Φ7-186-91

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION

02-LOT-001-202-2-02 Revision 6

TITLE: REACTOR RECIRCULATION FLOW CONTROL SYSTEM

	SIGNATURE	DATE
PREPARER		5-23-91
TRAINING AREA SUPERVISOR		5-23-91
TRAINING SUPPORT SUPERVISOR		5-24-91
PLANT SUPERVISOR/ USER GROUP SUPERVISOR		5-29-91

Summary of Pages

(Effective Date: 5/29/91)

Number of Pages: 24

Date	Pages
March 1991	1 - 24

THIS LESSON PLAN IS A GENERAL REWRITE

TRAINING DEPARTMENT RECORDS ADMINISTRATION ONLY:

VERIFICATION: _____

DATA ENTRY: _____

RECORDS: _____

27 5/3/94

I. TRAINING DESCRIPTION

A. Title of Lesson: Reactor Recirculation Flow Control System

B. Lesson Description: This lesson contains information pertaining to the Reactor Recirculation Flow Control System. The scope of this training is defined by the learning objectives and in general covers the knowledge required of a Licensed Control Room Operator.

C. Estimate of the Duration of the Lesson: Approximately 8 hours

D. Method of Evaluation, Grade Format, and Standard of Evaluation: Written exam, passing grade of 80% or greater.

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

F. Prerequisites:

1. Instructor:
   a. Certified in accordance with NTP-16
2. Trainee:
   a. Initial License Candidate - In accordance with the eligibility requirements of NTP-10.
   b. Licensed Operator Requal - In accordance with the requirements of NTP-11.

G. References:

1. Technical Specifications
   Tech. Spec. 3.4.1.1, Recirculation loops
   Tech. Spec. 3.4.1.2, Jet pumps
   Tech. Spec. 3.4.1.3, Recirculation loop flow
   Tech. Spec. 3.4.1.4, Idle recirculation loop start-up
2. Procedures
   N2-OP-29, Reactor Recirculation Flow Control System
   N2-OP-101A, Plant Start-Up
   N2-OP-101C, Plant Shutdown
   N2-OP-101D, Plant Operation
3. NMP-2 FSAR
   NMP2 FSAR, Design Basis, Vol 16, Chapter 7, Page 7.7-18

II. REQUIREMENTS

A. AP-9, Administration of Training

B. NTP-10, Training of Licensed Operator Candidates

C. NTP-11, Licensed Operator Requalification Training

D. NTP-12, Unlicensed Operator Training

III. TRAINING MATERIALS

A. Instructor Materials:

1. Classroom
2. Lesson plan
3. TR
4. Transparency package
5. Overhead projector
6. Applicable references
7. Trainee handouts
8. Course Evaluation Sheets

B. Trainee Materials:

1. Handouts (can include text, drawings, objectives, procedures, etc.)
2. Pens, pencils, paper
3. Course Evaluation

IV. EXAM AND MASTER ANSWER KEYS

A. Exams will be generated and administered as necessary.

B. Exams and master answer keys will be on permanent file in the records room.

V. LEARNING OBJECTIVES

A. Terminal Objectives:

Upon completion of this lesson, the trainee will demonstrate the knowledge to:

TO#	Terminal Objective	Task Number
TO-1.0	Perform the actions for one recirc pump trip.	2000010501
TO-2.0	Perform the actions required for two recirc pump trip.	2000020501
TO-3.0	Respond to an increase in recirculation flow.	2009270501
TO-4.0	Adjust the recirc flow using loop manual control.	2020020101
TO-5.0	Transfer recirc flow control from loop manual to loop auto (FLUX MANUAL) and control flow.	2020050101
TO-6.0	Monitor operation of recirc pumps.	2020060101
TO-7.0	Conduct recirc system flow control valve testing N2-OSP-RCS-R004.	2020060201
TO-8.0	(SRO ONLY) Determine power to flow to be within Tech. Spec. limits.	2029010403
TO-9.0	(SRO ONLY) Determine applicable limits for single loop operation.	2029020403
TO-10.0	(SRO ONLY) Determine if flow mismatch exceeds Tech. Spec. requirements.	2029050403
TO-11.0	Startup the hydraulic power unit from the control room and transfer to alternate sub-loop.	2029070101
TO-12.0	Transfer recirc pump speed from 15Hz to 60Hz.	2029090101
TO-13.0	Transfer recirc flow control from loop auto to flux auto.	2029110101
TO-14.0	Transfer a recirc pump from 60Hz to 15Hz.	2029150101
TO-15.0	Shutdown a hydraulic power unit.	2029160101
TO-16.0	Increase power to rated using recirc flow and rods.	2029270101
TO-17.0	Perform the actions necessary during low core flow conditions.	2029290101
TO-18.0	Perform the actions required for FCV runback low speed recirc pump operation.	2029330401

TO-19.0	Respond to a failure of a flow control valve hydraulic power unit.	2029340101
TO-20.0	(SRO ONLY) Direct the removal of a recirc pump	3419080303
TO-21.0	(SRO ONLY) Direct reactor power changes (>10%) using recirc flow or control rods.	3419140103
TO-22.0	(SRO ONLY) Respond to a reactor recirc pump trip.	3449650403
TO-23.0	(SRO ONLY) Respond to a trip of both reactor recirc pumps.	3449660403
TO-24.0	(SRO ONLY) Respond to a loss of cooling water to the recirculation pumps.	3449680403
TO-25.0	(SRO ONLY) Operate the plant in the single recirculation loop mode.	3449710403

B. Enabling Objectives:

EO-1.0 Explain the purpose and function of the Reactor Recirculation Flow Control System.

EO-2.0 Describe the purpose and function of each of the following major components of the Reactor Recirculation Flow Control System.

a. High flux limiter
b. Flux controller
c. Flow demand high limiter
d. Flow demand low limiter
e. Flux estimator
f. Loop flow controller
g. Loop flow high limiter
h. RVDT and LVT transmitters

EO-3.0 Locate and use the correct drawings of the Reactor Recirculation Flow Control System to perform the following:

a. Identify electrical and mechanical components
b. Trace the flowpath of fluids or electricity
c. Identify interlocks and setpoints
d. Describe system operation
e. Locate information about specific components
f. Identify system interrelations

EO-4.0 State the setpoint and describe its purpose for the following interlocks:

a. Flow control valve runback
b. Flow control valve motion inhibit
c. High drywell pressure interlock
d. Controller transfer to manual
e. HPU auto starts

EO-5.0 Describe the interrelationship between the Reactor Recirculation Flow Control System and the following list of systems:

a. Feedwater (FWS)
b. Neutron monitoring (NMS)
c. Vessel instrumentation (RVI)
d. Electrical distribution

EO-6.0 (SRO ONLY) Determine the appropriate bases, limiting conditions for operation, and limiting safety system settings, and/or action statement as applicable given the NMP2 Technical Specifications and a set of plant conditions.

EO-7.0 Explain the basis for each applicable precaution and limitation listed in N2-OP-29, 101A, 101C and 101D.

EO-8.0 Determine and use the correct procedure to identify the actions and/or locate information related to the following Reactor Recirculation Flow Control System operations.

a. Startup
b. Shutdown
c. Normal Operations
d. Off-Normal Operations
e. Annunciator Responses

EO-9.0 Determine how the Reactor Recirculation Flow Control System responds given a specific set of plant conditions.

EO-10.0 Describe the immediate operator actions required given a specific set of plant conditions.

EO-11.0 Describe how the Reactor Recirculation Flow Control System is utilized during the performance of the EOP's.

VI. LESSON CONTENT

LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES
I. INTRODUCTION		
A. Introduction		
1. Have students fill out TR.	Distribute TR for completion	
2. Explain purpose of Course Evaluation and how to use it.	Distribute Course Evaluation Forms and describe their use.	
3. Explain method of evaluation.	Describe daily quizzes/weekly exams.	
4. Review Student Learning Objectives.	Review learning objectives with the class.	
5. Course Agenda	List the agenda on a flipchart or whiteboard or provide handout and review.	
B. System Purpose The Reactor Recirculation Flow Control (RRFC) system controls the recirculation water flow rate through the core and, in so doing, controls the reactor power level over a limited range. The water flow rate is controlled by varying the position of flow control valves by means of hydraulic cylinders and motor driven hydraulic power units.		EO-1.0
C. General Description The reactor recirculation flow rate is varied by throttling the recirculation pump discharge with the recirculation system control valves.	Project the diagram with which the students should be familiar.	

Name each major component and point out inlets, outlets, interconnections and instrumentation.

II. DETAILED DESCRIPTION

A. Master Controller

Show T.P. Figure 2A

1. Located in the Control Room on Panel P602.
2. Controls both recirculation FCV's when the Flux and Flow Controllers are in automatic.
3. Is always in manual mode. Auto mode is not functional (load follow).
4. Master controller output is a neutron flux demand signal.
   a. High flux limiter limits the demand signal to 110% to prevent possible fuel damage. EO-2.0a
   b. Summing unit compares signal to flux feedback.
   c. APRM feedback signal normally supplied by channel C with channel E as backup.
   d. Isolation amplifier and filter
      1) Isolates the flow control system electronics from the particular APRM instrument which supplies its input signal.
      2) Filters high frequency noise in the APRM signal

5. Flux error signal - difference between the Master Controller flux demand and the flux feedback.
   a. Flux error limiter - limits the size of the signal to + 20% of rated flux.
   b. Limiter output applied to the flux controller.
   c. A high rate of change in the flux error signal will cause the Flux Controller to transfer to the "manual" mode.

B. Flux Controller

EO-2.0b

1. Located on the P602 panel

Use T.P. of Figure 2A to show flux controller.

2. Generates a total flow demand signal.
3. Manual mode, operator uses slide-switch to raise or lower the flow demand signal.
4. Bumpless transfer to auto and tracking of the manual setpoint is provided by the signal tracking unit.
   a. Interlock prevents transferring to automatic unless input error is near zero (can be adjusted)
5. Automatic mode, accepts the flux error signal from the error limiter and master controller.

a. Flow demand high limiter prevents drive flow demand from exceeding 102.5%. This keeps the flow within the bounds of the design operating map. EO-2.0c

b. Flow demand low limiter EO-2.0d

1) Only in the circuit during flux controller automatic mode

2) Prevents the flow demand signal from dropping below 40% due to flow instabilities occurring below this point.

3) No low flow limit in manual mode

c. Flux controller signal failure unit transfers loop flow controllers to manual on high rate of change of signal.

C. Neutron Flux Estimator — Show T.P. Figure 2A — EO-2.0e

1. Provides a low noise flux feedback signal during steady state operation.
2. Used because conventional filters cannot remove enough noise from the APRM signal.
3. Flux estimator is comprised of a flux estimation circuit and a selection circuit
4. Flux estimation circuit uses APRM and flux controller output to produce estimated flux signal.
5. Selection circuit

a. Inputs

1) Actual flux
2) Estimated flux

b. Output
1) The flux feedback signal

6. The flux feedback signal is then compared to the output of the Master Controller, produces flux error signal.

7. A selector switch on P602, (OPER or BYPASS) allows selection of feedback signals.

a. With the bypass switch positioned to select the estimated flux (OPER), the flux feedback signal will be the estimated flux if both of the following conditions exist:
1) APRM Signal is less than or equal to 105% of rated neutron flux, and
2) Estimated Signal minus APRM Signal is less than or equal to 2.5%

b. With the switch positioned to select the estimated flux (OPER), the flux feedback signal will be the APRM Signal if either of the following conditions exist:
1) APRM Signal is >110%, or
2) Estimated Signal minus APRM Signal is >5%

c. With the switch positioned to select the estimated flux (OPER position), the flux feedback signal will be the current signal being used (either estimated or APRM) during the following conditions:

1) 105% < APRM Signal <110%, or

2) 2.5% < Estimated Signal minus APRM Signal <5.0%

(if the values fall between the limits, with the switch in OPER, the signal applied is the current signal being used).

d. With the switch positioned for the APRM Signal (BYPASS), the flux feedback signal will always be the APRM signal.

D. Loop Flow Controllers

Show T.P. Figure 2B

EO-2.0f

1. Located on P602
2. Provides a flow demand signal to control the respective loop flow control valves position and rate of movement.
3. Can be manually operated with the raise and lower slide switch.
4. Automatic mode
   a. Flow demand signal from Flux Controller is compared to a flow feedback signal (from RRS suction).

b. Flow feedback signal from recirculation pump suction line flow.

5. If a flow error exists, the loop controller increases or decreases the output demand signal. A boost circuit provides for faster valve/system response to demand flow changes.

6. Loop Flow Controller Output signal is limited by a High Flow limiter (45%) in the event of a loss of a reactor Feed Pump. EO-2.0g

   a. Activates when a feed pump trips with a reactor water low level alarm (Level 4).

      1) FCV closes to reduce power to approximately 68% to stay within the capacity of one feed pump.

      2) Loop Flow Controller is automatically transferred to manual.

   b. Cause must be corrected, and circuit reset with the Feedwater Pump Trip Interlock Reset switch on Panel 602 prior to manual FCV manipulation.

7. Function generator changes flow demand signal into a valve position demand signal.

E. Servo Controllers - Take valve position demand signal and send this signal to the servo valve on the HPU.

Show T.P. Figure 2B

1. Valve position demand is compared to the FCV position feedback signal from a rotary variable differential transformer (RVDT).

EO-2.0h

   a. Position controller deviation output passes through an output limiter to restrict the maximum (- or +) position deviation output.
   b. Position controller's output is a velocity setpoint signal sent to the velocity controller.
   c. Valve position is provided on P602 from 0 to 100%. Valve position is 14%-17% indicated with the valve at minimum position and approximately 85% at maximum open position.

Show T.P. Figure 5

2. Velocity controller compares velocity setpoint demand with the actuator velocity feedback signal from the Linear Velocity Transmitter (LVT)
   a. Feedback signal limits overshoot and hunting and smooth response to system demand.

b. Velocity deviation signal is applied to the operating subloop servo control valve.

F. Actuator and Motion Inhibit Valves

Show T.P. Figure 4

1. Hydraulic actuator provides mechanical input to the FCV in response to flow from the HPU.
2. Pressure directed to pilot ports of pilot check valve.
   a. Causes check valves to open.
   b. Allows flow to "open" and "close" ports.
   c. Manual or Auto shutdown vents pilot pressure and inhibits FCV motion.

G. Hydraulic Power Unit

EO-3.0

Show T.P. Figure 4

Numbers correlate to numbered components on Figure 4.

(1) Hydraulic Pump
(2) Solenoid operated 4-way valve
(3) Pilot operated 4-way valve
(4) Flow control valve actuator
(5) Pilot operated check valves
(6) Velocity limit orifice
(7) Shuttle valve
(8) Hydraulic reservoir
(9) Pump and fan motors
(10) Pressure control valve
(11) Accumulator
(12) Air-Oil heat exchanger
(13) Temperature control valve
(14) Back pressure control valve

1. 2 sub-loops (identical, redundant); interconnected at:
   a. "Open" and "close" lines which conduct flow to the "open" and "close" cylinder ports.
   b. Shuttle valve and "pilot" line which conduct pressure to the actuator units pilot operated check valve pilot ports.
   c. Common reservoir and drain header
2. One subloop normally runs (LEAD): alternate subloop auto starts if the LEAD subloop fails to function and/or shuts down.
   a. A second malfunction will shutdown the alternate subloop.
3. HPU pumps and motor (1)(9)
   a. The hydraulic pumps have 40 hp motors powered from 2NHS-MVV014A and B.
   b. Hydraulic power is generated by a fixed displacement pump.
   c. Pressure controlled at 1900 psig by relief valve (10) which meters unneeded flow back to the reservoir.
4. Accumulators (11) reduce pressure transients when demand increases or decreases faster than the relief valve can respond.

5. Response to electrical signals increases or decreases the servo valve opening thus the actuator's velocity.
6. Alternate subloop is isolated from the actuator and other subloop by its solenoid-operated isolation valve (2), pilot operated isolation valve (3), and shuttle valve (7).
   a. Shuttle valve (7)
      1) Interconnects operational subloop with the plot line and isolates the other subloop from the pilot line and the operational subloop.
      2) Pressure from the other subloop shifts the shuttle valve poppet to the other end of the pilot line, and subloops switch operation.
      3) Shuttle valve malfunction cannot prevent actuator lockup because of its construction.
   b. Pilot operated isolation valves (3)
      1) Interconnect their respective subloops with the common "open" and "close" lines to the actuator.

2) 3-position, 4-way spool valves. Spool stroke limit is set to prevent the spool from shifting past center in one direction, thus disabling the valve position.

3) Valve opens when pressure is directed to the "operate" pilot port and vented for the "isolate" pilot port.

4) Venting of both ports spring closes the valve.

c. Solenoid-operated isolation valve (2)

1) Provides interface between electronic logic circuits and hydraulic subloop isolation circuits.

2) Energization of the solenoid valve directs pressure to the pilot line and shuttle valve and opens the respective subloop's pilot operated isolation valve.

3) Loss of electrical signals isolate the subloop.

4) Logic circuits also stop the pump, causing pressure to decay.

7. Reservoir temperature is maintained at 125°F by an air-oil heat exchanger (12).
   a. Fan motor runs whenever its subloop's pump motor is running.
   b. Temp. control valves (13) meter flow through the heat exchanger to maintain the temperature.

At this point utilize Figure 4 and explain flowpath to open/close the FCV.

H. Flow Control Valve

Show T.P. Figure 3

1. Designed to have linear flow characteristics.
2. Limit switches mounted on actuator shaft
   a. Minimum valve position of (0% indicated) inputs to pump start logic.

III. INSTRUMENTATION, CONTROLS AND INTERLOCKS

A. Controls

1. Loop Flow Controller
   The loop flow controllers are used to control the individual loop flow control valve. This is the lowest level of control. The controllers are located on panel 602.
2. Recirculation Flux Controller
   The recirculation flux controller is used to control both of the flow control valves when in manual control. This is the intermediate level of control. The controller is located on panel 602.

3. Recirculation Master Controller
   The recirculation master controller is used to control both of the flow control valves when in master manual control. All other controllers will be in automatic at this point. This is the highest level of control. The controller is located on panel 602.

B. INTERLOCKS

1. Flow Control Valve
   a. Runback on loss of reactor feed pump and low level alarm (178.3"). EO-4.0a
   b. FCV motion inhibit; see Table 1 EO-4.0b
2. Controllers
   a. Loop flow controllers transfer from automatic to manual:
      1) Any initiation of high to low recirculation pump speed transfer (manual or automatic).
      2) High drywell pressure (1.68 psig) EO-4.0c
      3) Loss of feedpump with concurrent vessel water low level alarm (178.3") (L4).

4) Excessive rate of change of the Flux Controller output

5) Deviation of 1% between the Loop Controller input and manual output signal (tracking failure) in automatic.

b. Flux controller transfer from automatic to manual: EO-4.0d

1) Excessive rate of change of the Master Controller output.

2) Either Loop controller transferring to manual (manual or automatic).

3. Hydraulic Power Unit

a. Standby HPU pump automatically starts and assumes control of actuator: EO-4.0e

1) Oil temperature (145°F)

2) Tank low level (70 gal.)

3) Operating pump overload or undervoltage, or

4) Low discharge pressure (1650 psig)

b. If standby loop is in maintenance mode the trip of the operating subloop is delayed.

1) Oil temperature (150°F)

2) Tank low level (60 gal)

IV. SYSTEM OPERATION

1. Individual Loop Manual Flow Control
   a. Flow in each recirculation loop is controlled individually with the Loop Flow Controllers.
   b. FCV must be at minimum position before starting recirculation pump at any speed or shifting to high speed.
   c. To place a Loop Flow controller in Manual, depress the MAN pushbutton, operate the control lever until servo error indication is zero (and then reset the Motion Inhibit Interlock if necessary).
2. Flux Manual Control
   a. With Loop Flow controllers in "automatic" the Flux Controller controls the FCV's simultaneously.
   b. Flow demand signal sent to each Loop Flow Controller by the manually controlled Flux Controller.

c. To establish Flux Manual, establish approximately the same output meter readings on both M/A stations. Operate the control lever on the Flux M/A station until the M/A error meters for both M/A stations are reading zero. Depress the AUTO pushbutton on each Flow M/A station.

3. Master Manual Control

a. Loop Flow Controllers and Flux Controller are in "automatic". Master Flow Controller in "manual".

b. Power demand signal compared to flux feedback signal for automatic adjustments of small changes in reactor power.

c. To establish Master Manual operate the control lever on the Master M/A station until the flux error meter reads zero. Depress the AUTO pushbutton on the Flux M/A station.

V. SYSTEM INTERRELATIONS

A. FWS - RRFC System receives reactor feed pump signals to determine feed pump status

EO-5.0a

B. NMS - RRFC receives a conditioned APRM power signal for neutron flux feedback — EO-5.0b

C. RVI - RRFC receives vessel water level and drywell pressure for FCV interlocks — EO-5.0c

D. Electrical - HPU 'A' - 2NHS-MCC014A
'B' - 2NHS-MCC014B — EO-5.0d

VI. DETAILED SYSTEM REFERENCE REVIEW

- Review each of the following referenced documents with class.

A. Technical Specifications — EO-6.0

Specification For:	APPLICABLE SECTION INCLUDING BASES			
	SL	LSSS	LCO	SR
Recirculation Loops			3.4.1.1	
Jet Pumps			3.4.1.2	
Recirculation Loop Flow			3.4.1.3	
Idle Recirculation Loop Startup			3.4.1.4	

B. Procedures — EO-7.0

1. N2-OP-29 Reactor Recirculation — EO-8.0
2. N2-OP-101A Plant Startup — EO-9.0
3. N2-OP-101C Plant Shutdown — EO-10.0
4. N2-OP-101D Plant Operation

C. Emergency Operating Procedures — EO-11.0

1. N2-EOP-RQ

VII. WRAP-UP

A. Review the student learning objectives.

Table 1

PCV MOTION INHIBIT INTERLOCKS

Actuation Setpoints

1) Hydraulic Power Unit Failure
   a) Undervoltage or overcurrent on the operating pump, when the standby pump is not available.
   b) Low discharge pressure (1650 psig) of the operating pump when the standby pump is not available.
   c) High oil reservoir temperature (150°F).
   d) Low oil reservoir level (60 gallons).

2) The Control Circuit Failure
   a) Velocity Controller deviation above preset limits.
   b) Position setpoint (demand) signal exceeds preset limits.
   c) Velocity feedback signal abnormally high or low.
   d) Position feedback signal rate of change abnormally high.
   e) Velocity controller deviation error oscillations.

3) High Drywell Pressure (1.68 psig).

07-786-91

ATTACHMENT 6
LESSON PLAN TEMPORARY/PUBLICATION/ADDENDUM CHANGE FORM

The attached change was made to:

Lesson plan title: Reactor Protection System

Lesson plan number: 02-20T-001-212-2-00 Rev 6

Name of instructor initiating change: Glen Bridges

Reason for the change: TCO # 02-20T-90-100, Industry Concerns GE Sw CR2940 (3 position switch) malfunction causing potential Rx scrams etc. in the systems

Type of change:

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

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: G Bridges /Date 7/5/91

Training Area Supervisor (or designee): G Bridges for F. White /Date 7/5/91