NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION

UNIT II OPERATIONS

Ø7-184-91

02-REQ-001-202-2-02 Revision 5

TITLE: REACTOR RECIRCULATION FLOW CONTROL SYSTEM

	SIGNATURE	DATE
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Summary on Pages

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THIS LESSON PLAN IS GENERAL REFERENCE

TRAINING DEPARTMENT RECORDS ADMINISTRATION ONLY:

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20 pp.
5/4/31

I. TRAINING DESCRIPTION

A. Title of Lesson: Reactor Recirculation Flow Control System

B. Lesson Description:

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. Estimate of the Duration of the Lesson: 4 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:

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

F. 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 II, or a similar plant, or successful completion of SRO training including simulator certification at the SRO level for Nine Mile Point Unit II, and
   c. Qualified in instructional skills as certified by NTP-16.
2. Trainee:
   a. Meet eligibility requirements per 10CFR55, or
   b. Be recommended for this training by Operations Superintendent, his designee, or Training Superintendent.

G. References:

1. Technical Specifications
   a. 3.4.1.1 Recirculation Loops
   b. 3.4.1.2 Jet Pumps
   c. 3.4.1.3 Recirculation Loop Flow
   d. 3.4.1.4 Idle Recirculation Loop Start-Up
2. Procedures
   a. N2-OP-29 Reactor Recirculation System
   b. N2-OP-101A Plant Start-Up
   c. N2-OP-101C Plant Shutdown
3. NMP2 FSAR
   a. Design Basis, Vol 16, Chapter 7, Page 7.7-18

II. REQUIREMENTS

A. Requirements for Class:

1. AP-9, Administration of Training
2. NTP-10, Rev. 4, Training of Licensed Operator Candidates
3. NTP-11, Rev. 8, Licensed Operator Requalification Training
4. NTP-12, Rev. 4, Unlicensed Operator Training

III. TRAINING MATERIALS

A. Instructor Materials:

1. Transparency Package
2. Overhead Projector
3. Whiteboard and Felt Tip Markers
4. 02-REQ-001-202-2-02
5. Operations Technology - Reactor Recirc Flow Control System
6. See Section I.G.1
7. See Section I.G.2
8. See Section I-G.3

B. Trainee Materials:

1. Text: Operations Technology - Reactor Recirc Flow Control System
2. See Section I.6.1
3. See Section I.6.2

IV. EXAM AND MASTER ANSWER KEYS

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

V. LEARNING OBJECTIVES

A. Terminal Objectives

Upon completion of this training the trainee will have gained the knowledge necessary to:

TO-1.0 Given N2-OP-29 Reactor Recirculation System perform lineups on the Recirc System.
RO 2020010101, K/A 3.50

TO-2.0 Given N2-OP-29 Reactor Recirculation System adjust the recirc flow using loop manual control.
RO 2020020101, K/A 3.70

TO-3.0 Given N2-OP-29 Reactor Recirculation System transfer recirc flow control from loop manual to loop auto (flux manual and control flow).
RO 2020050101, K/A 3.30

TO-4.0 Given N2-OP-29 Reactor Recirculation System transfer recirc flow control from loop auto to flux auto.
RO 2029110101, K/A 3.30

TO-5.0 Given N2-OP-29 Reactor Recirculation System operate the Recirc System in single loop mode.
RO 2029180101, K/A 3.10

TO-6.0 Given N2-OP-29 Reactor Recirculation System and N2-OP-101A plant startup increase power to rated using recirc flow and rods.
RO 2029270101, K/A 3.90

TO-7.0 Given N2-OP-29 Reactor Recirculation System perform the actions required for a FCV runback and low pump speed operation.
RO 2029330401, K/A 3.30

TO-8.0 Given N2-OP-29 Reactor Recirculation System respond to a failure of a flow control valve hydraulic power unit.
RO 2029340101, K/A 3.30

TO-9.0 Given N2-OP-29 Reactor Recirculation System perform the actions required for a FCV motion inhibit.

SRO TO-10.0 Given NMP-2 Technical Specifications determine power to flow to be within Tech Spec limits.
SRO 2029010403, K/A 3.60

SRO TO-11.0 Given NMP-2 Technical Specifications and N2-OP-29 Reactor Recirculation System determine applicable limits for single loop operation.
SRO 2029020403, K/A 3.60

SRO TO-12.0 Given NMP-2 Technical Specifications and N2-OP-29 Reactor Recirculation System determine if flow mismatch exceeds Tech Spec requirements.
SRO 2029050403, K/A 3.40

B. Enabling Objectives:

EO-1.0 State the purpose of the Reactor Recirculation Flow Control System (RRFC).

EO-2.0 State the purpose of the following components:

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 Given a diagram of the RRFC Hydraulic Power Unit (HPU) trace the normal flowpath to:

a. Open the flow control valve
b. Close the flow control valve

EO-4.0 State the power supplies to the HPU pump and fan motors.

EO-5.0 State the purpose of the following RRFC HPU components:

a. Hydraulic Pump
b. Accumulator
c. Shuttle Valve
d. Temperature Control Valve

EO-6.0 For the following automatic functions of the RRFC System list the signals causing the automatic function and state the purpose of the automatic function.

a. Flow Control Valve Runback
b. High Drywell Pressure Interlock
c. Controller Transfer to Manual
d. Flow Control Valve Motion Inhibit

EO-7.0 Concerning the autostart feature of the HPU pumps, state the following:

a. Auto start initiation signals and their associated setpoints.
b. Conditions which will cause a delay in the auto start feature and the signals and associated setpoints required for the initiation.

EO-8.0 Given N2-OP-29 Reactor Recirculation System, N2-OP-101A Plant Startup and N2-OP-101C Plant Shutdown, use the procedure to identify the appropriate actions and/or locate information related to:

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

EO-9.0 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 Reactor Recirculation Flow Control System.

A. Introduction

1. Trainee Learning Objectives
2. System Purpose — EO-1.0

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.

3. General Description

a. Reactor recirculation flow rate is varied by throttling the recirculation pump discharge with the recirculation system control valves.

Project "RR Overview Handout"
Identify major components and discuss important features.
Point out inlets, outlets, interconnections and instrumentation.

B. Detailed Description

1. Master Controller

a. Located in the Control Room on Panel P602.
b. Controls both recirculation FCV's when the Flux Controller and Flow Controller are in automatic.
c. Is always operated in manual via the slide switch to raise or lower flux demand signal.

Project "Recirculation Flow Controllers"
Discuss panel layout

LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES
d. Master controller output is a neutron flux demand signal.	Project "RRFC Master/Flux Controllers"	
1) High flux limiter limits the demand signal to 110% to prevent possible fuel damage.	Prevents overpowering the fuel.	EO-2.0a
2) Summing unit compares signal to flux feedback.		
3) APRM feedback signal normally supplied by channel C with channel E as backup.	If channel C APRM fails must bypass channel C using joystick on P602 to allow channel E APRM to become the backup.	
4) Isolation amplifier and filter		
a) Isolates the flow control system electronics from the particular APRM instrument which supplies its input signal.		
b) Filters high frequency noise in the APRM signal.		
e. Flux error signal - difference between the Master Controller flux demand and the flux feedback.	Relate meter indication on 602 to monitoring point on "RRFC Master/Flux Controller" diagram.	
1) Flux error limiter - limits the size of the signal to ± 20% of rated flux.		
2) Limiter output applied to the flux controller.		
3) A high rate of change in the flux error signal will cause the Flux Controller to transfer to the "manual" mode.		

2. Flux Controller — EO-2.0b

   a. Located on the P602 panel

   b. Generates a total flow demand signal.

   c. Manual mode, operator uses slide-switch to raise or lower the flow demand signal.

   d. Bumpless transfer from auto to the manual setpoint is provided by the signal tracking unit.

      1) Interlocked to prevent transferring to automatic unless input error is near zero and also provides ramp instead of a step change if the error is large.

         Error interlock is adjustable to allow for varying the size of the permitted error.

   e. Automatic mode, accepts the flux error signal from the error limiter and master controller.

      1) 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

      2) Flow demand low limiter — EO-2.0d

         a) Only in the circuit during flux controller automatic mode.

b) Prevents the flow demand signal from dropping below 40% due to flow instabilities occurring below this point.	Power oscillations such as LaSalle Power Plant experienced can occur when operating at the 100% rod line or above with low recirculation flow. (TCO-02-REQ-90-045).	
c) No low flow limit in manual mode.	Review precautions in N2-OP-29.	EO-8.0a
3) Flux controller signal failure unit transfers loop flow controllers to manual on high rate of change of signal.		
3. Neutron Flux Estimator		EO-2.0e
a. Provides a low noise flux feedback signal during steady state operation.		
b. Used because conventional filters cannot differentiate between electronic and neutron noise in the APRM signal.		
c. Flux estimator is comprised of a flux estimation circuit and a selection circuit.		
d. Flux estimation circuit uses APRM and flux controller output to produce estimated flux signal.		
e. Selection circuit		
1) Inputs		
a) Actual flux		
b) Estimated flux		
2) Output		
a) The flux feedback signal		

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

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

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

2) With the switch positioned to Operate (estimated flux) the feedback signal will be the APRM Signal if either of the following conditions exist:
   a) APRM Signal is $\geq$110%, or
   b) Estimated Signal minus APRM Signal is $\geq$5%

3) With the switch positioned to Operate (estimated flux) the feedback signal will be the current signal being used (either estimated or APRM) during the following conditions:

Caution operators that light on P602 is out when switch is in bypass despite label plate which would imply the opposite.

LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES
a) 105% < APRM Signal <110%, or b) 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).	Explain alarms: 1. Flux estimater needs maintenance - 200 APRM/EST cycles in 5 minutes. 2. Flux estimater failure - selected to APRM for >20 minutes.	
4) With the switch positioned to Bypass (APRM Signal), the feedback signal will always be the APRM signal.		
4. Loop Flow Controllers	Project "RRFC Loop/Servo controllers"	EO-2.0f
a. Located on P602		
b. Provides a <u>flow demand signal</u> to control the respective loop flow control valves position and rate of movement.		
c. Can be manually operated with the raise and lower slide switch.	Fast and slow speed are both adjusted to slow for all 4 controllers.	
d. Automatic mode		
1) Flow demand signal from Flux Controller is compared to a flow feedback signal (from RRS suction).		
2) Flow feedback signal from recirculation pump suction line flow.	Note: The ability to calculate total core flow when in single loop operation was a noted weakness on the 1989 NRC requal exam.	

e. If a flow error exists, the loop controller increases or decreases the output demand signal.

f. Loop Flow Controller Output signal is limited by a High Flow limiter (45%) in the event of a loss of a reactor Feed Pump. — This provides the RCS FCV Runback. — EO-2.0g EO-6.0a

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

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

b) Loop Flow Controller is automatically transferred to manual.

2) Cause must be corrected, and circuit reset with the Feedwater Pump Trip Interlock Reset switch on Panel 602 prior to manual FCV manipulation. — Project "P602 operator bonchboard sloping section"

g. Function generator changes flow demand signal into a valve position demand signal and limits the FCV maximum position to 85%. — (TCO-02-REQ-90-116)

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

a. Valve position demand is compared to the FCV position feedback signal from a rotary variable differential transformer (RVDT). EO-2.0h
   1) Position controller deviation output passes through an output limiter to restrict the maximum (- or +) position deviation output.
   2) Position controller's output is a velocity setpoint signal sent to the velocity controller.

b. Velocity controller compares velocity setpoint demand with the actuator velocity feedback signal from the Linear Velocity Transmitter (LVT) EO-2.0h
   1) Feedback signal limits overshoot and hunting and provides smooth response to system demand.
   2) Velocity deviation signal is applied to the operating subloop servo control valve.

6. Actuator and Motion Inhibit Valves
   a. Hydraulic actuator provides mechanical input to the FCV in response to flow from the HPU.

b. Pressure directed to pilot ports of pilot check valve.
   1) Causes check valves to open.
   2) Allows flow to "open" and "close" ports.
   3) Manual or Auto shutdown vents pilot pressure and inhibits FCV motion.

7. Hydraulic Power Unit

Project "RR Hydraulics" and reference numbers in parenthesis.

EO-5.0

(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

a. 2 sub-loops (identical, redundant); interconnected at:
   1) "Open" and "close" lines which conduct flow to the "open" and "close" cylinder ports.
   2) Shuttle valve and "pilot" line which conduct pressure to the actuator units pilot operated check valve pilot ports.
   3) Common reservoir and drain header.

b. One subloop normally runs (LEAD): alternate subloop auto starts if the LEAD subloop fails to function and/or shuts down.
   1) A second malfunction will shutdown the alternate subloop.

c. HPU pumps and motor (1)(9)
   1) The hydraulic pumps have 40 hp motors powered from 2NHS-MCC014A and B. EO-5.0a
   2) Hydraulic power is generated by a fixed displacement pump.
   3) Pressure controlled at 1900 psig by relief valve (10) which meters unneeded flow back to the reservoir.

d. Accumulators (11) reduce pressure transients when demand increases or decreases faster than the relief valve can respond. EO-5.0b

e. Response to electrical signals increases or decreases the servo valve opening thus the actuator's velocity.

f. 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).

1) Shuttle valve (7)

EO-5.0c

a) Interconnects operational subloop with the plot line and isolates the other subloop from the pilot line and the operational subloop.

b) Pressure from the other subloop shifts the shuttle valve poppet to the other end of the pilot line, and subloops switch operation.

c) Shuttle valve malfunction cannot prevent actuator lockup because of its construction.

2) Pilot operated isolation valves (3)

a) Interconnect their respective subloops with the common "open" and "close" lines to the actuator.

b) 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.

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

d) Venting of both ports spring closes the valve.

3) Solenoid-operated isolation valve (2)

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

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

c) Loss of electrical signals isolate the subloop.

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

g. Reservoir temperature is maintained at 125°F by an air-oil heat exchanger (12). — EO-5.0d
   1) Fan motor runs whenever its subloop's pump motor is running.
   2) Temp. control valves (13) meter flow through the heat exchanger to maintain the temperature.

h. At this point utilize Figure 4 and explain flowpath to open/close the FCV. — Project "RR Hydraulics" — EO-3.0a, EO-3.0b

8. Flow Control Valve
   a. Designed to have linear flow characteristics.
   b. Limit switches mounted on actuator shaft
      1) Minimum valve position of (8% indicated) inputs to pump start logic.

C. Instrumentation, Controls and Interlocks
   1. Controls
      a. 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.

b. 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.

c. 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.

2. Interlocks

a. Flow Control Valve

1) Runback on loss of reactor feed pump and low level alarm (178.3").

b. Controllers

1) Loop flow controllers transfer from automatic to manual:

a) Any initiation of high to low recirculation pump speed transfer (manual or automatic).

b) High drywell pressure (1.68 psig)

Discuss FCV motion inhibit interlocks contained in Table 1.

EO-6.0d
EO-6.0b
EO-6.0c

c) Loss of feedpump with concurrent vessel water low level alarm (178.3") (L4).

d) Excessive rate of change of the Flux Controller output

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

2) Flux controller transfer from automatic to manual:

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

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

c. Hydraulic Power Unit

1) Standby HPU pump automatically starts and assumes control of actuator:

Project "Hydraulic Power Unit Status" EO-7.0a

a) Oil temperature (145°F)

b) Tank low level (70 gal.)

c) Operating pump overload or undervoltage, or

d) Low discharge pressure (1650 psig)

2) If standby loop is in maintenance mode the trip of the operating subloop is delayed until:
   a) Oil temperature (150°F)
   b) Tank low level (60 gal)

EO-7.0b

D. System Operation

Project "Recirculation Flow Controllers"

EO-8.0b

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 (8%) before starting recirculation pump at any speed or shifting to high speed.

8% minimum position prevents the FCV from "locking" up due to hi flow and large P.

   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.

E. System Interrelations

1. FWS - RRFC System receives reactor feed pump signals to determine feed pump status
2. NMS - RRFC receives a conditioned APRM power signal for neutron flux feedback
3. RVI - RRFC receives vessel water level and drywell pressure for FCV interlocks
4. Electrical - HPU 'A' - 2NHS-MCC014A
   'B' - 2NHS-MCC014B

EO-4.0

F. Detailed System Reference Review

- Review each of the following referenced documents with class.

1. Technical Specifications

EO-9.0

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	

LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES
2. Procedures		
a. N2-OP-29 Reactor Recirculation	Review changes to N2-OP-29 Reactor Recirculation System due to information contained in NRC Bulletin 88-07. (TCO-02-REQ-90-045)	EO-8.0a EO-8.0b EO-8.0c
b. N2-OP-101A Plant Startup		
c. N2-OP-101C Plant Shutdown	Review how to calculate total core flow when in single loop operation. Noted weakness during 1989 requal exam. (TCO-02-REQ-90-063)	EO-8.0d EO-8.0e
G. Related Plant Events Refer to Addendum "A" and review related plant events with class (if applicable).		
H. System History Refer to Addendum "B" and review related plant modifications with class (if applicable).		
I. Wrap-Up		
1. Review Student Learning Objectives		

Table 1

FCV 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).