NINE MILE POINT NUCLEAR STATION

UNIT II OPERATIONS

Ø2-189-91

LESSON PLAN

02-LEQ-0001-215-2-05-4

REACTOR CONTROL AND INDICATING SYSTEMS

AVERAGE POWER RANGE MONITORING SYSTEM

Prepared By: Unit #2 Training Department

APPROVALS	SIGNATURES	DATE AND INITIALS REVISION 4
Training Supervisor Nuclear - Unit #2 G. L. Weimer	G L Weimer	6/4/88
Assistant Training Superintendent - Nuclear R. Seifried	R. Seifried	RS 6/6/88
Superintendent of Operations Unit #2 R. G. Smith	R G Smith	6/6/88

Summary of Pages

Revision: 4 (Effective Date: 6/16/88)

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Date	Pages
April 1988	1 - 21

NIAGARA MOHAWK POWER CORPORATION

Attachment "A"

OBJECTIVE APPROVAL

Author: UNIT II OP's TRAINING

Training Dept: Unit II OPS.

Lesson Title: AVERAGE POWER RANGE MONITOR

Lesson Plan #: NZ-OLP-29

Training Setting(s): Classroom

Purpose: 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.

Trainee Job Title: LICENSED OPERATOR CANDIDATE
Non Licensed Operator
Licensed Operator Requalification

Approvals/Review	Signatures	Date
Training Supervisor	[signature]	6/4/88
Plant Supervisor	[signature]	6/6/88
Training Analysts Supervisor	[signature]	5-26-88

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

I. TRAINING DESCRIPTION

A. Title: Average Range Monitoring System

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: 1.5 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
   a. 2.2.1 Limiting Safety System Settings (RPS Setpoints)
   b. 3/4.2.2 APRM Setpoints
   c. 3/4.3.1 Reactor Protection System
   d. 3/4.3.6 Instrumentation and Control Rod Block Instrumentation
   e. 3.3.7.5 Accident Monitoring
2. Procedures
   a. N2-OP-92 Neutron Monitoring System
3. NMP-2 FSAR
   a. Design Basis, Vol 16, Section 7.6.1.4, Pg. 7.6-3

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 Continuing 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. 4
2. Students
   a. Meet eligibility requirements per 10CFR55, or
   b. Be recommended for this training by the Operations 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-29 Average Power Range Monitoring System
5. N2-OLT-29 Average Power Range Monitoring System
6. See Section I.E.1
7. See Section I.E.2

B. Student Materials:

1. N2-OLT-29 Average Power Range Monitoring System
2. See Section I.E.1
3. See Section I.E.2

IV. QUIZZES, TESTS, EXAMS AND ANSWER KEYS

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

V. LEARNING OBJECTIVES FOR THE AVERAGE POWER RANGE MONITORING SYSTEM (APRM)

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

29-1 State the purpose of the APRM system.

29-2 Using a block diagram of an APRM channel identify the major inputs and outputs, components, and instrumentation available to the operator.

29-3 For the following components, state their purposes and how the purpose is accomplished:

1. Averaging Circuit
2. Flow Units
3. Count Circuit
4. Trip Reference Circuit
5. Trip Circuit

29-4 List the APRM and Flow Unit Rod Block and Scram setpoints (automatic and administrative) including when each is bypassed.

29-5 State the power supplies for the APRM and Flow Unit System.

29-6 Given N2-OP-92 Neutron Monitoring, identify the appropriate actions and/or locate information related to:

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

29-7 SRO ONLY

Given Technical Specifications, identify the appropriate actions and/or locate information relating to Limiting Conditions for Operation, Bases and Surveillance Requirements for the APRM System.

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
I. INTRODUCTION			
Student Learning Objectives	i		
A. Purpose	1		1
1. Provides signals that are representative of reactor power from 1 to 125%.			
2. These signals are used by protection systems to protect the fuel during unanticipated transients			
3. Provides visual indication of reactor core thermal power.			
B. General Description			
1. APRM A, C, & E each receive inputs from 21 LPRM's (total of 63) APRM B, D, & F each receive inputs from 22 LPRM's (total of 66) Total of 129		1	2
The APRM channel provides an output proportional to the average of the LPRM signals.			
2. Associated annunciators warn the operator of rod blocks, scrams, or malfunctions that may occur.			
The LPRM's are assigned to assure each APRM channel receives signals representative of averaged neutron flux (both radially and axially) over entire core.		1	2
4. APRM system consists of 6 identical channels. Each receives and averages the inputs of its associated LPRM inputs, the APRM output is Proportional to the average flux level. LPRM signals are received from four core axial locations in a representative radial distribution.			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
a. RRS Flow Units provide the APRM system trip units with a signal proportional to total RRS driving flow. This signal is used to bias the rod block and scram setpoints, providing "power-following" trip setpoints (which increase as power increases due to RRS flow).	1 2	1	2

II. DETAILED DESCRIPTION

A. APRMs

1. Consists of six channels (A-F) located in the Power Range Monitoring Panel (P608).
2. Each APRM channel receives signals from:
   a. LPRM detectors which provide current signals proportional to neutron flux
   b. Two Flow Units which provide voltage signals proportional to RRS driving flow.

B. In-Core Detector Signal String — Text Ref. Page: 2; Text Ref. Fig.: 2; S.L.O.: 2

1. An APRM channel contains a signal string for each assigned LPRM. An LPRM detector string provides a representative indication of neutron flux levels throughout the core.
2. The circuitry converts the detector current signal to a 0-10 VAC analog voltage which is applied to:
   a. APRM averaging circuit
   b. Rod Block Monitor

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
c. Process Computer			
d. Indicating circuits (Upscale and Downscale alarm indications and annunciators)			
e. The Power Range Monitor Panel (P608)			
3. In order to average the proper number of LPRM input signals, the APRM senses the number of LPRM signals being inputed. The APRM will automatically compensate for the number of inoperable LPRM's feeding the averaging circuitry.	3		
4. Each APRM is assigned LPRM inputs which provide flux signals from each axial level and with a representative radial distribution.			
C. Averaging Circuit		2	3
1. The averaging circuit senses the number of LPRMs sending signals to the APRM channel and automatically adjusts the gain of the averaging amplifier to compensate for a change in the number of LPRM's sending signals.			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
2. The output of the averaging amplifier is applied to: a. Recorder on P603 b. PCS c. Panel meter on (P608) d. Quad trip unit e. Thermal trip unit f. Rod Block Monitor (APRM's C, D, E, F only) g. Reactor recirculation system (RRS--Ch. C or E) h. Redundant Reactivity Control	3	2	3
D. Flow Units	4		3
1. Each APRM receives a 0-10 VDC flow signal (equal to 0-125% flow) from each of two flow units.			
2. There are 4 flow channels (A-D): a. Flow Chs. A and C provide inputs to RBM A, and APRM's A, C, and E b. Chs. B and D--RBM B, APRM's B, D, and F			
3. Each flow channel consists of RRS driving flow transmitters, a flow unit, and remote and local indicators and switches. Loop A and B RRS flow transmitters provide inputs to the flow units in each flow channel.			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
4. A flow unit consists of two square root converters and a summer. Each square root converter receives a current signal proportional to the DP across the RRS driving flow elbow, and converts this signal to a voltage proportional to flow. The voltage signal from both square root converters are averaged in the summer circuit, which gives a DC signal representing 0-125% RRS driving flow to the Jet Pumps.	4		
5. Flow signals (representing 0-125% flow) from channels A and C pass thru a Low Value Auction ckt., so the lowest of the two signals is passed to the APRM and RBM flow biasing ckts.			
6. Flow Unit A signal also goes to an RRS flow recorder on P602.			
7. Flow Units A and D provide PCS inputs (e.g., heat balance, total flow--refer to the PCS chapter).			
8. Each flow unit summer ckt. has a flow comparator circuit which compares flow unit outputs, and trips (rod block) if the difference between them is excessive (>10%).			

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
a. When a flow unit is bypassed, its signal to the comparator is replaced with the signal from the flow unit supplying the bypassed unit's comparator (e.g., if Flow Unit A is bypassed, then Flow Unit C provides a flow signal to the comparator in Flow Unit A's place).	4		

E. APRM Trip Reference Circuit

1. The output from the Flow unit Low Auction circuit is sent thru the APRM Mode SW (S1--in the APRM drawer) to the Flow Control Trip Reference ckt. The input provides:
   a. Reference voltage to the thermal trip unit
   b. Reference voltage to the upscale alarm circuits (Rx mode switch in RUN).
   c. APRM recorders on P603 via Push to Record Pushbuttons.
2. A Trip Setpoint Setdown (reduction of trip setpoint) occurs when the Rx mode switch is not in RUN. When this occurs, a lower DC reference voltage is connected to the upscale alarm circuit. This setdown is necessary for protection during low pressure, low flow conditions.

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
F. Count Circuit	5		3
1. The count circuit receives a signal from each assigned LPRM that is in Operate. The outputs are:			
a) To the APRM meter (P608) when the meter Function SW is in Count. Since the count ckt. is adjusted to provide a 5% indication on the meter for each LPRM in Operate, the % indication divided by 5 gives the number of LPRM's going to the APRM [for 21(22) LPRM's, the max. indication is 105% (110%)].		1	
b) To the Inop trip circuit. The inop trip circuit is adjusted to trip if the number of LPRM's averaged by the APRM drops below 14.			4
c) Minimum numbers of LPRM's per axial location is 2. Administrative controls are necessary to assure this.			
G. APRM Trip Circuits			
1. Thermal Trip Ckt.--compares the signal output from the averaging circuit (core power) with the reference signal from the flow units. If the (core power) signal exceeds .66 (W - ΔW) + 51% not to exceed 113.5%			3

VI. LESSON CONTENT

Activity		Text Ref. Page	Text Ref. Fig.	S.L.O.
	for greater than the variable delay period (up to 6 time constants of 6 seconds each) the thermal trip circuit is actuated.	5	1	4
2.	The Quad Trip Unit consists of four trip circuits:			
a.	The Upscale Neutron trip circuit has two internal, fixed reference signals; the higher signal (118%) is operative if the mode switch is in (RUN), otherwise the lower reference signal (15%) is in effect. If the signal from the averaging circuit exceeds the reference signal, the upscale trip scram is actuated.		2	
b.	The Downscale trip circuit trips (rod block) if the signal from the averaging circuit decreases below the reference voltage (4%).			
c.	The Upscale Alarm operates similar to the Thermal Trip ckt. when the Rx. mode SW is in RUN, the setpoint is .66(W - ΔW) + 42%. When in other than RUN, the reference signal is reduced to 12% (setdown), representing a lower power level.			
d.	The Inop trip compares the LPRM Count Circuit signal to a reference signal, representing the minimum required number of LPRM's (14). If the reference is exceeded, a Inop trip results	6		

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
(inputs to the Inop trip ckt. will actuate the ckt. if any drawer module is unplugged, or if the APRM drawer Mode SW is not in Operate and the INOP Inhibit switch is not depressed).	6	2	3
H. Power Supply			5
1. APRM A, C and E and Flow Unit A,C are powered by 120 VAC Instrument Bus 2VBS-PNLA100, which is supplied by 2VBB-UPS3A.			
2. APRM B, D, and F and Flow Units B and D are powered by 120VAC Instrument Bus 2VBS PNLB100, which is supplied by 2VBB-UPS3B.			

III. INSTRUMENTATION, CONTROLS AND INTERLOCKS

A. Indications

1. P603 Recorders
   a. 6 channels from 4 2-pen recorders display APRM levels from o-125 percent. APRM trip reference signals are substituted when APRM Push to Record Alarm Level pushbutton is depressed.
2. P602 Recorders
   a. Flow indication on a 2-pen recorder with a range of 0-55 x 1000 gpm
3. P608 Meters
   a. Each APRM channel has a meter with scales of 0-10V (Black) and 0-125 percent (red)

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
4. P603 Status Lights	7		
a. Each APRM has the following lights that illuminate if trip signal received and channel not in BYPASS			
1) Red Upscale Trip or Inop lites on:			
a) Upscale neutron trip			
b) Upscale thermal trip			
c) Inoperative trip			
2) Amber Upscale Alarm lights on a high trip level signal			
3) White Downscale light lights on a low level			
4) White Bypass light if channel is bypassed			
b. Each flow unit has the following lights that light if unit not Bypassed			2
1) Amber Upscale or Inop light comes on if a high level or inoperative condition			
2) Amber Comparator Trip light comes on when the difference between units is excessive			
3) White Bypass light when flow unit is placed in bypass			
5. Panel 608 APRM Status Lights			
a. Meter Expand light on the APRM drawer indicates the internal meter switch is in either Expand or Reverse			
b. LPRM Bypassed light indicates the selected LPRM is either bypassed or in cal.			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
c. White Bypass light indicates the APRM channel has been bypassed to Panel 603	7	2	
d. White Inop Trip			
e. White Downscale Trip (seal-in)			
f. Amber Upscale Alarm Trip (seal-in)			
g. Red Upscale Neutron Trip (seal-in)			
h. Red Upscale Thermal Trip (seal-in)			
i. Red Upscale Neutron First (seal-in)			
j. Red Upscale Thermal First (seal-in) (The last two are in a sequential lockout circuit. The first to trip hold the others off)			
6. Panel 608 Flow Unit Status Lights	8		
a. White Inop with amber upscale trip indicates an upscale trip condition			
b. White Inop without amber upscale trip indicate mode switch not in operate or module unplugged			
c. White Bypass Trip			
d. Amber Comparator Trip			
e. Amber Upscale Trip			
B. Control Room Controls			
1. P603, eight channel select switches--select input to the 2-pen recorders.			
2. P603, four APRM Level Push to Record pushbuttons that interrupt APRM inputs and substitute the APRM reference signal.			
3. P603, two APRM bypass switches used to bypass one channel on each RPS bus.			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
4. Bypassing Channels C(D) substituting Channel E(F) signals to RBM A(B) and recirculation	8	2	
5. P603, two flow unit bypass switches used to bypass flow units (one on each RPS bus).			
6. P608, each channel as a drawer with a Power/Volts meter and switches.	9		
a. Mode switch; 5-position switch used to place APRM in Operate, Standby, or Test configuration.			
b. Reset switch on drawer resets any latched-in trip circuits that have cleared.			
C. Interlocks			4
1. The APRM Downscale trip occurs when, concurrently:			
a. Power is less than 4 percent,			
b. The APRM channel is not by-passed, and			
c. The reactor mode switch is in RUN.			
d. It provides a rod block to prevent further rod withdrawal, and sends a status signal to the redundant reactivity control system.			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
2. The APRM Upscale Alarm trip occurs when a. Power is greater than 12 percent with the reactor mode switch in any position other than RUN (APRM channel not bypassed) or b. 0.66 (W - ΔW) + 42 percent with the reactor mode switch in the RUN position (APRM channel not bypassed). c. It provides a rod withdrawal block to prevent operation in power/flow regions which would significantly reduce core thermal hydraulic limits and provides protection for the reactor core.	9	3	4
3. The APRM Inop trip occurs when an APRM channel is not bypassed and: a. The APRM mode switch is not in operate (APRM Inop inhibit push-button not depressed), or b. Any internal module is unplugged, or c. The number of LPRM inputs decrease to less than 14 for an APRM channel. d. The trip provides both rod block and scram signals, and sends a status signal to the RRCS system.	10		
4. The APRM Upscale Neutron trip (scram) occurs when a. Power is greater than 15 percent with the reactor mode switch in any position other than RUN (APRM channel not bypassed), or b. 118 percent with the reactor mode switch in RUN (APRM channel not bypassed).			

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
5. The APRM Upscale Thermal trip (scram) occurs when power is greater than 0.66 (W - ΔW)+ 51 percent, not to exceed 113.5 percent (APRM channel not bypassed). The trip provides a scram signal.	10	3	4
a. Additionally, the flux averaging circuit input to the Upscale Thermal trip goes through an R-C (resistive-capacitive) time constant circuit. This circuit consistsof three resistors which total 6MΩ and one capacitor of 1 μF. These in combination generate a 6-second time constant. This delays the signal to the trip unit and enables the trip unit to receive a signal more closely simulating actual core heat flux. This feature provides the system with the ability to tolerate reasonable transients of short duration that do not exceed 113.5 percent (the preset maximum value beyond which thermal power may not increase regardless of the value of W).			
6. The Flow Upscale Alarm trip will occur when flow exceeds 108 percent (flow unit not bypassed) and will generate a rod block signal.			

VI. LESSON CONTENT

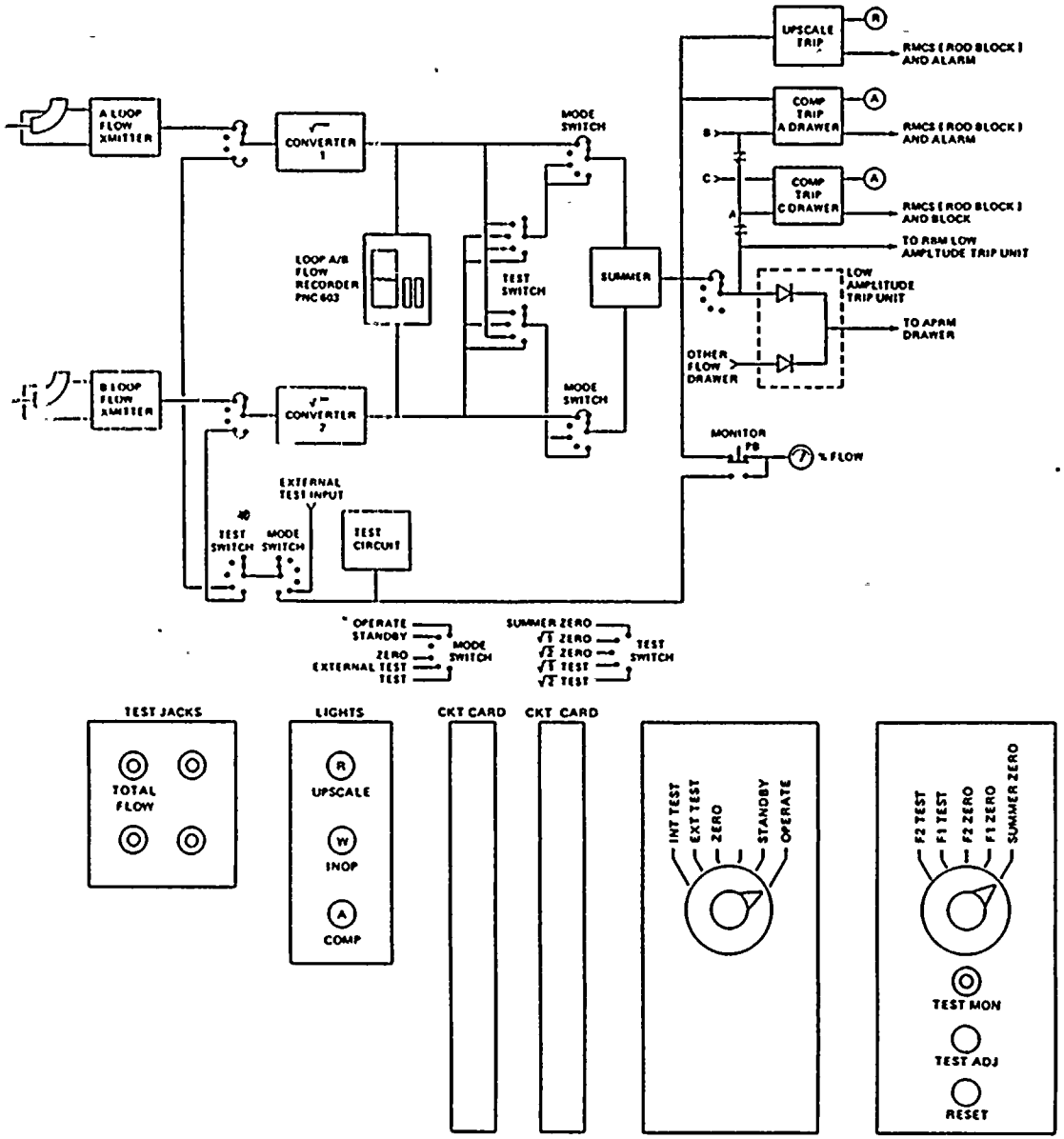
Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
7. The Flow Comparator trip occurs when an output flow signal from one flow unit differs by greater than 10 percent from the signal of the compared unit and will generate a rod block signal. Bypassed with flow unit bypass joystick on panel 603.	11	3	4
8. The Flow Inop trip occurs when: a. A flow upscale alarm is received, b. A flow unit mode switch is out of operate, or c. A flow module is unplugged. (This trip is bypassed when the affected flow unit is bypassed.)			4
IV. SYSTEM OPERATION			
A. Normal Operation			6
1. The APRM system, in operation at all times, is used during normal power operation (>2-3% power) to provide indication of average core thermal power.			
2. This indication is utilized to ensure proper reactor plant operation during up-power and downpower operation, and ensures adherence to safety limits.			
3. APRM's will monitor from a few percent to 125% of rated core thermal power, with only minor adjustments required to compensate for uranium depletion in the LPRM detectors, or changes in power distribution following a significant change in the rod pattern or total core flow.	11	3	

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
B. Startup	11	3	
1. During startup, APRM's come on scale at about Range 6 on the IRM's.			
2. Before withdrawing the IRM's, the readings of IRM's and APRM's are compared to ensure good correlation (overlap), after which the Reactor mode switch is placed in RUN (APRM's indicating 4-12%).			
V. SYSTEM INTERRELATIONS	12		
A. Uninterruptible Power Supplies (UPS) UPS 3A and 3B provide 120 VAC to the APRM/Flow Unit System			
B. Redundant Reactivity Control System (RRCS) APRM downscale trip, Inop trip and Bypass switches send signals to (RRCS) to determine the existance on Anticipated Transient Without Scram (ATWS) event			
1. APRM Channels A,C,E to RRCS Channel A of Div. 1 and 2			
2. APRM Channels B,D,F to RRCS Channel B of Div. 1 and 2			
C. Reactor Manual Control System (RDC) APRM System provides trips to RXMC to initiate rod blocks			
D. Reactor Protection System (RPS) APRM's provide trips to RPS to initiate a reactor scram			
1. RPS A - APRM A,C,E			
2. RPS B - APRM B,D,F			
E. Reactor Recirculation Flow Control (RRFC) APRM channel C provides a neutron flux signal to RRFC for use on flux control mode. If channel C is bypassed, Channel E is substituted	13		

VI. LESSON CONTENT

Activity	Text Ref. Page	Text Ref. Fig.	S.L.O.
F. Local Power Range Monitor (LPRM)	13		3
Each APRM receives inputs from specific			
G. Process Computer System (PCS)			
APRM System provides average thermal power information to the PCS			
VI. DETAILED SYSTEM REFERENCE REVIEW	14		7
Review each of the following referenced documents with the class.			
A. Technical Specifications			
1. 2.2.1 Limiting Safety System Settings (RPS Setpoints)			
2. 3/4.2.2 APRM Setpoints			
3. 3/4.3.1 Reactor Protection System			
4. 3/4.3.6 Instrumentation and Control Rod Block Instrumentation			
5. 3.3.7.5 Accident Monitoring			4
B. Procedures			6
1. N2-OP-92 Neutron Monitoring System			
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).			4
IX. WRAP-UP			
A. Review the Student Learning Objectives			



MODE SWITCH:

OPERATE: PLACES FLOW DRAWER IN THE NORMAL CONFIGURATION

STANDBY: SAME AS OPERATE EXCEPT INOP TRIP

ZERO: REMOVES INPUT SIGNALS TO THE FLOW UNIT TO PERMIT ZEROING AMPLIFIERS

EXTERNAL TEST: CONNECTS EXTERNAL TEST INPUT TO EITHER OF THE SQUARE ROOT CONVERTERS THROUGH THE TEST SWITCH $\sqrt{1}$ OR $\sqrt{2}$ POSITIONS

TEST: SAME AS EXTERNAL TEST EXCEPT TEST INPUT IS FROM TEST CARD

TEST SWITCH:

SUMMER ZERO: USED TO ZERO SUMMER AMPLIFIER WITH MODE SWITCH IN ZERO, TEST OR EXTERNAL TEST

$\sqrt{1}$ OR $\sqrt{2}$ ZERO: USED TO ZERO SQUARE ROOT CONVERTERS WITH MODE SWITCH IN ZERO, TEST OR EXTERNAL TEST

$\sqrt{1}$ OR $\sqrt{2}$ TEST: USED TO TEST SQUARE ROOT CONVERTERS WITH MODE SWITCH IN TEST

TEST MONITOR SWITCH:

DEPRESSED: CONNECTS TEST OUTPUT FROM TEST CARD TO METER

RESET SWITCH:

DEPRESSED: RESET TRIP CIRCUITS

FLOW DRAWER HANDOUT