable transmitter.

2. Remind the students that the 177 FA plants may have to shift connections in the RPS cabinets.

Transient 3.22 - Pressurizer Level Fails Low

Simulator Setup

IC Set: 15
Malfunction ID: RCS-21J
Malfunction Category: RCS Inst.
Severity: N/A

Notes:

1. This is a 20 minute transient.
2. The reactor tripped on high RCS pressure at 347 seconds.
3. The makeup pump tripped on low suction pressure at 18.5 minutes.

Point Explanation:

1. When the pressurizer level transmitter failed low, the makeup flow control valve opened fully. Pressurizer level is increasing because makeup flow is > 300 gpm, and letdown flow is only 50 gpm.

2. The decrease in makeup tank level reflects the increased makeup flow.

3. As pressurizer level increases, the steam bubble in the pressurizer is compressed, raising RCS pressure.

4. The reactor trip is caused by high RCS pressure.

5. The decrease in pressurizer level is caused by the temperature decrease following the reactor trip.

Transient 3.23 - Manual Reactor Trip

Simulator Setup

IC Set: 14 | Malfunction Category: none

Malfunction ID: none | Severity: N/A

Notes:
1. Transient initiated by manually tripping the reactor

POINT EXPLANATION

1. The manual pushbutton activates the UV coils in the reactor trip circuit breakers, and the rods are deenergized.

2. The decrease in reactor power is caused by the large negative reactivity addition from the rod insertion. Groups 1 through 7 add approximately -11% reactivity.

3. The turbine trips when the reactor trips. The turbine trip signal opens the load break switch and the exciter field breaker. Of course, all turbine valves are closed by the trip signal.

4. Header pressure setpoint is increased to 1200 psig by the ICS. Once it reaches this value, the turbine bypass valves and the atmospheric dump valves control header pressure.

5. Tavg will be decreased from 601F to saturation temperature for 1200 psig (~570F) because of the reactor trip bias values.

6. The temperature-induced density decrease causes an outsurge from the pressurizer.

7. The outsurge from the pressurizer results in a decrease in pressurizer pressure.

8. Relays T10 & 11 switch the FW demand to the valves to the level error signal. Since level is initially at 80 inches, the large level error results in a rapid reduction in feedwater flow.

9. The decrease in feedwater flow plus the dumping of steam results in a decrease in OTSG level.

10. The makeup flow control valve opens fully as pressurizer level drops below 220 inches. When the cooldown slows, the increase in makeup flow raises pzr level.

11. The RCS flow signal is density compensated by hot leg temperature which decreases following the trip. Actual mass flow rate increases because the water is more dense.

Transient 3.24 - Small Break LOCA

Simulator Setup

IC Set: 14
Malfunction ID: RCS-1B
Malfunction Category: RCS
Severity: 0.7%

Notes:

1. The initial leak rate is 1000 GPM.
2. The reactor tripped on low pzr level.
3. ESFAS Channels 1 and 2 were actuated by low RCS pressure.

Transient Initiator: Small Break LOCA

Point Explanation:

1. The loss of RCS inventory through the break decreases RCS pressure.

2. The decrease in pressurizer level allows the steam bubble to expand, lowering RCS pressure.

3. High energy fluid is escaping into the RB, raising its pressure.

4. The reactor trip was caused by low pressurizer level.

5. ESFAS is actuated by low RCS pressure.

6. HPI flow exceeds break flow and RCS inventory is being restored.

Discussion Items:

1. PRA insights will be discussed.

2. Discuss how ESFAS actuation signals can be determined.

Transient 3.25 - Large LOCA

Simulator Setup

IC Set: 14

Malfunction Category: RCS

Malfunction ID: RCS-1B

Severity: 100%

Notes:

1. Break flow, HPI, and AFW flow not plotted. Break flow is extremely large.
2. 100% severity corresponds to a double-ended rupture of the cold leg.
3. The reactor trips almost immediately, and ESFAS is actuated almost immediately.
4. The change in slope on the curve of RB pressure is due to spray.

POINT EXPLANATION

1. The large loss of inventory empties the pressurizer very quickly.
2. As the pressurizer empties, RCS pressure decreases.
3. High energy RCS fluid escapes into the RB, raising its pressure.
4. As the RCS empties, significant steam voids are formed in the system. The RCPs are attempting to pump steam.
5. ECCS flow from the HPI system and Core Flooding system has reduced system temperatures. SG pressure follows the decrease in temperature.

Discussion Items

1. The operator would trip the RCPs per procedure - loss of subcooling.
2. A cold leg break is more severe than a hot leg break.
3. Boron precipitation methods
4. Internal vent valves.

Transient 3.26 - Failed Open PORV

Simulator Setup

IC Set: 14

Malfunction Category: RCS

Malfunction ID: RCS-10

Severity: N/A

Notes:

1. Reactor Trip on low RCS pressure at t=70 seconds.

2. ESFAS channels 1 and 2 actuated on low RCS pressure at t=110 seconds.

3. The ESFAS signal to AFW was not placed in manual

4. The RCS did not reach saturation temperature in this transient.

POINT EXPLANATION

1. The decrease in RCS pressure is caused by the failed open PORV.

2. The reactor trip was initiated by low RCS pressure (2000 psig)

3. The increase in pressurizer level is due to HPI.

4. RB pressure remains constant because the PORV discharges to the RCDT and the rupture diaphragm did not break in 5 minutes.

Transient 3.27 - Main Steam Break inside the Reactor Building

Simulator Setup

IC Set: 13

Malfunction Category: Main Steam

Malfunction ID: MSS-1A

Severity: 100%

Notes:

1. ESFAS on high RB pressure prior to the reactor trip.
2. Reactor trip on high RCS pressure
3. Since the PORV setpoint was 2295, some spikes occur at the pressure.
4. Reactor demand goes crazy during this transient. The rapid decrease is caused by a combination of cross-limits, Tavg error and header pressure error.
5. Note the effect of delta Tc on the feedwater demands.

POINT EXPLANATION

1. Both steam generators are supplying the break at this time. Therefore, pressure in both generators decreases.
2. High energy steam is escaping into the reactor building raising its pressure. High RB pressure generates an ESFAS signal at approximately 14 seconds into the transient.
3. The steam break reduces steam flow to the turbine, and its output decreases. Note that generated MWe drops to zero prior to the reactor trip. This drop is caused by the ESFAS closure of the MSIVs.
4. The ESFAS signal closes the Main Feedwater Isolation Valves, and feedwater flow is isolated to the OTSGs.
5. At this point in the transient, reactor power is at 100%. However, the only energy removal from the RCS is break flow (~15% power). This large energy mismatch increases RCS temperature, resulting in a large insurge into the pressurizer. The insurge increases RCS pressure.
6. The reactor trip is caused by high RCS pressure.
7. When the MSIVs close, energy removal from the "B" OTSG ceases. The steam generator pressure is now a function of RCS temperatures.

3.27 (cont.)

8. "A" OTSG pressure is less than 600 psig, and the feed-only-good-generator logic isolates AFW.

9. The break still exists, and all feedwater has been isolated to the OTSG. Pressure drops because the generator is being boiled dry.

10. All feedwater has been isolated. The generator has boiled dry.

11. No water, no steam, no break!!

Transient 3.28 - Main Steam Break Downstream of the MSIVs

Simulator Setup

IC Set: 15 Malfunction Category: Main Steam

Malfunction ID: MSS-2B Severity: 100%

Notes:

1. Reactor trip on High Power at t=4 seconds
2. ESFAS channels 1&2 on low RCS pressure at t=16 seconds
3. ESFAS AFW signal not bypassed

POINT EXPLANATION

1. The rapid decrease in OTSG pressure is caused by the steam break.
2. The reactor trip is caused by high power. (EOL - large negative MTC)
3. The increase in OTSG level is caused by AFW flow. AFW was activated by ESFAS on low RCS pressure.
4. The decrease in Tavg was caused by the overcooling event.
5. The decrease in RCS pressure is caused by the outsurge from the pressurizer which, in turn, is caused by the temperature - induced density change.
6. The increase in pressurizer level is caused by HPI flow.

Discussion Items:

1. Should HPI/AFW be throttled?
2. Classical PTS scenario.

TRANSIENT 3.29 - MAIN STEAM SAFETY FAILS OPEN

INITIAL CONDITIONS

Reactor Power: 99%	Generated Megawatts: 1338
T Average: 601F	RCS Pressure: 2195 psig
Pzr Level: 220 in	Rod Index: 274

Transient Initiator: One main steam safety valve opens at 100% power.

Point Explanation:

1. When the safety opens, a higher RCS energy removal rate exists which lowers RCS temperatures and header pressure.

2. As header pressure drops because of the flow through the failed safety valve, actual generated MW decrease. The decrease in generated MW creates a megawatt error (ULD output has not changed) that modifies the header pressure setpoint The setpoint modification more than compensates for the reduction in header pressure, and a positive pressure error opens the governor valves. When all of the governor valves are fully open, generated MW decrease.

3. The decrease in T avg is caused by the excess in energy removal. In ATOG terms, this is an excessive heat removal event.

4. The T avg error and the header pressure error increase reactor demand.

5. The increase in reactor power is caused by the positive reactivity added by group 7 withdrawal (neutron error results from the Tavg error) and the Moderator Temperature Coefficient.

Transient 3.30 - Loss of Offsite Power

Simulator Setup

IC Set: 14 | Malfunction Category: Electrical

Malfunction ID: HVN-1 | Severity: N/A

Notes:

1. All three AFW pumps started when both FW pumps tripped.
2. Two Makeup pumps started after the diesels picked up the vital buses. The standby pump started on low seal injection flow.

Point Explanation:

1. When offsite power is lost, the RCPs coast down to 0 RPM. As the pumps coast down, flow decreases.
2. The reactor trips because power is lost to the rods. Also, the pump monitor (a part of the calculating module) will generate a reactor trip signal.
3. The increase in pressurizer level toward the end of the transient is caused by makeup flow and the increase in temperature.
4. All three AFW pumps started when both FW pumps were lost. The AFW flow is raising OTSG level.
5. Heat removal in the OTSG lowers Tc and the decay heat from the core increases Th. The delta T is necessary for natural circulation.

Discussion Items

1. The conditions necessary for natural circulation.

2. This transient will be taught with transient #31. The equipment available for transient mitigation with the diesels should be contrasted with the equipment that is available to cope with a station blackout.

Transient 3.31 - Loss of All AC (Station Blackout)

Simulator Setup

IC Set: 14

Malfunction Category: Electrical Diesels

Malfunction ID: HVN-1
EDG-1A
EDG-1B

Severity: N/A

Notes:

1. Only the turbine driven AFW pump started, and it started on low steam generator level.

Point Explanation:

1. When all AC power is lost, the RCPs coast down to 0 RPM. As the pumps coast down, flow decreases.

2. The reactor trips because power is lost to the rods. Also, the pump monitor (a part of the calculating module) will generate a trip signal.

3. The turbine-driven AFW pump starts on low steam generator level and flow from this pump raises OTSG levels.

Discussion Items:

1. The safety issues and fixes for this transient were discussed in the 506 lecture on station blackout. The instructor should review the concerns associated with this transient.

2. The PRA insights shall be covered.

Transient 3.32 - Anticipated Transient Without Scram

Simulator Setup

IC Set: 13

Malfunction Category: RPS
FWS

Malfunction ID: RPS-11C
FWS-1A
FWS-1B

Severity: N/A

Notes:

1. This is a two minute transient because the simulator bombs on high pzr level or some other large parameter.

Point Explanation:

1. The step decrease in generated megawatts is caused by a turbine trip which, in turn, is caused by a loss of both MFPs.

2. When the MFPs are tripped, feed flow drops.

3. The decrease in reactor demand is caused by the combination of feedwater cross limits and T avg error.

4. The decrease in reactor demand is compared with actual reactor power, and a positive neutron error is created. This error signal results in the insertion of group 7.

5. Energy is being removed by steam flow through the bypass and atmospheric dump valves; however, insufficient feed flow is available. Therefore, OTSG levels decrease.

6. The increase in T avg is due to the OTSGs boiling dry. The increase in T avg results in a large RCS density decrease that increases pressurizer level.

7. The increase in pressurizer level compresses the steam bubble and increases RCS pressure. Note that the reactor should have tripped on high RCS pressure.

8. The decrease in reactor power is caused by the insertion of group 7 rods and the moderator temperature coefficient.

9. As reactor power is reduced, the turbine bypass and atmospheric dump valves close. Steaming rate is decreased, and AFW starts to recover OTSG level.

10. The RCS is in saturation, and the RCPs are pumping a mixture of steam and water.

Transient 3.33 - Continuous Rod Withdrawal(BOL)

Simulator Setup

IC Set: 9 Malfunction Category: N/A

Malfunction ID: N/A Severity: N/A

Notes:

1. This transient was initiated by the manual withdrawal of group 6.

Point Explanation:

1. Group 6 is manually withdrawn.
2. Positive reactivity is added by the withdrawal of group 6, and reactor power increases.
3. A high Startup Rate withdrawal hold is generated by the intermediate range.
4. Reactor power is at the point of adding heat, and T average increases.
5. Power to delta T is the reactor trip signal.

Transient 3.34 - Continuous Rod Withdrawal

Simulator Setup

IC Set: 56 Malfunction Category: N/A

Malfunction ID: N/A Severity: N/A

Notes:

1. This transient was initiated by the manual withdrawal of group 6.
2. At ~98 seconds, the high SUR withdrawal hold cleared and the fault reset push button was depressed, allowing group 6 outward motion.

Point Explanation:

1. Group 6 is manually withdrawn.
2. Positive reactivity is added by the withdrawal of group 6, and reactor power increases.
3. The source range is automatically de-energized by the intermediate range.
4. A high Startup Rate withdrawal hold is generated by the intermediate range.
5. Reactor power is at the point of adding heat, and T average increases.
6. Power to delta T is the reactor trip signal.
7. The header pressure setpoint is increased by the reactor trip bias values, and the RCPs are slowly increasing system temperatures.

Transient 3.35 - Ejected Rod - 0% Power

Simulator Setup

IC Set: 57 Malfunction Category: CRD

Malfunction ID: CRD-6 Severity: N/A

Notes:
1. Rod Position is group average position

Point Explanation:

1. When the rod is ejected, the position indication system senses that the rod is at 100%. This raises the group average.

2. The ejected rod adds positive reactivity, and reactor power increases.

3. The rod is ejected through the top of the CRDM housing. This is a breach of the pressure boundary and causes RCS leakage. The decrease in level is caused by the leakage.

4. The Reactor trips on low pressurizer level.

5. When the reactor trips, the ICS adds bias to the header pressure setpoint. The slow increase is caused by the heat up from the RCPs.

6. Group 6 contains 8 rods. The average position is 100/8 = 8.33

Transient 3.36 - Ejected Rod - 100% Power

Simulator Setup

IC Set: 15 Malfunction Category: CRD

Malfunction ID: CRD-6 Severity: N/A

Notes:

1. Rod position graphs are of average group position

Point Explanation:

1. The rod is ejected because of a failure in the rod housing. The failure allows coolant to escape to the reactor building.

2. The reactor trips on low pressurizer level.

3. The ejected rod's position is 100%. The group average for group 6 includes the 100% value, i.e., 100/8 = 8.33%

4. ESF is actuated by low RCS pressure.