NINE MILE POINT NUCLEAR STATION

UNIT II OPERATIONS

LESSON PLAN

REACTOR VESSEL INSTRUMENTATION

02-REQ-0041-216-2-01

Prepared By: Nine Mile Point Unit 2
Operations Training Staff

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Summary of Pages

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NIAGARA MOHAWK POWER CORPORATION

UNIT #2

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Attachment "A"

OBJECTIVE APPROVAL

Author: R. Brown

Training Dept: Unit II Ops.

Lesson Title: Reactor Vessel Instrumentation

Lesson Plan #: N2-OLP-05

Training Setting(s): Classroom

Purpose: Instructor shall present information for the student to meet each Student Learning Objective. Additionally, he shall provide supplemental explanation to facilitate the student's understanding of the information presented.

Trainee Job Title: Licensed Operator Candidate

Approvals/Review	Signatures	Date
Training Supervisor		3/25/88
Plant Supervisor		6/25/88
Training Analysts Supervisor	W Bruse/MAB	3-24-88

When complete, attach this form to the master lesson plan.

I. TRAINING DESCRIPTION

A. Title: Reactor Vessel Instrumentation

B. Purpose: In a lecture presentation, the instructor shall present information for the student to meet each Student Learning Objective. Additionally, he shall provide sufficient explanation to facilitate the student's understanding of the information presented.

C. Total Time: 6 Hours

D. Teaching Methods:

- Classroom Lecture
- Assign the Student Learning Objectives as review problems with the students obtaining answers from the text, writing them down and handing them in for grading.

E. References:

1. Technical Specifications

	LCO	SURVEILLANCE
a. Water Level		
Low (Level 3)		
Primary Containment Isolation	3.3.2	4.3.2.1-3
Reactor protection System	3.3.1	4.3.1.1-3
Div I ECCS Actuation Automatic Depressurization System Trip System "A"	3.3.3	4.3.3.1-3
Div II ECCS Actuation Automatic Depressurization System Trip System B	3.3.3	4.3.3.1-3
Low Low (Level 2)		
Primary Containment Isolation	3.3.2	4.3.2.1-3
Div III ECCS Actuation HPCS	3.3.3	4.3.3.1-3
ATWS Recirculation Pump Trip	3.3.4	4.3.4.1.1-2
RCIC Actuation	3.3.5	4.3.5.1-2

	LCO	SURVEILLANCE	
a. Water Level (Cont'd.)			
Low Low Low (Level 1)			
Primary Containment Isolation	3.3.2	4.3.2.1-3	
Div I ECCS Actuation			
RHR-A (LPCI Mode) & LPCS	3.3.3	4.3.3.1-3	
Automatic Depressurization Trip System "A"	3.3.3	4.3.3.1-3	
Div II ECCS Actuation			
RHR B and C (LPCI Mode)	3.3.3	4.3.3.1-3	
Automatic Depressurization System Trip "B"	3.3.3	4.3.3.1-3	
High (Level B)			
Div III ECCS Trip	3.3.3	4.3.3.1-3	4
Feedwater System/Main Turbine Trip System Actuation	3.3.9	4.3.9.1-2	
RCIC Actuation Instrumentation	3.3.5	4.3.5.1-2	
Remote Shutdown Monitoring			
Wide & Narrow Range	3.3.7	4.3.7.4.1-2	
Accident Monitoring	3.3.7	4.3.7.5	
b. Pressure			
Steam Dome - Reactor Protection	3.3.1	4.3.1.1-3	
Primary Containment Isolation	3.3.2	4.3.2.1-3	
ATWS Recirculation Pump Trip	3.3.4	4.3.4.1.1-2	
High Pressure Limit	3.4.6	4.4.6.2	
Remote Shutdown Monitoring	3.3.7	4.3.7.4.1-2	
Accident Monitoring	3.3.7	4.3.7.5	

2. N2-OP-34 Nuclear Boiler Automatic Depressurization and Safety Relief Valve
3. NMP-2 FSAR, Vol. 13, Chapter 5, Pg. 5.4-16

II. REQUIREMENTS AND PREREQUISITES

A. Requirements for Class:
1. AP-9, Rev. 2, Administration of Training
2. NTP-10, Rev. 3, Training of Licensed Operator Candidates
3. NTP-11, Rev. 4, Licensed Operator Retraining and Continued Training
4. NTP-12, Rev. 2, Unlicensed Operator Training

B. Prerequisites:
1. Instructor
a. Demonstrated knowledge and skills in the subject, at or above the level to be achieved by the trainees, as evidenced by previous training or education, or
b. SRO license for Nine Mile Point Unit Two or a similar plant, or successful completion of SRO training, including Simulator certification at the SRO level for Nine Mile Point Unit Two.
c. Qualified in instructional skills as certified by the Training Analyst Supervisor.
2. Students
a. Meet eligibility requirements per 10CFR55, or
b. Be recommended for this training by the Operation Superintendent or his designee or the Training Superintendent.

III. TRAINING MATERIALS

A. Teaching Materials:

1. Transparency Package
2. Overhead Projector
3. Whiteboard and Felt Tip Markers
4. N2-OLP-05
5. N2-OLT-05
6. Section I.E.1
7. Section I.E.2

B. Student Materials

1. N2-OLT-05
2. Section I.E.1
3. Section I.E.2

IV. QUIZZES, TESTS AND ANSWER KEYS

Will be generated and administered as necessary. They will be on permanent file in the Records Room.

V. OBJECTIVES FOR THE REACTOR VESSEL INSTRUMENTATION SYSTEM (RVI)

Upon completion of this chapter, mastery of the required system knowledge will be demonstrated by performing the enabling objectives listed below.

5-1 State the purpose of the Reactor Vessel Instrumentation (RVI) system.

5-2 State the following with regard to temperature monitoring:

a. Types of detectors used |4

b. List the points on the RPV that are monitored. |

5-3 State the following with regard to water level monitoring:

a. Instrument Zero |4

b. Calibration conditions for each range

c. Trips associated with each level and which range provides the trip signal |4

d. Control Room panel location and instrument type (i.e. meter, recorder) |4 |

5-4 State the trips and setpoints associated with vessel pressure monitoring.

5-5 State the following with regard to core flow monitoring:

a. Number of Jet Pumps (JP's) and calibrated JP's

b. Purpose of monitoring core flow

c. How total core flow is determined. |4 |

5-6 State the following with regard to core plate D/P monitoring:

a. Purpose of monitoring core plate D/P

b. Location of sensing points |4

5-7 Discuss the principle of operation of the following RVI system instruments: |4

1. Thermocouple
2. RTD
3. Core Flow summing network

5-8 For the RVI system instrument response during accident conditions, discuss the following:

a. Response to ambient temperature change
b. Rupture in reference and variable legs

5-9 Given N2-OP-34, Nuclear Boiler, Automatic Depressurization and Safety Relief Valves, use the procedure to identify the appropriate actions and/or locate information related to: |4

a. Start-up
b. Normal Operation
c. Shutdown
d. Off-Normal Operations
e. Procedures for correcting alarm conditions

5-10 <u>SRO ONLY</u> Given Technical Specifications, identify the appropriate actions and/or locate information relating to limiting conditions for operation, bases, and surveillance requirements for the Reactor Vessel Instrumentation System.

VI. LESSON CONTENT

	Text Ref. Page	Text Ref. Fig.	S.L.O.
I. INTRODUCTION			
A. Student Learning Objectives	i, ii		
B. System Purpose			1
1. Purpose Provides indication, control inputs and recording of temperature, pressure, flow, water level and top head flange leakage. Also provides inputs for various alarms and protective functions.	1		
C. General Description			
1. Reactor Vessel Instrumentation System consists of several subsystems to measure basic reactor vessel parameters including: a. Temperature b. Water Level c. Pressure d. Flow	1		
2. Temperature - indicators provided for both vessel metal and fluid temperature. a. Vessel coolant saturation temperature calculated from vessel pressure.			
3. Vessel Water Level a. Five (5) different ranges provided to monitor coolant level.			
4. Vessel Pressure a. Provided on both narrow and wide range.			

		Text Ref. Page	Text Ref. Fig.	S.L.O.
5.	Core Coolant Flow	1		
	a. Total flow through core must also pass through jet pumps.			
	b. Flow through each jet pump is measured and summed to yield total core flow.			
II.	DETAILED DESCRIPTION			
A.	Temperature Monitoring	2		2a
1.	Types of devices			
	a. Thermocouples			
	b. Resistance temperatures detector (RTD)			
2.	Principle of operation			7a
	a. Thermocouple - two dissimilar metals in contact produce a voltage proportional to the temperature of the junction of the metals.			
	b. RTD - electrical resistance in a metal varies with temperature. Resistance can be converted to temperature.			7b
3.	Reactor vessel temperature	3		
	a. Measure temperature at four locations with thermocouples			2b |4
	1) Two on the vessel top head flange			
	2) Two on the vessel shell flange			
	3) Two on the vessel bottom head region			
	4) One dual element on the bottom head drain line			|4

	Text Ref. Page	Text Ref. Fig.	S.L.O.
b. The thermocouple wires terminate in a junction box in containment. The thermocouple signal goes to a multipoint recorder in the control room (P614).	3		
c. Thermocouples provide representative sample of vessel skin temperature for the following:			
1) Verifying temperature limitations are not exceeded.			
2) Aids in monitoring temperature gradient across vessel metal.			
4. Feedwater temperature			
a. Measure temperature of feedwater entering vessel.			
b. Used for reactor heat balance calculations.			
c. Uses an RTD.			|4
5. Reactor recirculation loop suction temperature			
a. Used for control room indication and recirc pump control and interlocks.			
b. Uses an RTD			|4

Text Ref. Page	Text Ref. Fig.	S.L.O.
4		

B. Water Level Monitoring

1. Water level signals provide
   a. Aid to the operator in safe operation of the reactor.
   b. Trip inputs to the Reactor Protection System (RPS), Primary Containment Isolation (ICS), and the Emergency Core Cooling Systems (ECCS).
2. The water level measured is the level existing in the downcomer annulus except for the fuel zone instruments. |4
3. To measure level, two connections are made to the reactor vessel and connected to a differential pressure detector.
   a. The upper penetration (reference leg) penetrates the reactor vessel in steam volume area and connects to condensing chamber. Steam condenses in chamber and collects in the reference leg which connects to the high pressure side of the transmitter.
   b. The lower penetration (variable leg) penetrates the reactor vessel in downcomer annulus region and connects to the low pressure side of level transmitter.
      - The variable leg for the fuel zone/range uses jet pump instrument tap (communicates inside shroud).

		Text Ref. Page	Text Ref. Fig.	S.L.O.
c.	With this arrangement reactor pressure is felt on both sides of the level transmitter.	4		
d.	Since reference leg level remains constant, any change in reactor vessel level is sensed as change in differential pressure.			
e.	Level transmitter converts this change in differential pressure to an electrical signal and transmits it to a control room indication, RPS trip channel or an alarm.	5		
f.	The instrument indicates maximum level when D/P is ZERO and indicates minimum level when D/P is maximum.			
g.	Non-compensated - each level instrument is calibrated for specific conditions and will only read correctly under these conditions.			
4.	Five ranges of level instruments provided: 1) Narrow range 2) Wide range 3) Shutdown range 4) Upset range 5) Fuel zone		1	
5.	Each instrument range has its own redundancy requirements and must be functionally independent of others.			

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
6.	"Instrument Zero"	5	1	3a	
	a. All level instruments are referenced to 380.69 inches above "vessel zero".				
	b. This is the top of the reactor vessel upper grid top guide).				
	c. Level setpoints referenced to instrument zero.				

NMP-2 LEVEL	NMP2 NOMENCLATURE	6
202.3"	High Level Trip	
187.3"	High Level Alarm	
	Normal Water Level	
178.3"	Low Level Alarm	
159.3"	Low Level Trip	
108.8"	Double Level Trip	
17.8"	Triple-Low Level Trip	

7.	Narrow Range Instrumentation			3b	|4
	a. Calibrated for saturated RPV conditions. 1000 psig in the reactor vessel and 135°F in the drywell.		2		
	b. Range is 145 inches to 205 inches				
	c. The level transmitters are divided among four condensing chambers.				
	1) Two transmitters send low level trip signals to the ADS system for confirmation of the triple Low level signal.				|4

		Text Ref. Page	Text Ref. Fig.	S.L.O.
2)	Four transmitters send signals to:	6	2	
	a) Four level indicating switches on the RPS logic panels in the control room (scram signals).			
	b) ISC systems for RHS isolation.			
3)	Three transmitters are part of the feedwater control system:	7		
	a) All three provide indication in the control room (P603).			3c
	b) Signals from one of two transmitters are routed through the Reactor Water Level A(B) Level switch on panel 603 providing an input to:			
	- Reactor water level alarm (high/lo)			
	- Reactor level recorder on panel P603.			3d
	- Low level signal to the RRFC system for a Flow Control Valve runback.			3c

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
	- Low level trip signal to RRS system to trip the RRS pumps to slow.	7	2	3c	
	- Feedwater control circuitry				
	- Process Computer				4
	c) All three transmitters send a 2 out of 3 trip signal to the EHC and feedwater system to trip the main turbine and feedpumps on a High level trip.				
	d) The B and C narrow range indicators are powered from normal 125 VDC (2BYS-PNLA102 and 2BYS-PNLB102).				
8.	Wide Range Instrumentation	7	3		
	a. Used for automatic initiation of ECCS systems.				
	b. Calibration conditions:			3b	
	1) 135°F in drywell				
	2) 1000 psig in vessel (saturated conditions) and 20 Btu/lbm subcooling below middle water level nozzle.				4
	3) No J.P. flow				
	c. Range is -5 inches to 205 inches referenced to instrument zero.				
	d. Condensing chambers are the same ones used by the narrow range.				4

	Text Ref. Page	Text Ref. Fig.	S.L.O.
e. Two wide range transmitters provide level signals to the post accident monitoring system recorders on panel 601. The two speed recorders shift to fast speed on a double low level trip.	8		3d
f. One transmitter provides a level signal to an indicator on panel 603.			
g. Four transmitters provide signals to indicating switches for triple low and non-indicating switches (trip function only) set at double low.			
1) Triple Low trips initiate			
a) LPCI			3c
b) Low pressure core spray (CSL)			
c) ADS			
d) Div I and II stand-by diesels.			
2) Double Low trips initiate			
a) Reactor core isolation cooling system (ICS)			
3) High level closes the ICS turbine steam admission valve.			
h. Four level transmitters provide inputs to:			
1) Indicating switches set at double low level			
2) Initiating logic of CSH and Division III diesel			

|4

		Text Ref. Page	Text Ref. Fig.	S.L.O.
	3) Double Low level alarm on panel 601	8		3c
	4) Process Computer			
i.	Four level transmitters send a signal to analog trip units which send a double low trip to the Redundant Reactivity Control System. (Prevents ATWS)			
j.	Four level transmitters send signals to:	9		
	1) Indicating switches set at triple low for MSIV isolation			
	2) Non-indicating switches set at double low for isolation of certain primary system and containment isolation valves (covered in the Primary Cont. Isol. chapter).			
k.	Two level transmitters provide local indication of wide range water level.			
4.	Shutdown Range Instrumentation		4	3b
a.	Calibration conditions			
	1) 120°F reactor water temperature			
	2) 0 psig in reactor vessel			
	3) 80°F in drywell			
b.	Range is 145 inches to 545 inches			
c.	Condensing chamber connects to a line from the reactor vessel head vent			
d.	Shutdown range uses one transmitter providing level to a meter indication on panel 851.			3d

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
5.	Upset Range Instrumentation	9	4	3b	
	a. Calibration conditions				
	1) 1000 psig in vessel (saturated conditions)				
	2) 135°F in drywell				
	b. Range is 145 to 325 inches referenced to instrument zero.				
	c. Condensing chamber is shared with Shutdown Range.				4
	d. Upset range instrumentation uses one transmitter sending a signal to a recorder on panel 603.	10		3d	
6.	Fuel Zone Instrumentation		4		
	a. Calibration conditions				
	1) Saturated conditions and 0 psig in vessel and drywell.			3b	
	2) No jet pump flow.				
	b. Range is -165 to 35 inches referenced to instrument zero.				
	c. The level instruments share two of the condensing chambers used for narrow and wide range while the low pressure tap uses two of the calibrated jet pump diffuser taps.				4
	1) This allows communication inside shroud.			3d	
	d. Two transmitters, one sends a signal to the fuel zone range recorder the other sends a signal to a level indicator. Both the indicator and recorder are on panel 601.				

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
C.	Reactor Vessel Pressure Monitoring		5		
1.	Reactor pressure is sensed in the steam area, using the same piping as the level instruments. The sensors are located on the reference legs of the four condensing chambers at 599 inch level.				
2.	Eight pressure switches and two indicating switches provide high pressure signals to the safety relief valves (SRV's).	10	5	4	
	a. Two SRV's open at 1076 psig				
	b. Four SRV's open at 1086 psig				
	c. Four SRV's open at 1096 psig				
	d. Four SRV's open at 1106 psig.				|4
	e. Four SRV's open at 1116 psig.				
3.	Four pressure transmitters				
	a. Initiate a reactor scram (1037 psig) from four pressure indicating switches via the RPS.	11			
	b. Send a trip signal (1050 psig) to the RRCS System.				
4.	Four pressure switches send an isolation signal (128 psig) to the RHS system, to protect the RHS pumps from a high temperature condition.				|4
5.	Two transmitters provide a pressure input to the Post Accident Monitor recorders on panel 601. (0-1500 psig)				| |4
	a. Each recorder is a dual pen recorder with wide range level and pressure indication.				| |
	b. On receipt of a high pressure signal (1050 psig) the recorder shifts to fast speed (also shifts on double-low level as previously mentioned).				

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
6.	One transmitter provides indication for the remote shutdown system.				
7.	Two pressure transmitters of the feedwater control system provide narrow and wide range pressure indication in the control room.	11			|4
a.	Narrow range (850-1050 psig) signals are sent to:				
1)	A dual pen recorder on panel 603 (shared with turbine steam flow).				
2)	RRS system cavitation interlock.				|4
b.	Wide range (0-1200 psig) signals provide				
1)	Indication on panel 603				
2)	Reactor high pressure alarm				
3)	A pressure signal to the RRS system for thermal shock interlocks.				
4)	Pressure reading to the Process Computer				
9.	One transmitter provides <u>another</u> steam dome saturation pressure signal to the RRS thermal shock interlock circuitry.				
D.	<u>Core Flow Monitoring</u>	12	6	5a	
1.	20 jet pumps in the reactor vessel, for identification number 1-20 clockwise, 1-10 loop A, 11-20 loop B.				
2.	Four jet pumps are calibrated at a test facility before installation.				
a.	Calibrated jet pumps are numbered 5, 10, 15 and 20.				
b.	The remaining jet pumps are calibrated against these four.				

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
3.	Flow in the calibrated jet pumps is measured from pressure taps at the jet pump throat and diffuser section.	12	6		
	a. The D/P signal is processed by a square root converter, converting D/P to a flow signal.				
	b. This flow indication is displayed on panel 602.				
4.	Flow in all 20 jet pump is measured from the pressure taps at the jet pump throat and the below core plate pressure line.				
	a. Flow signals for all twenty jet pumps are:				
	1) Indicated on jet pump instrument panel 619				|4
5.	Flow summation networks		7	5c,7c	
	a. The ten jet pump flows in each loop are summed to provide a loop flow signal				
	1) Loop flow is indicated on panel 602				
	b. 1) The two loop flows are combined to yield total core flow			5c,7c	
	2) During single loop operation the inactive loop flow is subtracted from the total loop flow by the relay logic system.				
	3) Total core flow signal is sent to a recorder on panel 603.				|4

		Text Ref. Page	Text Ref. Fig.	S.L.O.
6.	Calibrated jet pump DP is not used in the total core flow summation. The calibrated jet pump's throat pressures are used like the non-calibrated pumps for the total core flow summation.	13		
7.	Need accurate knowledge of core flow to determine Rx thermal power.			5b
8.	Need individual jet pump flows to monitor pump performance.			
E.	Core Plate D/P		8	
1.	The core plate differential pressure line consists of two concentric pipes; one inside the other. Above core plate pressure is sensed by outer pipe and below core plate pressure by inner pipe. The differential pressure is displayed on a recorder on panel 603.			6b
2.	Core plate D/P is an alternate way to measure total core flow.			6a
3.	The below core plate line is used for:			
a.	Comparison to downcomer annulus pressure for indication of jet pump total developed head. (J.P. Performance)			
b.	Used by reactor water cleanup system for bottom head drain flow rate.			
c.	By the 20 flow transmitters for jet pump flow measurements.			

	Text Ref. Page	Text Ref. Fig.	S.L.O.
4. The above core plate pressure is used:			
a. By the CRDH system for drive and cooling water D/P			
b. By the Leakage Detection System for determining if an internal pipe break exists in the High Pressure Core Spray System.			
III. INSTRUMENTATION, CONTROLS AND INTERLOCKS	14		
A. Indications			
1. Control Room			
a. Water Levels			
1) Narrow Range (145 to 205 inches) indication and a recorder on panel 603.		10	3d
2) Wide range (-5 to 205 inches) indication on panel 603 two recorders on panel 601 (PAM) also wide range pressure			3d
3) Shutdown range (145 inches to 545 inches) indication on panel 851.			3d
4) Upset range (145 inches to 325 inches) read on the same recorder as narrow range on panel 603.			3d
5) Fuel zone range (-165 to 35 inches) indicated on meter and recorder on panel 601.			3d
b. Reactor pressure			
1) Reactor steam dome pressure (0-1500 psig) read on PAM recorders on panel 601.			|4

	Text Ref. Page	Text Ref. Fig.	S.L.O.
2) Wide range pressure (0-1200 psig) indicated on panel 603.	14		
3) Narrow range pressure (850-1050 psig) indicated on panel 603.			4
c. Reactor vessel temperatures are indicated on a multi-point recorder on panel 614.			
d. Jet pump flow is indicated on:	15		
1) Calibrated jet pump flow meter on panel 602 (0-8M lb/hr)			
2) Loop flows on panel 602.			
3) Total core flow is indicated on the core press drop/total core flow recorder on panel 603 (0-125M lb/hr)			
4) Jet pump differential pressure indicated on the jet pump instrumentation rack panel 619			
e. Core plate differential pressure is indicated on panel 603 (0-100 psid).			

B. Controls

1. The RVI System contains sensor calibration adjustment but no operator controls.
   a. Only operator action of consequence is positioning of Reactor Water Level selector switch on panel 603.
   b. Selecting level A or B determines which level sensor is used for alarm, computer input, feedwater control system input and RRS automatic actions.

		Text Ref. Page	Text Ref. Fig.	S.L.O.
C.	Interlocks			
1.	The RVI system provides inputs to various system for controls and interlocks. There are no specific interlocks for the RVI system.			
IV.	SYSTEM OPERATION	15		
A.	Instrument response during abnormal conditions.			
1.	Response to ambient temperature change.			8a
a.	Sensing lines inside the drywell may experience a wide range of temperatures under accident conditions.			4
b.	The possible error that could be introduced due to a change in temperature in the drywell is reduced by designing the system so that the height of the column inside the drywell is the same for both the reference leg and the variable legs.			
c.	If a difference exists, an error will be introduced due to a change in the reference by density.	16		4
1)	If density of the reference leg decreases, the d/p decreases, so indicated level will be higher than actual.			
d.	Sensing lines outside the drywell do not see significant changes in operating temperature.			

		Text Ref. Page	Text Ref. Fig.	S.L.O.	
2.	Response to high drywell temperature.				
	a. May result in indicated water level higher than actual when reactor pressurized due to lower density in reference leg (drywell portion).	16			4
	b. Reference leg flashing may occur at elevated drywell temperatures if reactor is depressurized. This would result in level indicating higher than actual.				
	c. Lower ECCS and ICS initiation due to high drywell temperature have been shown to be inconsequential from safety stand point.				
	1) May result in reduction in redundance of ECCS and lead to some operator misinterpretation of actual reactor vessel water level.				
	d. High drywell temperature can cause stable on scale (or increasing if DW temp. increasing) level with actual level below lower instrument tap.	17			
	1) This is due to flashing in reference leg if reactor depressurized.				
3.	Instrument Line Break			8b	
	a. A break inside containment looks like small break LOCA, specifically:				
	1) Reference leg rupture, d/p sensed would decrease causing instrument to indicate high level.				4

	Text Ref. Page	Text Ref. Fig.	S.L.O.
2) Variable leg rupture, d/p sensed would increase causing instrument to indicate low level.	17		
4. Off-Calibration pressure and jet pump flow effects on Fuel Zone instruments are:			
a. Calibrated for saturated water conditions at 0 psig with no jet pump flow. Under accident conditions the fuel zone is subject to inaccuracies due to two effects:			
1) Higher saturated conditions			
2) Flow thru the jet pumps			
a) Due to natural circulation, or			
b) Normal recirc pump flow			
b. The level deviation as a result of higher saturated conditions produces an indication of lower level than actual.	18		
1) Fuel Zone range cannot be used during recirculation pump operation since it will be pegged high.			
c. Natural circulation flow results in indication of higher than true level, because pressure increases at the diffuser outlet with flow.			
d. Deviation from true level in other four ranges due to recirculation pump operation.			
1) Indicate lower than actual because indicated level measured outside shroud.			

Text Ref. Page	Text Ref. Fig.	S.L.O.
18		

e. Increasing vessel pressure would result in higher saturated conditions.

1) This would result in lower than actual level reading on instrument sensing outside shroud.

5. Instrument System Failure Modes

a. Loss of power supply

1) For indication meters (e.g., temp., press., flow), loss of power supply results in the indicator failing downscale.

b. Increase in Ambient Temperature around a Transducer

1) Transducers have ambient temperature limits to prevent overheating of electrical components, such as amplifiers.

2) Maximum ambient temperature limit for the three most common transducers:

a) Barton: 200°F

b) Rosemount: 200°F

c) Bailey: 185°F

3) Changes in temperature from normal ambient but not exceeding the maximum limit can result in instrument error.

4

	Text Ref. Page	Text Ref. Fig.	S.L.O.
4) Exceeding the maximum temperature limit implies that any accuracy claims made for a particular instrument are no longer valid. In addition, the instrument could be damaged due to over heating of electronic components.	19		

6. Bases for the Setpoints

a. Reactor Vessel Water Level

1) High level trip (202.3",L8)

a) Trip of the main turbine is to protect it against gross carryover and subsequent damage.

b) Trip of the feed pump is to prevent overfilling the reactor vessel.

c) ICS turbine steam admission valve shuts and CSH injection valve shuts to prevent vessel overfill and flooding of the main steam lines.

2) High level alarm (187.3",L7) warns of potential carryover.

3) Normal water level (182.8",L5,6), level at which carryover and carryunder are minimized.

	Text Ref. Page	Text Ref. Fig.	S.L.O.
4) Low level alarm (178.3",L4)	20		
a) Level below which carryunder will be greater than normal.			
b) Water level decrease to this point, coincident with less than two feed pumps running, causes the RRS Flow Control Valve to run back, reducing reactor power output to within the capacity of one feed pump.			
5) Low level trip (159.3",L3)			
a) With the trip at this level if a loss of feedwater occurs at power, water level will not reach ECCS initiation setpoint from boil-off or void collapse assuming ICS operates properly.			
b) RHS (shutdown cooling mode) isolates preventing potential further loss of coolant.			
c) Verifying low level to ADS logic.			4
d) RRS pumps shift to low speed to reduce error on wide range level instrument-reduces premature water level trips.			

		Text Ref. Page	Text Ref. Fig.	S.L.O.
e)	Protection against moisture carryover due to steam bypassing the dryer under the dryer seal skirt. The scram occurs while the water level is still above the bottom of the dryer seal skirt.	20		4
6)	Double Low level (108.8",L2)	21		
a)	Selected low enough so that ICS and CSH will not initiate after a scram (provided feedwater is still operating).			4
b)	Selected high enough so that upon loss of feedwater ICS starts soon enough to prevent low pressure ECCS from starting (Triple low setpoint).			
c)	Isolations at this setpoint are to prevent loss of coolant and release of radioactive material to the atmosphere.			
d)	RRS pumps are tripped to reduce power (by void formation) in the event of an ATWS.			

		Text Ref. Page	Text Ref. Fig.	S.L.O.
7)	Triple low level (17.8",L3)	21		
	a. Selected to initiate low pressure ECCS high enough above the top of the active fuel, to provide adequate core cooling and prevent core damage following LOCA.			
	b. ADS actuated to reduce pressure (after 105 second time delay).			
	c. MSIV's close to minimize mass loss.			
b.	Reactor Vessel Pressure	22		4a
1)	128 psig			
	a) Isolates RHS (shutdown cooling mode) to prevent RHS pumps from exceeding their design temperature.			
2)	1037 psig			
	a) High pressure alarm			
	b) Alerts the operator to abnormal system pressure.			
	c) Scram setpoint prevents reactor vessel overpressurization.			
	d) In conjunction with SRV's provides sufficient margin to the maximum allowed Nuclear Boiler System pressure.			

	Text Ref. Page	Text Ref. Fig.	S.L.O.
3) 1050 psig Activates the redundant reactivity control system to reduce power in case the reactor fails to scram.	22		
4) 1076, 1086, 1096, 1106, 1116 psig setpoints selected to prevent overpressurization of the reactor coolant system.			
5) 1148, 1175, 1185, 1195 and 1205 psig setpoints selected to prevent pressure above design pressure.			
	23		

V. SYSTEM INTERRELATIONS

A. Reactor Protection System (RPS)

The Reactor Protection System receives reactor vessel water level and pressure inputs for protection of the reactor (scrams) upon detection of potentially unsafe conditions.

B. Primary Containment Isolation System (ISC)

Reactor vessel water level input signals are used by the Primary Containment Isolation System to generate isolation signals for selected reactor and steam plant systems.

C. Reactor Core Isolation Cooling System (ICS)

Reactor vessel water level signals are used to initiate and shutdown the Reactor Core Isolation Cooling System components, while low reactor vessel pressure signals (from the Leak Detection System) are used for isolation.

		Text Ref. Page	Text Ref. Fig.	S.L.O.
D.	High Pressure Core Spray System (CSH) The High Pressure Core Spray System is initiated by a double low reactor vessel water level signal, and injection is secured by a high level signal. Core plate D/P signals are used for indication of CSH system integrity.	23		
E.	Residual Heat Removal System (RHS) Low reactor vessel water level and high reactor vessel pressure signals will isolate portions of the Residual Heat Removal system. A triple low level signal will initiate the Low Pressure Coolant Injection mode of RHS.			
F.	Feedwater Control System (FWS) Pressure and level transmitters that are part of the Feedwater Control System monitor reactor vessel pressure and level for indication, alarm, and level control functions.	24		
G.	Redundant Reactivity/Control System (RRCS) The RRCS uses low water level and high pressure signals to provide backup scram function trip/transfer recirculation pumps and (in conjunction with APRM's) initiate feedwater flow runback and initiate SLCS.			
H.	Post Accident Sampling System (PASS) A sample line is provided to obtain reactor coolant samples from two points in the jet pump instrumentation system for use by the Post Accident Sampling System (PASS). The JP diffuser lines exiting at 105° and 285° are utilized because they are optimum sample points for accident conditions (well protected from damage and debris).			

		Text Ref. Page	Text Ref. Fig.	S.L.O.
I.	Turbine Electro-Hydraulic Control System (EHC) The Turbine Hydraulic Control System utilizes high reactor water level signals to trip the main turbine.	24		
J.	Reactor Recirculation System (RRS) The Reactor Recirculation System uses water level signals for speed shifts, and vessel pressure and temperature inputs for use in cavitation and thermal shock interlocks.			
K.	Main Steam System (MSS) The Main Steam System Safety Relief Valves receive relief actuation signals from vessel pressure signals.	25		
L.	Control Rod Drive Hydraulic System (CRDH) The Control Rod Drive Hydraulic System receives vessel pressure information from the above core plate instrumentation.			
M.	Reactor Water Cleanup System (WCS) The Reactor Water Cleanup System uses below core plate D/P information.			
N.	Process Computer System (PCS) The Process Computer System uses feedwater temperature for core heat balance calculations. It also displays vessel temperature, level, pressure, and flow.			
O.	Reactor Recirculation Flow Control (RRFC) The Reactor Recirculation Flow Control System uses a low water level signal (concurrent with the loss of a feedwater pump) to cause a flow control valve runback.			
P.	Automatic Depressurization System (ADS) The Automatic Depressurization System uses two separate water level trip setpoint signals to detect and confirm a low water level condition for system actuation.	25		

	Text Ref. Page	Text Ref. Fig.	S.L.O.

VI. DETAILED SYSTEM REFERENCE REVIEW

Review each of the following referenced documents with the class.

A. Technical Specifications

	LCO	SURVEILLANCE
Water Level		
Low (Level 3)		
Primary Containment Isolation	3.3.2	4.3.2.1-3
Reactor protection System	3.3.1	4.3.1.1-3
Div I ECCS Actuation	3.3.3	4.3.3.1-3
Automatic Depressurization System Trip System "A"		
Div II ECCS Actuation	3.3.3	4.3.3.1-3
Automatic Depressurization System Trip System B		
Low Low (Level 2)		
Primary Containment Isolation	3.3.2	4.3.2.1-3
Div III ECCS Actuation HPCS	3.3.3	4.3.3.1-3
ATWS Recirculation Pump Trip	3.3.4	4.3.4.1.1-2
RCIC Actuation	3.3.5	4.3.5.1-2
Low Low Low (Level 1)		
Primary Containment Isolation	3.3.2	4.3.2.1-3
Div I ECCS Actuation		
RHR-A (LPCI Mode) & LPCS	3.3.3	4.3.3.1-3
Automatic Depressurization Trip System "A"	3.3.3	4.3.3.1-3
Div II ECCS Actuation		
RHR B and C (LPCI Mode)	3.3.3	4.3.3.1-3
Automatic Depressurization System Trip "B"	3.3.3	4.3.3.1-3

	Text Ref. Page	Text Ref. Fig.	S.L.O.
A. Technical Specifications	LCO		Surveillance
High (Level B)			
Div III ECCS Trip	3.3.3		4.3.3.1-3
Feedwater System/Main Turbine Trip System Actuation	3.3.9		4.3.9.1-2
RCIC Actuation Instrumentation	3.3.5		4.3.5.1-2
Remote Shutdown Monitoring Wide & Narrow Range	3.3.7		4.3.7.4.1-2
Accident Monitoring	3.3.7		4.3.7.5
Pressure			
Steam Dome - Reactor Protection	3.3.1		4.3.1.1-3
Primary Containment Isolation	3.3.2		4.3.2.1-3
ATWS Recirculation Pump Trip	3.3.4		4.3.4.1.1-2
High Pressure Limit	3.4.6		4.4.6.2
Remote Shutdown Monitoring	3.3.7		4.3.7.4.1-2
Accident Monitoring	3.3.7		4.3.7.5
B. Procedures			
1. N2-OP-34, Nuclear Boiler Automatic Depressurization and Safety Relief Valves			

VII. RELATED PLANT EVENTS

A. Refer to Addendum "A" and review related events with class. (if applicable)

VIII. SYSTEM HISTORY

A. Refer to Addendum "B" and review related modifications with class. (if applicable)

IX. WRAP-UP

A. Review Student Learning Objectives