07-186-91

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION

UNIT II OPERATIONS

02-LOT-001-215-2-05 Revision 6

TITLE: AVERAGE POWER RANGE MONITORING SYSTEM

	SIGNATURE	DATE
PREPARER	[signature]	6/4/91
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PLANT SUPERVISOR/ USER GROUP SUPERVISOR	[signature] J B MACLEAN	6/19/91

Summary of Pages

(Effective Date: 6/19/91)

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TRAINING DEPARTMENT RECORDS ADMINISTRATION ONLY

VERIFICATION: _____ _____

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26
5/3/118

ATTACHMENT 5
LESSON PLAN TEMPORARY/PUBLICATION/ADDENDUM CHANGE FORM

The attached change was made to:

Lesson plan title: Average Power Range Monitoring System

Lesson plan number: 02-LOT-0001-215-2-05

Name of instructor initiating change: Pat Walsh

Reason for the change: Incorporate SOER 90-03, NI Modifications Problems into lesson plan - add as a ref. (sect 6-5) pg 1 add to Related events sect. VII pg 24.

Type of change:

1. Temporary change X
2. Publication change ____
3. Addendum change ____

Disposition:

X 1. Incorporate this change during the next scheduled revision.

____ 2. Begin revising the lesson plan immediately. Supervisor initiate the process.

____ 3. To be used one time only.

Approvals:

Instructor: _____ /Date 7/30/91

Supervisor Operations Training (or designee): _____ /Date 7/30/91

I. TRAINING DESCRIPTION |6

A. Title of Lesson: Average Power Range Monitoring System |

B. Lesson Description: This lesson contains information pertaining to the Average Power Range Monitoring System. The scope of this training is defined by the learning objectives and in general covers the knowledge requirements of a Licensed Control Room Operator. |

C. Estimate of the Duration of the Lesson: 3.0 hours |

D. Method of Evaluation, Grade Format, and Standard of Evaluation: Written examination: Passing grade of 80% or greater. |

E. Method and Setting of Instruction: This training should be conducted in the classroom. |

F. Prerequisites: |

1. Instructor: |

a. The instructor shall be familiar with the lesson materials and have achieved the necessary instructor certification in accordance with NTP-16. |

2. Trainee: |

a. In accordance with eligibility requirements of NTP-10. |

G. 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 Instrumentation |6

d. 3/4.3.6 Control Rod Block Instrumentation

e. 3.3.7.5 Accident Monitoring

2. Procedures

a. N2-OP-92 Neutron Monitoring System

b. N2-RAP-10 APRM Gain Adjustment |6

3. NMP-2 FSAR

a. Design Basis, Vol 16, Section 7.6.1.4, Pg. 7.6-3

4. GE Print 807E163TY |6

5. SOER 90-03 Nuclear Instrument Miscalibration Events 7/30/91

II. REQUIREMENTS

A. AP-9, Administration of Training

B. NTP-10, Training of Licensed Operator Candidates

III. TRAINING MATERIALS

A. Instructor Materials:

1. Training Record
2. Instructor's working copy of the lesson plan
3. Whiteboard and Markers
4. Overhead Projector
5. Transparencies as needed
6. Flip Chart (if necessary)
7. Copy of trainee handouts
8. Trainee Course Evaluation Forms

B. Trainee Materials:

1. Handouts
2. Paper or Notebook
3. Pen or Pencil

IV. EXAM AND MASTER ANSWER KEYS

A. Will be generated and administered as necessary. They will be on permanent file with the designated clerk.

V. LEARNING OBJECTIVES

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

A. Terminal Objectives:

TO-1.0 Respond to an inoperable APRM channel. (3449860403) |6

TO-2.0 Locate the Nuclear Instrumentation power supplies. (2150050101) |

TO-3.0 Operate the APRM's during a reactor startup. (2150220101) |

B. Enabling Objectives:

EO-1.0 State the purpose of the APRM system.

EO-2.0 Identify the major inputs and outputs, components, and instrumentation available to the operator. Using a block diagram of an APRM channel

EO-3.0 State the purposes and how the purpose is accomplished, for the following components:

a. Averaging Circuit
b. Flow Units
c. Trip Reference Circuit
d. Count Circuit
e. Trip Circuit

EO-4.0 List the APRM and Flow Unit Rod Block and Scram setpoints (automatic and administrative) including when each is bypassed.

EO-5.0 State the power supplies for the APRM and Flow Unit System.

EO-6.0 Describe the interrelationship of the following list of systems with the APRM System.

a. Uninterruptible Power Supplies (UPS)
b. Redundant Reactivity Control (RRCS) |6
c. Reactor Manual Control System (RDC) |
d. Reactor Protection System (RPS) |
e. Reactor Recirc Flow Control (RRFC) |
f. Local Power Range Monitors (LPRM) |
g. Process Computer System (PCS) |

EO-7.0	Given NMP2 Technical Specifications and a set of plant conditions, determine the appropriate bases, limiting condition for operations, limiting safety system setting, and/or action statement as appropriate.	6
EO-8.0	Regarding the APRM System, determine and use the correct procedure to identify the actions and/or locate information related to:	
	a. Startup	
	b. Shutdown	
	c. Normal	
	d. Off Normal	
	e. Annunciator Response Procedures	
EO-9.0	Explain the basis for the precautions and limitations listed in N2-OP-92.	
EO-10.0	Describe how the APRM System is utilized during the performance of the EOP's.	

VI. LESSON CONTENT LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES
I. INTRODUCTION	Preliminary Activity	6
	1. Introduce self to trainees (if unfamiliar)	
	2. Circulate and explain Training Record.	
	3. Explain method of evaluation.	
	4. Pass out Course Evaluation Forms.	
	Pass out copies of Learning Objectives.	
Student Learning Objectives		EO-1.0
A. Purpose		
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. 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.
3. 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.
   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).

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: EO-2.0 |6
   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

1. An APRM channel contains an LPRM card for each assigned LPRM. An LPRM detector provides a representative indication of neutron flux levels throughout the core. |6

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
   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 inputted. The APRM will automatically compensate for the number of inoperable LPRM's feeding the averaging circuitry.

Sensed by position of LPRM card mode selector switch. |6

4. Each APRM is assigned LPRM inputs which provide flux signals from each axial level and with a representative radial distribution.

C. Averaging Circuit — EO-3.0a |6

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.

Sensed by position of LPRM card mode selector switch.

2. The output of the averaging amplifier is applied to: — EO-2.0 |6

   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

D. Flow Units — EO-3.0b |6

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.
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.

   $\text{Flow} = k\sqrt{\Delta P}$ | 6
5. Flow signals (representing 0-125% flow) from channels A and C pass thru a Low Value Auction circuit, so the lowest of the two signals is passed to the APRM and RBM flow biasing ckts.

   Ensures the most conservative flow signal is used resulting in lowest scram and rod block setpoints. | 6

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%).
   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).

Put on board:
→A→B→D→C→

(use to explain comparator relationship)

6

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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.

Variable reference voltage varies the trip unit setpoints.

6

EO-3.0c

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.

Setpoint of 15% provides adequate thermal margin to the Safety Limit (25%). |6

F. Count Circuit

EO-3.0d |6

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%)].

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.

c) Minimum numbers of LPRM's per axial location is 2. Administrative controls are necessary to assure this.

This does not cause an automatic INOP trip. |6

G. APRM Trip Circuits EO-3.0e EO-4.0 |6

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% for greater than the variable delay period (up to 6 time constants of 6 seconds each) the thermal trip circuit is actuated.

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.

This trip has no time delay. |6

b. The Downscale trip circuit trips (rod block) if the signal from the averaging circuit decreases below the reference voltage (4%). EO-3.0e EO-4.0 |6 |

c. The Upscale Alarm operates similar to the Thermal Trip ckt. when the Rx. mode SW is in RUN, the setpoint is .66(W - W) +42%. When in other than RUN, the reference signal is reduced to 12% (setdown), representing a lower power level. Stress that the flow biased signal becomes a fixed signal (compare with scram). |6 | |

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 (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).

H. Power Supply

1. APRM A and E and Flow Unit A and C are powered by 120 VAC Instrument Bus 2VBS*PNLA103, which is supplied by 2VBB*UPS3A. EO-5.0 |6

APRM C is powered by 2VBS*PNL A104. |6 | |

2. APRM B and F and Flow Units B and D are powered by 120VAC Instrument Bus 2VBS * PNLB103 which is supplied by 2VBB-UPS3B. APRM D is powered by 2VBS*PNLB104. EO-5.0 |6

III. INSTRUMENTATION, CONTROLS AND INTERLOCKS

A. Indications

1. P603 Recorders

a. 6 channels from 4 2-pen recorders display APRM levels from 0-125 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)

4. P603 Status Lights

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
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.
c. White Bypass light indicates the APRM channel has been bypassed to Panel 603
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)

These two lights provide a first hit indication. |6

(The last two are in a sequential lockout circuit. The first to trip hold the others off)

6. Panel 608 Flow Unit Status Lights
   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.
4. Bypassing Channels C(D) substituting Channel E(F) signals to RBM A(B) and recirculation
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.
   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

1. The APRM Downscale trip occurs when, concurrently:
   a. Power is less than 4 percent,
   b. The APRM channel is not by-passed, and

EO-4.0 |6

EO-4.0 |6

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.

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.

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. EO-4.0 |6

d. The trip provides both rod block and scram signals, and sends a status signal to the RRCS system. If INOP tripped and not bypassed, RRCS "sees" channel as > 4%. |6 |

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).

5. The APRM Upscale Thermal trip (scram) occurs when power is greater than 0.66 (W - W)+ 51 percent, not to exceed 113.5 percent (APRM channel not bypassed). The trip provides a scram signal.

a. Additionally, the flux averaging circuit input to the Upscale Thermal trip goes through an R-C (resistive-capacitive) time constant circuit. This circuit consists of three resistors which total 6 Meg ohm and one capacitor of 1 micro farad. EO-4.0 |6

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.
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.

EO-4.0 |6

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.)

IV. SYSTEM OPERATION

A. Normal Operation

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.

Review N2-RAP-10 for APRM gain adjustment. |6

B. Startup

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%).

Proper overlap is only required for a shutdown. |6

V. SYSTEM INTERRELATIONS

A. Uninterruptible Power Supplies (UPS). UPS 3A and 3B provide 120 VAC to the APRM/Flow Unit System

EO-6.0a

B. Redundant Reactivity Control System (RRCS) APRM downscale trip, Inop trip and Bypass switches send signals to (RRCS) to determine the existence on Anticipated Transient Without Scram (ATWS) event.

EO-6.0b

1. APRM Channels A,C,E to RRCS Channel A of Div. 1 and 2.

|6

Put this table on board:

RRCS

|6

		Division 1	Division 2
Channel	A	A, E	C, E
	B	B, F	D, F

|6

|6

This is the distribution of APRM channels into RRCS.

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. EO-6.0c |6

D. Reactor Protection System (RPS) APRM's provide trips to RPS to initiate a reactor scram. EO-6.0d |6

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. EO-6.0e |6

F. Local Power Range Monitor (LPRM). Each APRM receives inputs from specific LPRM's. EO-6.0f |6

G. Process Computer System (PCS). APRM System provides average thermal power information to the PCS. EO-6.0g |6

VI. DETAILED SYSTEM REFERENCE REVIEW

Review each of the following referenced documents with the class.

A. Technical Specifications EO-7.0 |6

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 Instrumentation
4. 3/4.3.6 Control Rod Block Instrumentation
5. 3.33.7.5 Accident Monitoring

B. Procedures

1. N2-OP-92 Neutron Monitoring System
2. N2-RAP-10 APRM Gain Adjustment
3. N2-EOP-RPV Control
4. N2-EOP-C5 Level Power Control

EO-8.0, EO-9.0

EO-10.0

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VII. RELATED PLANT EVENTS

A. Refer to: LER 86-04
88-26
89-05
89-36
SOER 90-03

Review LER's with trainees.

Review SOER with trainees. CG 7/30/91

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VIII. SYSTEM HISTORY

A. Refer to: N/A

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IX. WRAP-UP

A. Review the Student Learning Objectives